Attachment 1.1 Non-Technical Summary

CenterPoint Energy
Cause No. 45501
Petitioner's Exhibit 4
MAR WP1 (Public)

2019/2020 Integrated Resource Plan

VECTREN
A CenterPoint Energy Company

Non-Technical Summary

I. Introduction

Southern Indiana Gas and Electric Company d/b/a Vectren a CenterPoint Energy Company's ("Vectren") 2019/2020 Integrated Resource Plan is submitted in accordance with the requirements of the Indiana Utility Regulatory Commission (IURC or Commission) and the guidance provided in the Commission's recent orders related to the preferred portfolio described in Vectren's previous 2016 Integrated Resource Plan ("IRP"). The preferred portfolio in Vectren's previous 2016 IRP contemplated replacement of some of Vectren's coal fleet by the end of 2023 with a mix of renewable, energy efficiency and gas resources while retaining other coal resources. To implement this plan, Vectren filed two cases seeking Certificates of Public Convenience and Necessity ("CPCN") to (1) own and operate a 50 MW solar project located on its system (the "Troy Solar Project"), (2) install equipment designed to achieve compliance with environmental regulations in order to continue operation of its 270 MW Culley Unit 3 beyond 2023 and construct a 700-850 MW Combined Cycle Gas Turbine ("CCGT"). The Commission approved issuance of CPCNs authorizing the construction of the Troy Solar Project and Culley Unit 3 compliance projects. The Commission order denying a CPCN for the 700-850 MW CCGT urged Vectren to:

- Focus on outcomes that reasonably minimize the potential risk of an asset becoming uneconomic in an environment of rapid technological innovation;
- Fully consider options that provide a bridge to the future;
- Utilize a request for proposals ("RFP") to determine the price and availability of renewables; and
- Consider resource diversity and alternatives that provide off ramps that would allow Vectren to react to changing circumstances.

Vectren began its 2019/2020 IRP process in April 2019 with the objective of engaging in a generation planning process responsive to the Commission's guidance and seeking input from a variety of stakeholders. As part of its 2019/2020 IRP process, Vectren's evaluation has focused on exploring all new and existing supply-side and demand side resource options to reliably serve Vectren customers over the next 20 years. While the fundamentals of integrated resource planning were adhered to in developing the 2016 IRP, Vectren has enhanced its process and analysis in several ways. These enhancements include, but are not limited to the following:

- Issuance of an All-Source RFP to provide current market project pricing to be utilized in IRP modeling and potential projects to pursue, particularly for renewable resources such as wind and solar;
- An exhaustive review of reasonable options that leverage existing coal resources;
- increased participation and collaboration from stakeholders on all aspects of the analysis, inputs and resource evaluation criteria, with specific considerations and responses from Vectren;
- An encompassing analysis of wholesale market dynamics that accounts for MISO developments and market trends;
- The use of a more sophisticated IRP modeling tool, Aurora, which provided several benefits (simultaneous evaluation of many resources, evaluation of portfolios on an hourly basis and consistency in modeling, including least cost long-term capacity expansion planning optimization, simulated dispatch of resources and probabilistic modeling); and
- A more robust risk analysis, which encompasses a broad consideration of risks and an exploration of resource performance over a wide range of potential futures.

Based on this planning process and detailed analysis, Vectren has selected a preferred portfolio plan that significantly yet prudently diversifies the resource mix for its generation portfolio with the addition of significant solar and wind energy resources, the retirement or exit of four coal units, and continued investment in energy efficiency. These resources are complemented with dispatchable resources including continued operation of Culley Unit 3 and the addition of two flexible natural gas Combustion Turbines (CTs). The gas units represent a much smaller portion of Vectren's generation portfolio as compared to the 2016 IRP preferred portfolio while still providing reliable capacity and energy. The highly dispatchable and fast-ramping gas units are an important match with the significant renewable investment, enabling Vectren to maintain constant electric supply during potentially extended periods of low output from renewable energy sources. The units ramp quickly and provide load following capability, complimenting renewable energy production, which is expected to grow throughout the MISO footprint. Vectren's preferred portfolio reduces its cost of providing service to customers over the next 20 years by more than $320 million as compared to continuing with its existing generation fleet. Additionally, the preferred portfolio reduces carbon dioxide output by approximately 67% by 2025 and 75% by 2035 when compared to 2005 levels, which helps Vectren's parent company, CenterPoint Energy, achieve its commitments to environmental stewardship and sustainability, while meeting customer expectations for clean energy that is reliable and affordable.

Vectren's preferred resource plan reduces risk through diversification, reduces the cost to serve load over the next 20 years and provides the flexibility to continue to evaluate and respond to future needs through subsequent IRPs. The preferred portfolio has several advantages: including: 1) Energy supplied by this portfolio is generated primarily through a significant amount of near-term renewable solar and wind projects that take advantage of the Investment Tax Credit and the Production Tax Credit. This lowers portfolio costs and takes advantage of current tax-advantaged assets. 2) Two new, low-cost gas combustion turbines, continued use of Vectren's most efficient coal unit (Culley 3) and new battery storage resources, provide resilient, dispatchable power to Vectren's system that is complementary to significant investment in new intermittent renewable resources. This is very important, as coal plants, which have provided these attributes in the past, continue to retire in MISO Zone 6. 3) The portfolio provides flexibility to adapt to and perform well under a wide range of potential future legislative, regulatory, and market conditions. The preferred portfolio performed well under CO_2, methane constraints, and other related regulations such as a fracking ban. The cost position of this portfolio that is backed up by the two combustion turbine capacity resources does not change because the gas turbines predominantly run during peak load conditions. This provides a financial hedge against periodic instances of high market energy and capacity prices, while also providing reactive reserves and system reliability in times of extended renewable generation droughts, i.e., cloud cover and low wind. 4) It reasonably balances energy sales against purchases to remain poised to adapt to market shifts. 5) It includes new solar capacity when it is most economic to the portfolio. 6) Finally, it is timely. New combustion turbines can come online quickly to replace coal generation that retires by the end of 2023, minimizing in-service lag and reducing exposure to the market.

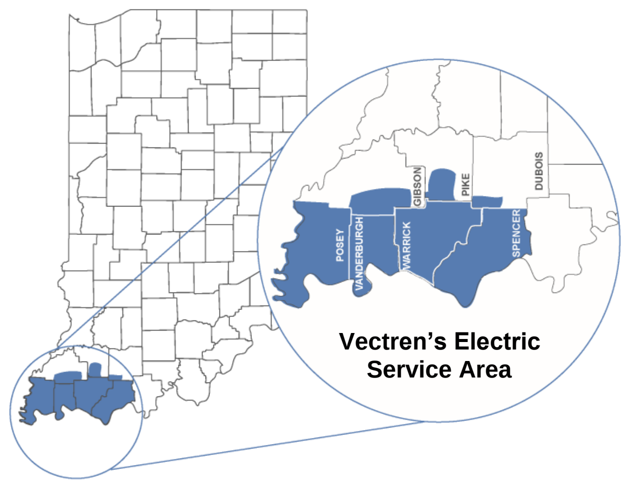
The resource options selected in this plan provide a bridge to the future. For example, CT's allow time for battery storage technology to continue to become more competitive in price and further develop longer duration storage capabilities. Further, should there be a need for new baseload generation in the future to accommodate a large load addition or to replace Warrick 4 and Culley 3, one or both CT's could be converted to a CCGT, a highly efficient gas energy resource. Even with the large commitment in the near term to renewable resources, additional renewable resources can be added over time.

The preferred portfolio also provides several off-ramps (future transitional inflection points) should they be needed. 1) Vectren continues to speak with Alcoa about a possible extension of Warrick 4 (W4) joint operations through 2026. This option could provide additional time and shield Vectren customers from capacity purchases at a time where the market is expected to be tight, causing much higher projected prices than today. Additionally, time may be needed to allow Vectren to secure the level of renewable resources identified in the preferred portfolio and to allow for contingency for permitting and construction of new combustion turbines. 2) While Culley 3 is not scheduled to be retired within the timeframe of this analysis, including thermal dispatchable generation in this portfolio will allow Vectren flexibility to evaluate this option in future IRPs. 3) Vectren will work to secure attractive renewables projects from the recent All-Source RFP but will likely require a second RFP to fully secure 700-1,000 MWs of solar on multiple sites and 300 MWs of wind constructed over a span of several years. Issuing a second RFP provides two main benefits. It allows more local renewable options to select from, as some offered proposals are no longer available. Second, it provides additional time to better understand how MISO intends to move forward with market adjustments, such as capacity accreditation and energy price formation. MISO's wholesale market is adapting to fleet transition that is moving toward intermittent renewable resources.

What follows is a summary of Vectren's process to identify this portfolio, focusing on Vectren's operations, an explanation of the planning process and a summary of the preferred portfolio.

II. Vectren Overview

Vectren provides energy delivery services to more than 146,000 electric customers located near Evansville in Southwestern Indiana. In 2018, approximately 44% of electric sales were made to large (primarily industrial) customers, 30% were made to residential customers and 26% were made to small commercial customers.



The table below shows Vectren generating units. Since the last IRP, Vectren has formally retired four, older small natural gas units[1] rather than investing significant capital dollars to ensure safety and reliability. Note that Vectren also offers customers energy efficiency programs to help lower customer energy usage and bills.

Unit	Installed Capacity ICAP (MW)	Primary Fuel	Year in Service	Unit Age	Coal Unit Environmental Controls[2]
A.B. Brown 1	245	Coal	1979	41	Yes
A.B. Brown 2	245	Coal	1986	34	Yes
F.B. Culley 2	90	Coal	1966	54	Yes
F.B. Culley 3	270	Coal	1973	47	Yes

[1] In 2018, Vectren retired BAGS 1 (50 MW). In 2019, Vectren retired Northeast 1&2 (20 MW) and BAGS2 (65 MW)

[2] All coal units are controlled for Sulfur Dioxide (SO_2), Nitrogen Oxide (NO_X), Particulate Matter (dust), and Mercury. All coal units are controlled for Sulfur Trioxide (SO_3) and Sulfuric Acid ($H2SO_4$) except F.B. Culley 2.

Unit	Installed Capacity ICAP (MW)	Primary Fuel	Year in Service	Unit Age	Coal Unit Environmental Controls[2]
Warrick 4	150	Coal	1970	50	Yes
A.B. Brown 3	80	Gas	1991	29	
A.B. Brown 4	80	Gas	2002	18	
Blackfoot[3]	3	Landfill Gas	2009	11	
Fowler Ridge	50	Wind PPA	2010	10	
Benton County	30	Wind PPA	2007	13	
Oak Hill[4]	2	Solar	2018	<2	
Volkman Rd[5]	2	Solar	2018	<2	
Troy	50	Solar	2021		

III. Integrated Resource Plan

Every three years Vectren submits an IRP to the IURC as required by IURC rules. The IRP describes the analysis process used to evaluate the best mix of generation and energy efficiency resources (resource portfolio) to meet customers' needs for reliable, low cost, environmentally sustainable power over the next 20 years. The IRP can be thought of as a compass setting the direction for future generation and energy efficiency options. Future analysis, filings and subsequent approvals from the IURC are needed to implement selection of new resources.

Vectren utilized direct feedback on analysis methodology, analysis inputs, and evaluation criteria from stakeholders, including but not limited to Vectren residential, commercial and industrial customers, regulators, elected officials, customer advocacy groups and environmental advocacy groups. Vectren continues to place an emphasis on reliability, customer cost, risk, resource diversity, and sustainability. The IRP process has become increasingly complex in nature as renewable resources have become more cost competitive, battery energy storage has become more viable, and existing coal resources are dispatched less and less.

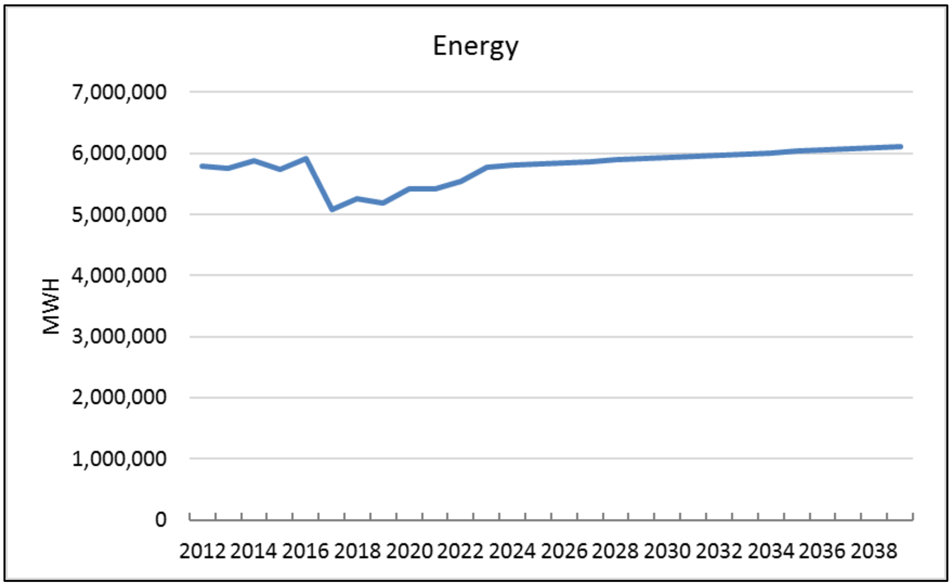
[3] The Blackfoot landfill gas generators are connected at the distribution level.
[4] Oak Hill Solar is connected at the distribution level.
[5] Volkman Rd. Solar is connected at the distribution level.

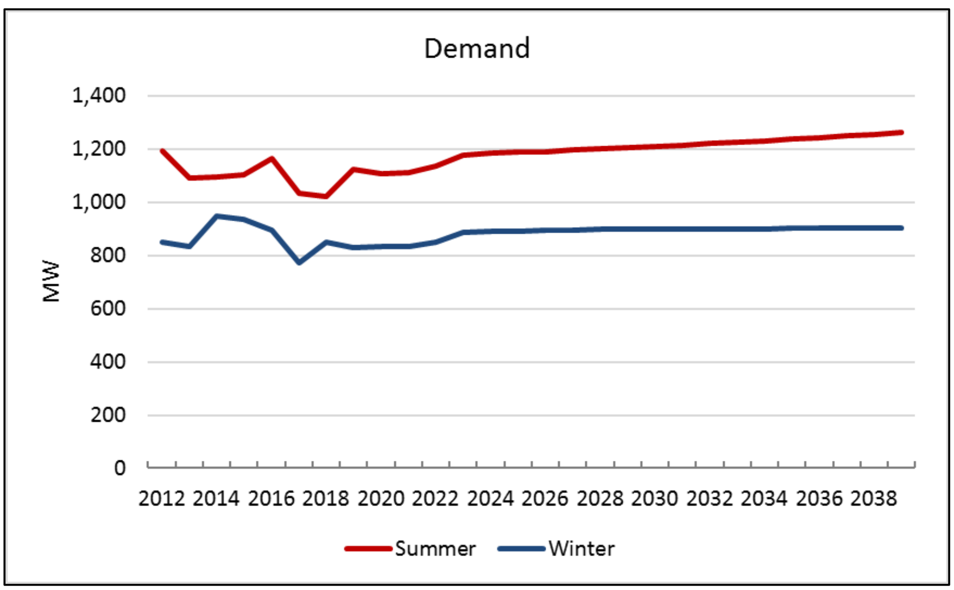
A. Customer Energy Needs

The IRP begins by evaluating customers' need for electricity over the 20-year planning horizon. Vectren worked with Itron, Inc., a leader in the energy forecasting industry, to develop a forecast of customer energy and demand requirements. Demand is the amount of power being consumed by customers at a given point in time, while energy is the amount of power being consumed over time. Energy is typically measured in Megawatt hours (MWh) and demand is typically measured in Megawatts (MW). Both are important considerations in the IRP. While Vectren purchases some power from the market, Vectren is required to have enough generation and energy efficiency resources available to meet expected customers' annual peak demand plus additional reserve resources to meet MISO's Planning Reserve Margin Requirement (PRMR) for reliability. Reserve resources are necessary to minimize the chance of rolling black outs; moreover, as a MISO (Midcontinent Independent System Operator) member, Vectren must comply with MISO's evolving rules to maintain reliability.

Historically, IRPs have focused on meeting customer demand in the summer, which is typically when reserve margins are at a minimum. As the regional resource mix changes towards intermittent (variable) renewable generation, it is important to ensure that resources are available to meet this demand in all hours of the year, particularly in the times of greatest need (summer and winter). MISO functions as the regional transmission operator for 15 Midwestern and Southern states, including Indiana (also parts of Canada). In recognition of MISO's ongoing evaluation of how changes in the future resource mix impact seasonal reliability, Vectren ensured that its preferred portfolio would have adequate reserve margins for meeting both the winter and summer peak demand. Later in this document it is further explained how MISO is evaluating measures to help ensure year-round reliability.

Vectren utilizes sophisticated models to help determine energy needs for residential, commercial and large customers. These models include projections for the major drivers of energy consumption, including but not limited to, the economy, appliance efficiency trends, population growth, price of electricity, weather, specific changes in existing large customer demand and customer adoption of solar and electric vehicles. Overall, customer energy and summer demand are expected to grow by 0.6% per year. Winter demand grows at a slightly slower pace of 0.5%.





B. Resource Options

Energy Efficiency/Demand Response

Natural Gas

Coal

Renewables, Wind & Solar

Battery Storage

The next step in an IRP is identifying resource options to satisfy customers' anticipated need. Many resources were evaluated to meet customer energy needs over the next 20 years. Vectren considered both new and existing resource options. Burns and McDonnell, a well-respected engineering firm, conducted an All-Source RFP which generated 110 unique proposals to provide energy and capacity from a wide range of technologies, including: solar, solar + short duration battery storage, standalone short duration battery storage, demand response, wind, gas and coal. These project bids provided up-to-date market-based information to inform the analysis and provide actionable projects to pursue to meet customer needs in the near to midterm. Additionally, Vectren utilized other information sources for long term costs and operating characteristics for these resources and others over the entire 20-year period. Other options include continuation of existing coal units, conversion of coal units to natural gas, various natural gas resources, hydro, landfill gas, and long-duration batteries, as well as partnering with other load-serving entities. Every IRP is a snapshot in time producing a direction based on the best information known at the time. It is helpful to provide some background into significant issues that help shape the IRP analysis, including but not limited to: projected low stable gas prices, low cost and projected high penetration of intermittent renewable resources, future of coal resources, new technology and projected changes in the MISO market to adapt and help ensure reliability.

i. Industry Transition

The cost of fuel used by generation facilities to produce electricity is also accounted for in evaluating the cost of various electric supply alternatives. Gas prices are near record low levels and are projected to remain stable over the long term. Shale gas has revolutionized the industry, driving these low gas prices and has fueled a surge in low-cost gas generation around the country. Vectren's IRP reflects the benefit low gas prices provide to the market, as gas units are on the margin and typically set market prices for energy.

Within the MISO footprint, energy from gas generation has increased from less than 10% of total electric generation, used primarily to meet the needs during peak demand conditions in 2005, to approximately 26% of total generation in 2018[6]. Meanwhile, the cost of renewable energy has declined dramatically over this time period due to improvements in technology and helped by government incentives in the forms of the Production Tax Credit for wind and the Investment Tax Credit (ITC) for solar, both of which are set to expire or ratchet down significantly over the next few years.

MISO Energy Mix Transition (GWH) from 2005 to 2018 to 2030 (Based on Utility Announcements and State Integrated Resource Plans)*

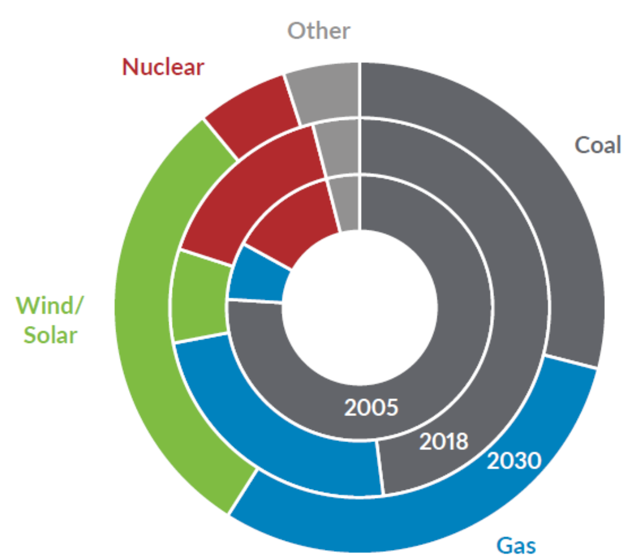


*Chart reflects ratios of generation.

The move toward low cost renewable and gas energy has come at the expense of coal generation, which has been rapidly retiring for several reasons. Coal plants have not been able to compete on price with low cost renewable and gas energy. Operationally, the move toward intermittent renewable energy requires coal plants to more frequently cycle on and off. These plants were not

[6] MISO Forward Report, March 2019, page 10. https://cdn.misoenergy.org/MISO%20FORWARD324749.pdf

designed to operate in this manner. The result is increased maintenance costs and more frequent outages. Additionally, older, inefficient coal plants are being retired to avoid spending significant dollars on necessary upgrades to achieve compliance with Environmental Protection Agency (EPA) regulations. Finally, public and investor pressure, coupled with future cost risk associated with the objective of decreasing carbon emissions, has driven unit retirements. Based on these and other major factors, MISO expects the generation mix in 2030 to be much more balanced than in the past with roughly one third renewables, one third gas and one third coal. Some large nuclear plants remain but have also found it challenging to compete on cost.

ii. Changing Market Rules to Help Ensure Reliability

MISO recognizes these major changes in the way energy is being produced. Traditionally, baseload coal plants produced energy at a constant level, while peaking gas plants were available to come online as needed to meet peak demand. Gradual increases and decreases in energy demand throughout the day and seasonally were easily managed with these traditional resources. As described above, the energy landscape is continuing its rapid change with increased adoption of more intermittent renewable generation which is available when the sun is shining, or the wind is blowing. This creates much more variability by hour in energy production. Some periods will have over production (more energy produced than is needed at the time) and other periods will have low to no renewable energy production, requiring dispatchable resources to meet real time demand for power. MISO is in the process of studying how this transition will affect the electrical grid and what is needed to maintain reliable service, as renewables penetrations reach 30-50%. Possible ramifications include challenges to the ability to maintain acceptable voltage and thermal limits on the grid.

To deal with these challenges, MISO has been working through a series of studies and has put forth guidance for how they intend to evaluate resources moving forward. One significant development is the recognition that all hours matter. In the past, MISO resource adequacy requirements focused on only the peak hour each year. Recent MISO emergencies in all seasons have demonstrated that the system can experience potential energy shortfalls in any hour due to changing resource conditions. As such, MISO is planning for new requirements to ensure resources are available for reliability in each of the 8,760 hours of the year. Each resource has different operating characteristics and different output levels, depending on the season. Vectren has accounted for these changes by validating that portfolios in this analysis provide sufficient resources to meets its MISO obligations[7] in the two heaviest demand periods (summer/winter). MISO has initiatives underway that include new testing requirements to ensure that Demand Response (DR) resources are available when needed. MISO's annual Market Road Map process has prioritized the development of mechanisms to more accurately account for resource availability. This includes an evaluation of how to best incent resources with the right kinds of critical attributes needed to keep the system operating reliably. Incentives are contemplated for resources that are available (dispatchable), flexible (ability to start quickly and meet changing load conditions when needed) and visible (have a better understanding of customer owned generation in addition to larger utility assets). MISO expects that traditional dispatchable coal and gas resources will continue to provide resilience to the grid.

iii. Battery Storage and Transmission Resources

Increasingly, utilities are considering the opportunity to add battery storage to resource portfolios to help provide the availability, flexibility and visibility needed to move to more reliance on intermittent renewable resources. Lithium-ion batteries have seen significant cost declines over the last several years as the technology begins to mature and as the auto industry creates economies of scale by increasing production to meet the anticipated demand for electric vehicles. Large scale batteries for utility applications have begun to emerge around the country, particularly where incentives

[7] Some portfolios have a heavy reliance on the market for both energy and capacity.

are available to lower the cost of this emerging technology or for special applications that improve the economics.

There are many applications for this resource, from shifting the use of renewable generation from time of generation to the time of need, to grid support for maintaining the reliability of the transmission system. Vectren has installed a 1 MW battery designed to capture energy from an adjacent solar project. This test project is providing information regarding the ability to store energy for use during the evening hours to meet customer energy demand. Along with the benefits provided by this technology, there are some limitations to keep in mind as utility scale battery storage is still evolving. Currently, commercially feasible batteries are short duration, typically four hours. There are some commercially available longer-duration batteries that show promise, but these are still very expensive. Additionally, safety standards are being developed and fire departments are being trained for the fire risk posed by L-ion batteries. Other chemistries are being developed to account for this issue but are not commercially imminent. Moreover, batteries today are a net energy draw on the system. They can produce about 90-95 percent of the energy that is stored in them. Part of this loss is due to the need to be well ventilated, cool and dry, which takes energy. Batteries are promising and have their place in current energy infrastructure, but they do not yet replace the need for other forms of dispatchable generation during extended periods without sun and wind. Vectren's All-Source RFP included bids for stand-alone batteries and batteries connected to solar resources.

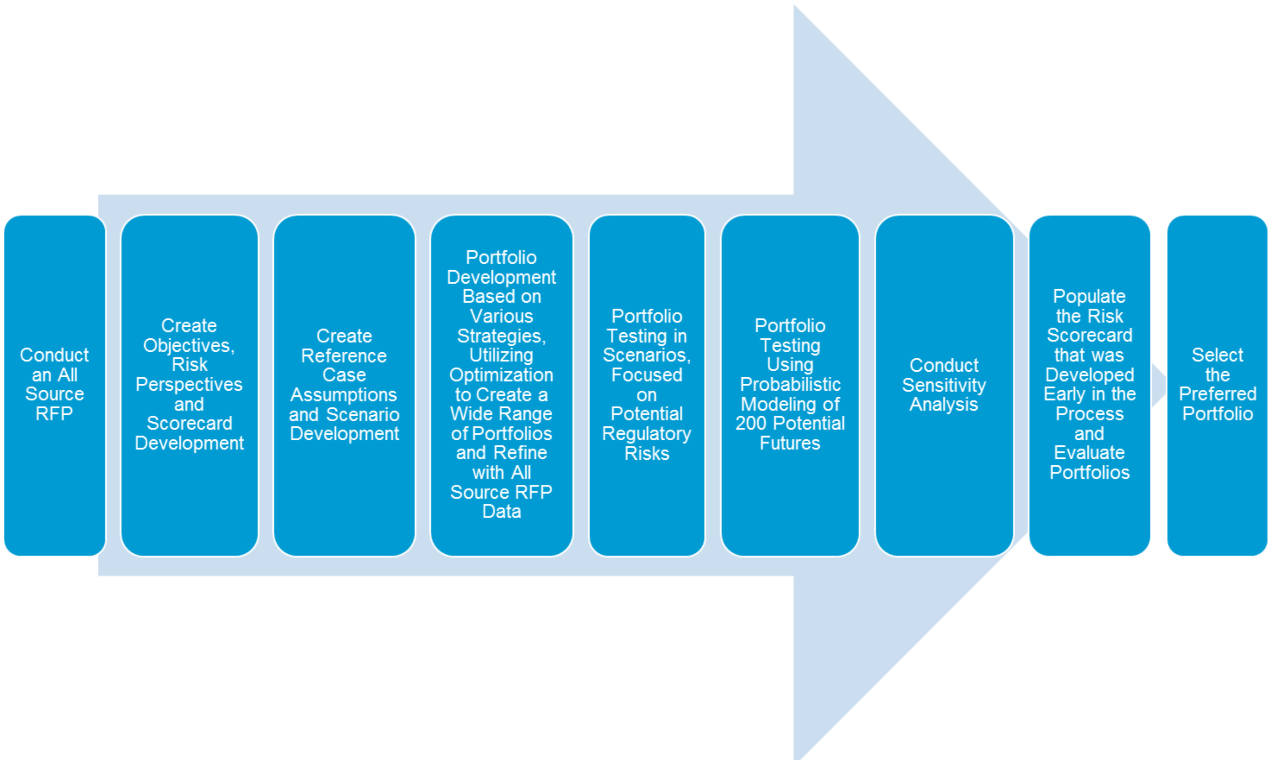
C. Uncertainty/Risk

The future is far from certain. Uncertainty creates a risk that a generation portfolio that is reasonable under an anticipated future fails to perform as expected if the future turns out differently. Vectren's IRP analysis was developed to identify the best resource mix of generation and energy efficiency to serve customer energy needs over a wide range of possible future states. Vectren performed two sets of risk analyses, one exposing a defined set of portfolios to a limited number of scenarios and another that exposed the same portfolios to 200 scenarios (stochastic or probabilistic risk assessment). To help better understand the wide range of possibilities for wholesale market dynamics, regulations, technological breakthroughs and shifts in the economy, complex models were utilized with varying assumptions for major inputs (commodity price forecasts, energy/demand forecasts, market power prices, etc.) to develop and test portfolios with diverse resource mixes.

IV. Analysis

Vectren's analysis included a step-by-step process to identify the preferred portfolio. The graphic below summarizes the major steps which included the following:

1. Conduct an All-Source RFP to better understand resource cost and availability.
2. Work with stakeholders to develop a scorecard as a tool in the full risk analysis to help highlight several tradeoffs among various portfolios of resources.
3. Work with stakeholders to develop a wide range of future states, called scenarios, to be used for testing of portfolios (mixes of various resource combinations to serve customer power and energy need).
4. Work with stakeholders to develop a wide range of portfolios for testing and evaluation within scenarios, sensitivity analysis and probabilistic analysis. Each of these analyses involves complex modeling.
5. Utilize the quantitative scorecard measures and judgement to select the preferred portfolio (the best mix of resources to reliably and affordably serve customer energy needs while minimizing known risks and maintaining flexibility).



V. Stakeholder Process

Vectren reevaluated how to conduct the stakeholder process based on comments in the Director's report, stakeholder feedback and the Commission order in Cause number 45052. Careful consideration was taken to ensure that the time spent was mutually beneficial.

Each of the first three stakeholder meetings began with stakeholder feedback. Vectren would review requests since the last stakeholder meeting and provide feedback. Suggestions were taken and in instances where suggestions were not acted upon, Vectren made a point to further discuss and explain why not. Per stakeholder feedback, notes for each meeting were included in question and answer format, summarizing the conversations. Additionally, feedback was received, and questions were answered via e-mail (irp@centerpointenergy.com) and with phone calls/meetings in between each session per request.

Three of four public stakeholder meetings were held at Vectren in Evansville, IN. The final stakeholder meeting on June 15, 2020 was held via webinar due to the COVID-19 situation. Dates and topics covered are listed below:

August 15, 2019	October 10, 2019	December 13, 2019	June 15, 2020*
• 2019/2020 IRP Process • Objectives and Measures • All-Source RFP • Environmental Update • Draft Reference Case Market Inputs & Scenarios	• RFP Update • Draft Resource Costs • Sales and Demand Forecast • DSM MPS/ Modeling Inputs • Scenario Modeling Inputs • Portfolio Development	• Draft Portfolios • Draft Reference Case Modeling Results • All-Source RFP Results and Final Modeling Inputs • Scenario Testing and Probabilistic Modeling Approach and Assumptions	• Final Reference Case and Scenario Modeling Results • Probabilistic Modeling Results • Risk Analysis Results • Preview the Preferred Portfolio

- Moved final stakeholder meeting date per stakeholder request and the COVID-19 situation

Based on this stakeholder engagement, Vectren made fundamental changes to the analysis in real time to address concerns and strengthen the plan. IRP inputs and several of the evaluation measures used to help determine the preferred portfolio were updated through this process. Vectren utilized stakeholder information to create boundary conditions that were wide enough to produce plausible future conditions that would favor opposing resource portfolios (i.e. Indiana Coal Council (ICC) request to continue coal through 2029 or 2039 and environmental stakeholders' request to utilize all renewable resources by 2030). For example, the low regulatory future includes declining coal prices and higher gas prices, which was a request from the ICC. The High Regulatory scenario, which was heavily influenced by environmental stakeholders, is the other plausible future bookend with a natural gas fracking ban (sustained high price), a social cost of carbon fee starting at $50 per ton in 2022 and lower renewables cost trajectory than what is expected. Additionally, an evaluation measure was adjusted based on direct stakeholder input. Vectren included the life cycle of carbon emissions for all resources in response to the ICC and environmental stakeholders. The table below shows key stakeholder requests made during the process and Vectren's response.

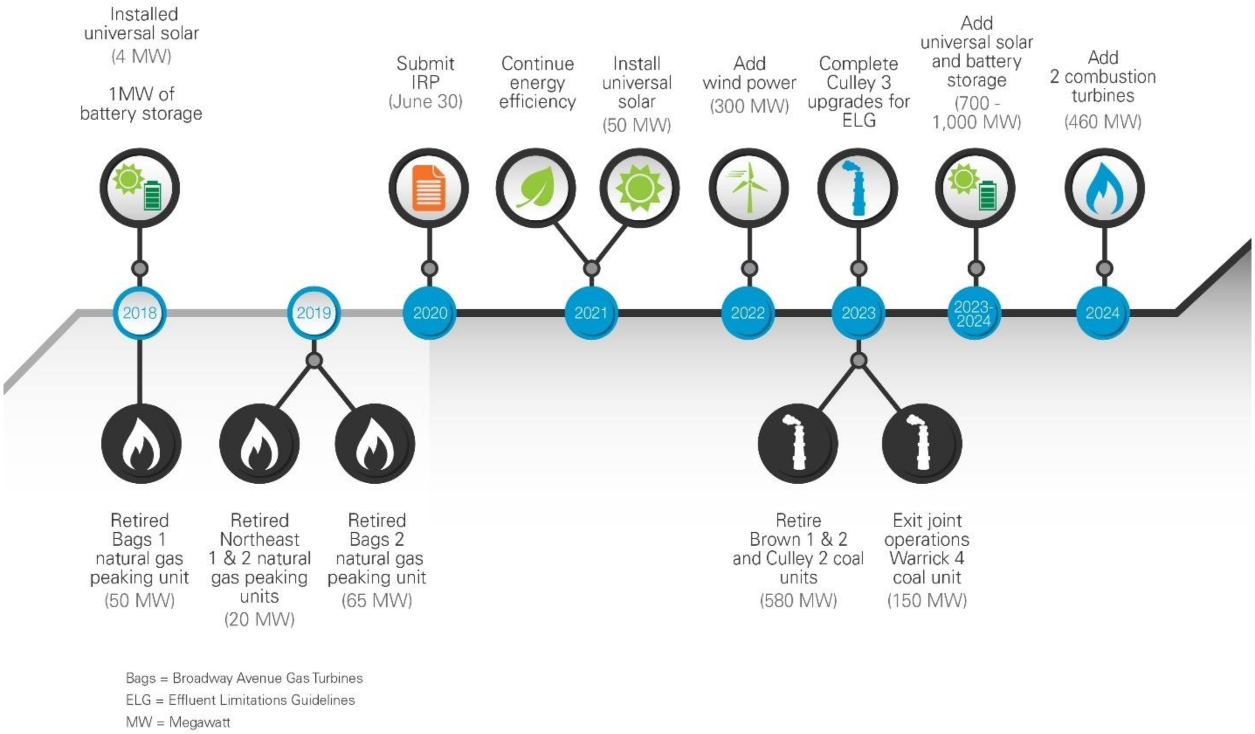
Request	Response
Update the High Regulatory scenario to include a carbon fee and dividend	Included a fee and dividend construct which assumed a balanced impact on the load (the economic drag from a carbon fee is neutralized by the economic stimulus of a dividend)
Lower renewables costs in the High Regulatory and 80% CO_2 Reduction scenarios	Updated scenario to include lower costs for renewables and storage than the Reference scenario
Consider life cycle emissions using CO_2 equivalent	Included a quantitative measure on the risk scorecard based on National Renewable Energy Lab (NREL) Life Cycle Greenhouse Gas Emissions (CO_2e) from Electricity Generation by Resource
Include a measure within the risk score card that considers the risk that assets become uneconomic	Included an uneconomic asset risk as a consideration in the overall evaluation. Not included in the scorecard.
Include a scenario with a carbon dividend modeled after HB 763 with a CO_2 price that was approximately $200 by the end of the forecast	Utilized a scenario with these prices to create an additional portfolio. Ultimately, this portfolio was not selected for the risk analysis, as the amount of generation built

Request	Response
	within modeling vastly exceeded Vectren's need and resulted in large energy sales
Reconsider the use of a seasonal construct for MISO resource accreditation	Reviewed calculation for solar accreditation in winter and utilized an alternate methodology, increasing accreditation in the winter
Include a CO_2 price in the reference case	Included mid-range CO_2 prices 8 years into the forecast. The Low Regulatory scenario did not include a CO_2 price, thus becoming a boundary condition

Meeting materials of each meeting can be found on www.vectren.com/irp and in Technical Appendix Attachment 3.1 Stakeholder Materials.

VI. The Preferred Portfolio

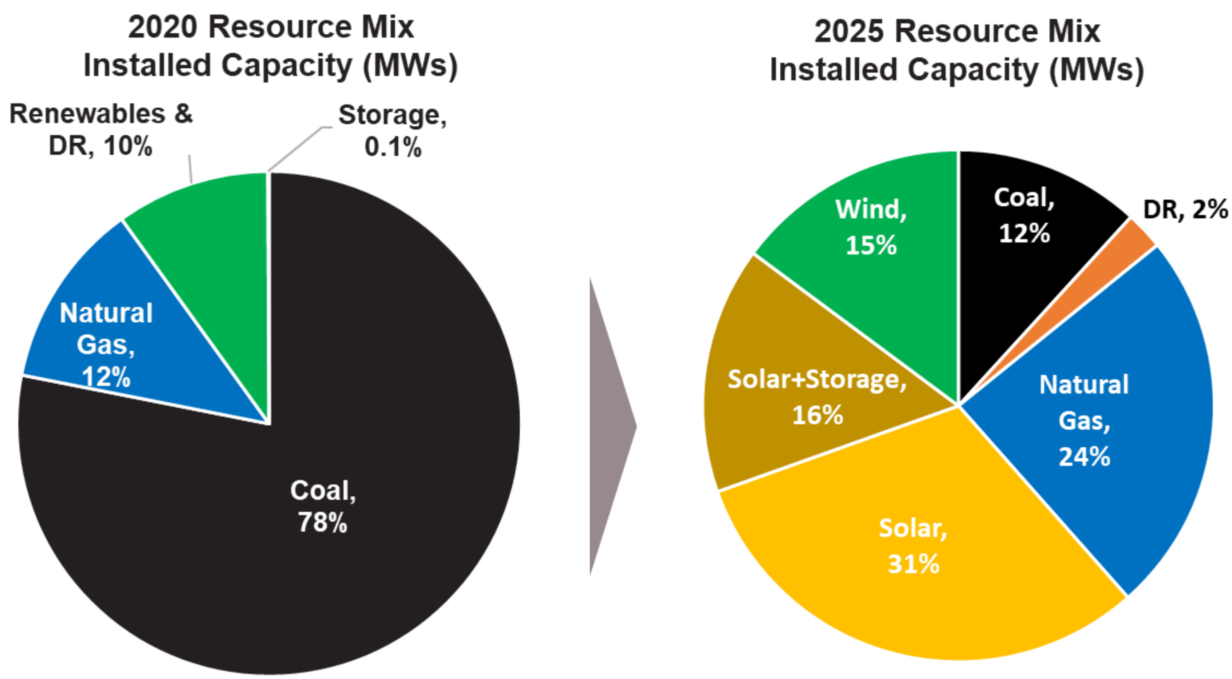
The Preferred Portfolio recommendation is to retire or exit 730 MWs of coal generation and replace with 700-1,000 MWs of solar generation (some connected to battery storage), add 300 MWs of wind backed by dispatchable generation that consists of 2 new Combustion Turbine (CT) gas units and maintaining Culley 3 (coal unit).



This preferred portfolio:

- Allows customers to enjoy the benefits of low-cost renewable energy, while ensuring continued reliable service as Vectren moves toward higher levels of intermittent renewable energy in the future.
- Saves customers over $320 million over the next 20 years when compared to continued operation of Vectren's coal fleet. The preferred portfolio is a low-cost portfolio in the near, mid and long term.
- Reduces lifecycle greenhouse gas emissions, which includes methane, by nearly 60% over the next 20 years. Direct carbon emissions are reduced 75% from 2005 levels by 2035.

- Includes a diverse mix of resources (renewables, gas and coal), mitigates the impacts of extended periods of limited renewable generation and protects against overreliance on the market for energy and capacity.
- Maintains future flexibility with several off ramps to accommodate a rapidly evolving industry, includes a multi-year build out of resources on several sites and maintains the option to extend the contract with Alcoa for Warrick 4 for a few years and maintains the option to consider the replacement of Culley 3 in the future when appropriate based on continual evaluation of changing conditions. These options will be revaluated in future IRPs.
- Provides the flexibility to adapt to future environmental regulations or upward shifts in fuel prices relative to Reference Case assumptions. The preferred portfolio performed consistently well across a wide range of potential future environmental regulations, including CO_2, methane and fracking.
- Adds some battery energy storage in the near term, paired with solar resources to provide clean renewable energy when solar is not available. Provides time for technological advances that will allow for high penetration of renewables across the system, further cost declines and further Vectren operational experience to meet Vectren's customers' energy needs.
- Continues Vectren's energy efficiency programs with near term energy savings of 1.25% of eligible sales and further long-term energy savings opportunities identified over the next 20 years. Vectren is committed to Energy Efficiency to help customers save money on their energy bills and will continue to evaluate this option in future IRPs.



VII. Next Steps

The preferred portfolio calls for Vectren to make changes to its generation fleet. Some of these changes require action in the near term. First, Vectren will finalize the selection process to secure renewable projects from the All-Source RFP and seek approval from the IURC for attractive projects. Second, the IRP calls for continuation of energy efficiency. Vectren filed a 2021-2023 plan with the IURC in June of 2020, consistent with the IRP. Third, Vectren intends to pursue two natural gas combustion turbines to provide dispatchable support to the large renewables based preferred portfolio. These filings will be consistent with the preferred portfolio. However, the assumptions included in any IRP can change over time, causing possible changes to resource planning. Changes in commodities, regulations, political policies, customer need and other assumptions could warrant deviations from the preferred plan.

Vectren's plan must be flexible; as several items are not certain at this time.

- The timing of exiting joint operations of the Warrick 4 coal plant could change. The plant is jointly owned with Alcoa. Without incremental investment, the plant does not comply with the ELG and other water discharge control requirements. Vectren therefore continues to talk to Alcoa about its plans.

- The availability of attractive renewable projects is currently being evaluated. Negotiations for resources must take place to finalize availability and cost of projects. The Coronavirus has put pressure on supply chains and put in jeopardy the ability of full utilization of the Production Tax Credit and Investment Tax Credit for some projects. Competition for these projects is steep, with multiple, on-going RFP processes in the state of Indiana.
- Finally, MISO continues to evaluate the accreditation of resources. Vectren will continue to follow developments to determine the right amount of renewable resources to pursue in the near term.

Attachment 1.2 Vectren Technology Assessment Summary Table

VECTREN 2019 IRP TECHNOLOGY ASSESSMENT
SIMPLE CYCLE TECHNOLOGY ASSESSMENT PROJECT OPTIONS
PRELIMINARY - NOT FOR CONSTRUCTION
December 2019

PROJECT TYPE	1x Aeroderivative SCGT - Natural Gas		1x Aeroderivative SCGT - Natural Gas		1x E Class Frame SCGT - Natural Gas		1x F Class Frame SCGT - Natural Gas		1x G/H Class Frame SCGT - Natural Gas	
BASE PLANT DESCRIPTION	First Unit	Next Unit	First Unit	Next Unit	First Unit	Next Unit	First Unit	Next Unit	First Unit	Next Unit
Number of Gas Turbines/Engines/Units	1	1	1	1	1	1	1	1	1	1
Representative Class Gas Turbine	GE LM6000 PF		LMS100 PB		GE 7E.03		GE 7F.05		GE HA.01	
Capacity Factor, %	Peaking (10%)		Peaking (10%)		Peaking (10%)		Peaking (10%)		Peaking (10%)	
Startup Time to Base Load, min (Notes 1, 2)	5		10		10 fast start / 30 conventional		10 fast start / 30 conventional		10 fast start / 30 conventional	
Startup Time to MECL, min (Note 3)	4		8		8 fast start / 24 conventional		8 fast start / 24 conventional		8 fast start / 24 conventional	
Cold Startup Time to SCR Compliance, min (Note 3)	N/A		N/A		N/A		N/A		45	
Maximum Ramp Rate, MW/min (Online)	10		32		10		40		30	
Book Life, Years	30		30		30		30		30	
Equivalent Planned Outage Rate, % (Note 4, 15)	22.3%		22.3%		26.8%		26.8%		26.8%	
Equivalent Forced Outage Rate, % (Notes 4, 15)	25.9%		25.9%		5.8%		5.8%		5.8%	
Equivalent Availability Factor, % (Notes 4, 15)	90.6%		90.6%		93.8%		93.8%		93.8%	
Assumed Land Use, Acres	30	15	30	15	30	15	30	15	30	15
Fuel Design	Natural Gas Only		Natural Gas Only		Natural Gas Only		Natural Gas Only		Natural Gas Only	
Heat Rejection	Fin Fan Heat Exchanger		Fin Fan Heat Exchanger		Fin Fan Heat Exchanger		Fin Fan Heat Exchanger		Fin Fan Heat Exchanger	
NO_x Control	Dry Low NOx		Dry Low NOx		Dry Low NOx		Dry Low NOx		Dry Low NOx / SCR	
CO Control	Good Combustion Practice		Good Combustion Practice		Good Combustion Practice		Good Combustion Practice		CO Catalyst	
Particulate Control	Good Combustion Practice		Good Combustion Practice		Good Combustion Practice		Good Combustion Practice		Good Combustion Practice	
Technology Rating	Mature		Mature		Mature		Mature		Mature	
Permitting & Construction Schedule (Years from FNTP)	3		3		3		3		3	
ESTIMATED PERFORMANCE (All BASED ON NATURAL GAS OPERATION)										
Nominal Base Load Performance @59° F (ISO Conditions)										
Net Plant Output, kW	41,580	41,580	97,222	97,222	84,721	84,721	236,635	236,635	279,319	279,319
Net Plant Heat Rate, Btu/kWh (HHV)	9,280	9,280	8,895	8,895	11,527	11,527	9,928	9,928	9,311	9,311
Heat Input, MMBtu/h (HHV)	386	386	865	865	977	977	2,349	2,349	2,601	2,601
Nominal Min Load @ 59° F (ISO Conditions)										
Net Plant Output, kW	20,790	20,790	48,611	48,611	42,361	42,361	96,448	96,448	83,197	83,197
Net Plant Heat Rate, Btu/kWh (HHV)	12,170	12,170	10,431	10,431	15,158	15,158	13,240	13,240	13,527	13,527
Heat Input, MMBtu/h (HHV)	253	253	507	507	642	642	1,277	1,277	1,125	1,125
Base Load Performance @ 20° F (Winter Design)										
Net Plant Output, kW	48,100	48,100	98,709	98,709	95,908	95,908	234,585	234,585	287,269	287,269
Net Plant Heat Rate, Btu/kWh (HHV)	9,050	9,050	8,840	8,840	11,254	11,254	9,813	9,813	9,226	9,226
Heat Input, MMBtu/h (HHV)	435	435	873	873	1,079	1,079	2,302	2,302	2,650	2,650
Min Load Operational Status @ 20° F (Winter Design)										
Net Plant Output, kW	24,050	24,050	49,354	49,354	47,954	47,954	100,440	100,440	85,521	85,521
Net Plant Heat Rate, Btu/kWh (HHV)	11,650	11,650	10,407	10,407	14,608	14,608	13,240	13,240	13,653	13,653
Heat Input, MMBtu/h (HHV)	280	280	514	514	701	701	1,330	1,330	1,168	1,168
Base Load Performance @ 90° F (Summer Design)										
Net Plant Output, kW	32,610	32,610	86,225	86,225	75,072	75,072	216,502	216,502	256,829	256,829
Net Plant Heat Rate, Btu/kWh (HHV)	9,790	9,790	9,198	9,198	11,906	11,906	10,086	10,086	9,476	9,476
Heat Input, MMBtu/h (HHV)	319	319	793	793	894	894	2,184	2,184	2,434	2,434
Min Load Operational Status @ 90° F (Summer Design)										
Net Plant Output, kW	16,300	16,300	43,113	43,113	37,536	37,536	90,576	90,576	84,246	84,246
Net Plant Heat Rate, Btu/kWh (HHV)	13,830	13,830	11,040	11,040	15,866	15,866	13,645	13,645	13,327	13,327
Heat Input, MMBtu/h (HHV)	226	226	476	476	596	596	1,236	1,236	1,123	1,123

VECTREN 2019 IRP TECHNOLOGY ASSESSMENT
SIMPLE CYCLE TECHNOLOGY ASSESSMENT PROJECT OPTIONS
PRELIMINARY - NOT FOR CONSTRUCTION
December 2019

PROJECT TYPE	**1x Aeroderivative SCGT - Natural Gas**		**1x Aeroderivative SCGT - Natural Gas**		**1x E Class Frame SCGT - Natural Gas**		**1x F Class Frame SCGT - Natural Gas**		**1x G/H Class Frame SCGT - Natural Gas**	
BASE PLANT DESCRIPTION	First Unit	Next Unit	First Unit	Next Unit	First Unit	Next Unit	First Unit	Next Unit	First Unit	Next Unit
ESTIMATED CAPITAL AND O&M COSTS										
EPC Project Capital Costs, 2019 MM$ (w/o Owner's Costs)	**$65**	**$46**	**$123**	**$86**	**$85**	**$60**	**$125**	**$93**	**$168**	**$134**
Owner's Costs, 2019 MM$	**$27**	**$13**	**$38**	**$20**	**$40**	**$21**	**$48**	**$27**	**$57**	**$36**
Owner's Project Development	$0.3	$0.0	$0.3	$0.0	$0.3	$0.0	$0.3	$0.0	$0.3	$0.0
Owner's Operational Personnel Prior to COD	$0.3	$0.0	$0.3	$0.0	$0.3	$0.0	$0.3	$0.0	$0.3	$0.0
Owner's Engineer	$0.8	$0.0	$0.8	$0.0	$0.8	$0.0	$0.8	$0.0	$0.8	$0.1
Owner's Project Management	$1.0	$0.0	$1.0	$0.0	$1.0	$0.0	$1.0	$0.0	$1.0	$0.2
Owner's Legal Costs	$0.5	$0.0	$0.5	$0.0	$0.5	$0.0	$0.5	$0.0	$0.5	$0.0
Owner's Start-up Engineering and Commissioning	$1.2	$0.6	$1.2	$0.6	$1.5	$0.8	$1.5	$0.8	$1.6	$0.8
Land	$0.2	$0.1	$0.2	$0.1	$0.2	$0.1	$0.2	$0.1	$0.2	$0.1
Construction Power and Water	$0.5	$0.1	$0.5	$0.1	$0.5	$0.1	$0.5	$0.1	$0.5	$0.1
Permitting and Licensing Fees	$0.5	$0.0	$0.5	$0.0	$0.5	$0.0	$0.5	$0.0	$0.5	$0.1
Switchyard	$5.3	$1.8	$5.3	$1.8	$5.3	$1.8	$5.3	$1.8	$5.2	$1.7
Political Concessions & Area Development Fees	$0.5	$0.0	$0.5	$0.0	$0.5	$0.0	$0.5	$0.0	$0.5	$0.0
Startup/Testing (Fuel & Consumables)	$0.5	$0.4	$0.5	$0.4	$2.0	$1.8	$2.0	$1.8	$2.3	$2.0
Initial Fuel Inventory	$0.6	$0.6	$0.6	$0.6	$3.1	$3.1	$3.1	$3.1	$3.6	$3.6
Site Security	$0.4	$0.0	$0.4	$0.0	$0.4	$0.0	$0.4	$0.0	$0.4	$0.0
Operating Spare Parts	$1.8	$0.5	$1.8	$0.5	$5.5	$1.4	$5.5	$1.4	$6.0	$1.5
Water Supply Infrastructure	Excluded	Excluded	Excluded	Excluded	Excluded	Excluded	Excluded	Excluded	Excluded	Excluded
Natural Gas Supply Infrastructure	Excluded	Excluded	Excluded	Excluded	Excluded	Excluded	Excluded	Excluded	Excluded	Excluded
Transmission Interconnect	$0.2	$0.2	$0.4	$0.4	$0.3	$0.3	$0.9	$0.9	$1.1	$1.1
Transmission Upgrade Costs	Excluded	Excluded	Excluded	Excluded	Excluded	Excluded	Excluded	Excluded	Excluded	Excluded
Firm Gas Supply Reservation Charge	Provided by Owner	Provided by Owner	Provided by Owner	Provided by Owner	Provided by Owner	Provided by Owner	Provided by Owner	Provided by Owner	Provided by Owner	Provided by Owner
Permanent Plant Equipment and Furnishings	$0.3	$0.0	$0.3	$0.0	$0.3	$0.0	$0.3	$0.0	$0.3	$0.0
AFUDC (12.2% of EPC Project Capital Costs)	$7.9	$5.6	$15.0	$10.5	$10.3	$7.3	$15.3	$11.4	$20.5	$16.3
Builders Risk Insurance (0.45% of Construction Costs)	$0.3	$0.2	$0.6	$0.4	$0.4	$0.3	$0.6	$0.4	$0.8	$0.6
Owner's Contingency (5% for Screening Purposes)	$4.4	$2.8	$7.7	$5.1	$5.9	$3.8	$8.2	$5.7	$10.7	$8.1
Total Project Costs, 2019 MM$	**$93**	**$59**	**$161**	**$106**	**$124**	**$81**	**$173**	**$121**	**$225**	**$170**
EPC Cost Per kW, 2019 $/kW (Note 7)	**$1,570**	**$1,110**	**$1,270**	**$890**	**$1,000**	**$710**	**$530**	**$390**	**$600**	**$480**
Total Cost Per kW, 2019 $/kW (Note 7)	**$2,230**	**$1,420**	**$1,660**	**$1,090**	**$1,470**	**$950**	**$730**	**$510**	**$810**	**$610**
FIXED O&M COSTS (Note 8)										
Fixed O&M Cost - LABOR, 2019$MM/Yr	$0.8	$0.0	$0.9	$0.0	$0.9	$0.0	$0.9	$0.0	$0.8	$0.0
Fixed O&M Cost - OTHER, 2019$MM/Yr	$0.7	$0.3	$0.7	$0.3	$0.9	$0.5	$1.1	$0.4	$1.4	$0.4
LEVELIZED CAPITAL MAINTENANCE COSTS										
Major Maintenance Cost, 2019$/GT-hr or $/engine-hr (Notes 9, 10)	$190	$190	$190	$190	$370	$370	$350	$350	$600	$600
Major Maintenance Cost, 2019$/GT-start	N/A	N/A	N/A	N/A	$10,000	$10,000	$9,500	$9,500	$16,200	$16,200
Major Maintenance Cost, 2019$/MWh	$4.60	$4.60	$2.00	$2.00	$4.40	$4.40	$1.50	$1.50	$2.20	$2.20
Catalyst Replacement Cost, 2019$/MWh	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$0.30	$0.30
NON-FUEL VARIABLE O&M COSTS (EXCLUDES MAJOR MAINTENANCE, Note 11)										
Total Variable O&M Cost, 2019$/MWh	$0.90	$0.90	$1.24	$1.24	$0.90	$0.90	$0.90	$0.90	$1.10	$1.10
Water Related O&M, $/MWh	$0.00	$0.00	$0.34	$0.34	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
SCR Reagent, $/MWh	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$0.20	$0.20
Other Consumables and Variable O&M, $/MWh	$0.90	$0.90	$0.90	$0.90	$0.90	$0.90	$0.90	$0.90	$0.90	$0.90
ESTIMATED BASE LOAD OPERATING EMISSIONS: NATURAL GAS (See Note 13)										
Turbine Only (lb/MMBtu, HHV)										
NO_x	0.12	0.12	0.09	0.09	0.03	0.03	0.03	0.03	0.01	0.01
SO_2	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
CO	0.048	0.048	0.026	0.026	0.056	0.056	0.014	0.014	0.004	0.004
CO_2	120	120	120	120	120	120.00	120	120	120	120

VECTREN 2019 IRP TECHNOLOGY ASSESSMENT
SIMPLE CYCLE TECHNOLOGY ASSESSMENT PROJECT OPTIONS
PRELIMINARY - NOT FOR CONSTRUCTION
December 2019

PROJECT TYPE	1x Aeroderivative SCGT - Natural Gas		1x Aeroderivative SCGT - Natural Gas		1x E Class Frame SCGT - Natural Gas		1x F Class Frame SCGT - Natural Gas		1x G/H Class Frame SCGT - Natural Gas	
BASE PLANT DESCRIPTION	First Unit	Next Unit	First Unit	Next Unit	First Unit	Next Unit	First Unit	Next Unit	First Unit	Next Unit

Notes

Note 1: Simple cycle GT starts are not affected by hot, warm or cold conditions. Simple cycle starts assume purge credits are available. Recip engine start times assume the engines are kept warm when not operational.
Note 2: Fast start package options allow 10 minute GT start.
Note 3: MECL start time assumes the min load at which the GT achieves the steady state NOx emissions ppm rate. The SCR compliance start time assumes a cold start, ending at the time when the catalysts are heated and the NOx levels meet the desired SCR emissions.
Note 4: Outage and availability statistics are collected using the NERC Generating Availability Data System. Simple cycle data is based on North American units that came online in 2006 or later. Reporting period is 2011-2016. Note that a unique gas reciprocating engine category does not exist in GADS. Diesel Engine data is used as a proxy.
Note 5: New and clean performance assumed for all scenarios. All performance ratings based on NATURAL GAS operation. Minimum loads are based on OEM information at requested ambient conditions.
Note 6: For the reciprocating engine option, it is assumed that six engines tie to one GSU.
Note 7: Capital and fixed O&M costs are presented in 2019 USD $MM.
Note 8: All Gas Turbine FOM costs assume 7 full time personnel for first unit. No additional personnel are included for the next unit(s). FOM costs do not include engine lease fees that may be available with LTSA, depending on OEM.
Note 9: Major maintenance $/hr holds for all aero gas turbines. Major maintenance $/hr holds for frame gas turbines where hours per start is >27.

Note 10: Recip engine FOM assumes 8 FTE for the first 200 MW plant. The NEXT plant adds 3 FTE. Major maintenance $/hr is per engine. LTSA costs are split in two categories: major overhauls and catalyst replacements are shown as capitalized maintenance, while scheduled minor maintenance supervision is shown in VOM.

Note 11: VOM assumes the use of temporarily trailers for demineralized water treatment, where applicable.
Note 12: This reflects startup when OEM fast start package is included. Fast start options are NOT reflected in base capital costs. Market trends suggest that O&M impacts from fast starts are negligible.
Note 13: Emissions estimates are shown for steady state operation at annual average conditions. Estimates account for the impacts of SCR and CO catalysts, as applicable.
Note 14: Performance ratings are based on elevation of 750 ft above msl.

Note 15: EFOR data from GADS may not accurately represent the benefits of a reciprocating plant, depending on how events are recorded. Typically, a maintenance event will not impact all engines simultaneously, so the plant would not be completely offline as it may be during an event at 1x gas turbine plant.

Note 16: Fuel Oil emissions based on ultra low sulfur diesel. Per the US EPA, this fuel must meet 15 ppm sulfur.
Note 17: Fuel oil performance conversion factors are included in a separate Fuel Oil Conversion tab in this workbook.
Note 18: Estimated Costs exclude decommissioning costs and salvage values.

VECTREN 2019 IRP TECHNOLOGY ASSESSMENT
RECIPROCATING ENGINE TECHNOLOGY ASSESSMENT PROJECT OPTIONS
PRELIMINARY - NOT FOR CONSTRUCTION
December 2019

PROJECT TYPE	**Reciprocating Engine (9 MW Engines) Natural Gas**		**Reciprocating Engine (18 MW Engines) Natural Gas**	
BASE PLANT DESCRIPTION	First Unit	Next Unit	First Unit	Next Unit
Number of Gas Turbines/Engines/Units	6	6	6	6
Representative Class Gas Turbine	Wartsila 20V34SG		Wartsila 18V50SG	
Capacity Factor, %	Peaking (10%)		Peaking (10%)	
Startup Time to Base Load, min (Notes 1)	5		5	
Startup Time to MECL, min	4		4	
Cold Startup Time to SCR Compliance, min	45		45	
Maximum Ramp Rate, MW/min (Online)	10		100	
Book Life, Years	35		35	
Equivalent Planned Outage Rate, % (Note 2, 10)	4.0%		4.0%	
Equivalent Forced Outage Rate, % (Notes 2, 10)	7.3%		7.3%	
Equivalent Availability Factor, % (Notes 2, 10)	94.3%		94.3%	
Assumed Land Use, Acres	30	10	30	10
Fuel Design	Natural Gas Only		Natural Gas Only	
Heat Rejection	Fin Fan Heat Exchanger		Fin Fan Heat Exchanger	
NO_x Control	SCR		SCR	
CO Control	Oxidation Catalyst		Oxidation Catalyst	
Particulate Control	Good Combustion Practice		Good Combustion Practice	
Technology Rating	Mature		Mature	
Permitting & Construction Schedule (Years from FNTP)	3		3	
ESTIMATED PERFORMANCE (All BASED ON NATURAL GAS OPERATION) (Note 9)				
Nominal Base Load Performance @59° F (ISO Conditions)				
Net Plant Output, kW	54,600	54,600	109,900	109,900
Net Plant Heat Rate, Btu/kWh (HHV)	8,480	8,480	8,290	8,290
Heat Input, MMBtu/h (HHV)	450	450	910	910
Nominal Min Load @ 59° F (ISO Conditions) - Single Engine				
Net Plant Output, kW	2,300	2,300	4,600	4,600
Net Plant Heat Rate, Btu/kWh (HHV)	12,150	12,150	11,040	11,040
Heat Input, MMBtu/h (HHV)	30	30	40	40
Base Load Performance @ 20° F (Winter Design)				
Net Plant Output, kW	54,600	54,600	109,900	109,900
Net Plant Heat Rate, Btu/kWh (HHV)	8,480	8,480	8,290	8,290
Heat Input, MMBtu/h (HHV)	450	450	910	910

VECTREN 2019 IRP TECHNOLOGY ASSESSMENT
RECIPROCATING ENGINE TECHNOLOGY ASSESSMENT PROJECT OPTIONS
PRELIMINARY - NOT FOR CONSTRUCTION
December 2019

PROJECT TYPE	Reciprocating Engine (9 MW Engines) Natural Gas		Reciprocating Engine (18 MW Engines) Natural Gas	
BASE PLANT DESCRIPTION	First Unit	Next Unit	First Unit	Next Unit
Min Load Operational Status @ 20° F (Winter Design) - Single Engine				
Net Plant Output, kW	2,300	2,300	4,600	4,600
Net Plant Heat Rate, Btu/kWh (HHV)	12,150	12,150	11,040	11,040
Heat Input, MMBtu/h (HHV)	30	30	40	40
Base Load Performance @ 90° F (Summer Design)				
Net Plant Output, kW	54,600	54,600	109,900	109,900
Net Plant Heat Rate, Btu/kWh (HHV)	8,480	8,480	8,310	8,310
Heat Input, MMBtu/h (HHV)	450	450	910	910
Min Load Operational Status @ 90° F (Summer Design) - Single Engine				
Net Plant Output, kW	2,300	2,300	4,600	4,600
Net Plant Heat Rate, Btu/kWh (HHV)	12,150	12,150	11,040	11,040
Heat Input, MMBtu/h (HHV)	30	30	40	40
ESTIMATED CAPITAL AND O&M COSTS				
EPC Project Capital Costs, 2019 MM$ (w/o Owner's Costs)	**$81**	**$61**	**$120**	**$100**
Engineering	$3.3	$0.3	$5	$1
Gas Turbines/Engines	$10.3	$8.8	$112	$112
GSU (Note 6)	$0.4	$0.1	$2	$2
Environmental Equipment (SCR/CO)	Included with Engines	Included with Engines	Included with Engines	Included with Engines
BOP Equipment and Materials	$2.1	$1.4	$28	$21
Construction	$10.7	$10.4	$46	$28
Indirects and Fees	$4.1	$2.2	$15	$10
EPC Contingency	$1.0	$0.7	$10	$8

VECTREN 2019 IRP TECHNOLOGY ASSESSMENT
RECIPROCATING ENGINE TECHNOLOGY ASSESSMENT PROJECT OPTIONS
PRELIMINARY - NOT FOR CONSTRUCTION
December 2019

PROJECT TYPE	Reciprocating Engine (9 MW Engines) Natural Gas		Reciprocating Engine (18 MW Engines) Natural Gas	
BASE PLANT DESCRIPTION	First Unit	Next Unit	First Unit	Next Unit
Owner's Costs, 2019 MM$	**$27**	**$14**	**$39**	**$24**
Owner's Project Development	$0.3	$0.0	$0.3	$0.0
Owner's Operational Personnel Prior to COD	$0.3	$0.0	$0.3	$0.0
Owner's Engineer	$0.8	$0.0	$0.5	$0.0
Owner's Project Management	$1.0	$0.0	$1.0	$0.0
Owner's Legal Costs	$0.5	$0.0	$0.5	$0.0
Owner's Start-up Engineering and Commissioning	$0.4	$0.2	$0.9	$0.5
Land	$0.2	$0.0	$0.2	$0.1
Construction Power and Water	$0.5	$0.1	$0.5	$0.1
Permitting and Licensing Fees	$0.5	$0.0	$0.5	$0.0
Switchyard	$5.3	$1.8	$7.1	$3.6
Political Concessions & Area Development Fees	$0.5	$0.0	$0.5	$0.0
Startup/Testing (Fuel & Consumables)	$0.1	$0.09	$0.5	$0.4
Initial Fuel Inventory	$0.0	$0.0	$0.0	$0.0
Site Security	$0.3	$0.0	$0.4	$0.0
Operating Spare Parts	$0.2	$0.1	$2.0	$0.5
Water Supply Infrastructure	Excluded	Excluded	Excluded	Excluded
Natural Gas Supply Infrastructure	Excluded	Excluded	Excluded	Excluded
Transmission Interconnect	$0.2	$0.2	$0.4	$0.4
Transmission Upgrade Costs	Excluded	Excluded	Excluded	Excluded
Firm Gas Supply Reservation Charge	Provided by Owner	Provided by Owner	Provided by Owner	Provided by Owner
Permanent Plant Equipment and Furnishings	$0.3	$0.0	$0.3	$0.0
AFUDC (12.2% of EPC Project Capital Costs)	$9.9	$7.4	$14.6	$12.2
Builders Risk Insurance (0.45% of Construction Costs)	$0.4	$0.3	$0.5	$0.5
Owner's Contingency (5% for Screening Purposes)	$5.1	$3.5	$7.6	$5.9
Total Project Costs, 2019 MM$	**$108**	**$74**	**$159**	**$124**
EPC Cost Per kW, 2019 $/kW	**$1,480**	**$1,110**	**$1,090**	**$910**
Total Cost Per kW, 2019 $/kW	**$1,970**	**$1,360**	**$1,440**	**$1,130**
FIXED O&M COSTS				
Fixed O&M Cost - LABOR, 2019$MM/Yr	$1.0	$0.0	$1.0	$0.4
Fixed O&M Cost - OTHER, 2019$MM/Yr	$1.5	$0.20	$0.98	$0.35

VECTREN 2019 IRP TECHNOLOGY ASSESSMENT
RECIPROCATING ENGINE TECHNOLOGY ASSESSMENT PROJECT OPTIONS
PRELIMINARY - NOT FOR CONSTRUCTION
December 2019

PROJECT TYPE	Reciprocating Engine (9 MW Engines) Natural Gas		Reciprocating Engine (18 MW Engines) Natural Gas	
BASE PLANT DESCRIPTION	First Unit	Next Unit	First Unit	Next Unit
LEVELIZED CAPITAL MAINTENANCE COSTS				
Major Maintenance Cost, 2019$/GT-hr or $/engine-hr (Notes 6, 11)	$0.07	$0.07	$0.00	$0.00
Major Maintenance Cost, 2019$/GT-start	N/A	N/A	N/A	N/A
Major Maintenance Cost, 2019$/MWh	$1.40	$1.40	$0.00	$0.00
Catalyst Replacement Cost, 2019$/MWh	$0.30	$0.30	$0.20	$0.20
NON-FUEL VARIABLE O&M COSTS (EXCLUDES MAJOR MAINTENANCE, Note 7)				
Total Variable O&M Cost, 2019$/MWh	$4.50	$4.50	$4.50	$4.50
Water Related O&M, $/MWh	$0.00	$0.00	$0.00	$0.00
SCR Reagent, $/MWh	$0.90	$0.90	$0.90	$0.90
Other Consumables and Variable O&M, $/MWh	$3.60	$3.60	$3.60	$3.60
ESTIMATED BASE LOAD OPERATING EMISSIONS: NATURAL GAS (See Note 8)				
Engine Only (lb/MMBtu, HHV)				
NO_X	0.33	0.33	0.32	0.32
SO_2	< 0.002	< 0.002	< 0.002	< 0.002
CO	0.52	0.52	0.51	0.51
CO_2	120	120	120	120
Engine with SCR and CO Catalyst (lb/MMBtu, HHV)				
NO_X	0.017	0.017	0.016	0.016
SO_2	< 0.002	< 0.002	< 0.002	< 0.002
CO	0.03	0.03	0.031	0.031
CO_2	120	120	120	120

Notes

Note 1: Recip engine start times assume the engines are kept warm when not operational.
Note 2: Outage and availability statistics are collected using the NERC Generating Availability Data System. Note that a unique gas reciprocating engine category does not exist in GADS. Diesel Engine data is used as a proxy.
Note 3: New and clean performance assumed for all scenarios. All performance ratings based on NATURAL GAS operation. Minimum loads are based on OEM information at requested ambient conditions.
Note 4: It is assumed that a maximum of six reciprocating engines tie to one GSU.
Note 5: Capital and fixed O&M costs are presented in 2019 USD $MM.
Note 6: Recip engine FOM assumes 8 FTE for the first 200 MW plant. Major maintenance $/hr is per engine. LTSA costs are split in two categories: major overhauls and catalyst replacements are shown as

Note 7: VOM assumes the use of temporarily trailers for demineralized water treatment, if required.

Note 8: Emissions estimates are shown for steady state operation at annual average conditions. Estimates account for the impacts of SCR and CO catalysts, as applicable.
Note 9: Performance ratings are based on elevation of 750 ft above msl.

Note 10: EFOR data from GADS may not accurately represent the benefits of a reciprocating plant, depending on how events are recorded. Typically, a maintenance event will not impact all engines simultaneously, so the plant would not be completely offline as it may be during an event at 1x gas turbine plant.

VECTREN 2019 IRP TECHNOLOGY ASSESSMENT
RECIPROCATING ENGINE TECHNOLOGY ASSESSMENT PROJECT OPTIONS
PRELIMINARY - NOT FOR CONSTRUCTION
December 2019

PROJECT TYPE	**Reciprocating Engine (9 MW Engines) Natural Gas**		**Reciprocating Engine (18 MW Engines) Natural Gas**	
BASE PLANT DESCRIPTION	First Unit	Next Unit	First Unit	Next Unit

Note: 11: If major maintenance is $0.00 - the units have will not reach a major overhaul even per manufacturer's recommendations of hours of operation based on the life of the plant and the capacity factor.

VECTREN 2019 IRP TECHNOLOGY ASSESSMENT
COMBINED CYCLE TECHNOLOGY ASSESSMENT PROJECT OPTIONS
PRELIMINARY - NOT FOR CONSTRUCTION
December 2019

PROJECT TYPE	**1x1 F Class CCGT - Unfired**	**1x1 F Class CCGT - Fired**	**1x1 G/H Class CCGT - Unfired**	**1x1 G/H Class CCGT - Fired**
BASE PLANT DESCRIPTION	Unfired	Fired	Unfired	Fired
Number of Gas Turbines	1	1	1	1
Number of Steam Turbines	1	1	1	1
Representative Class Gas Turbine	GE 7F.05		GE 7HA.01	
Steam Conditions (Main Steam / Reheat)	1,050°F / 1,050°F		1,050°F / 1,050°F	
Main Steam Pressure	2,330		2,330	
Steam Cycle Type	Subcritical		Subcritical	
Capacity Factor (%)	70%		70%	
Startup Time, Minutes (Cold Start to Unfired Base Load) (Note 7, 8)	180		180	
Startup Time, Minutes (Warm Start to Unfired Base Load) (Note 7, 8)	120		120	
Startup Time, Minutes (Hot Start to Unfired Base Load) (Note 7, 8)	80		80	
Startup Time, Minutes (Cold Start to Stack Emissions Compliance) (See note 4)	60		60	
Maximum Ramp Rate, MW/min (Online)	36		41	
Book Life (Years)	30		30	
Equivalent Planned Outage Rate (%)	10.1%		10.1%	
Equivalent Forced Outage Rate (%)	3.6%		3.6%	
Equivalent Availability Factor (%)	86.5%		86.5%	
Assumed Land Use (Acres)	70	30	70	30
Fuel Design	Natural Gas		Natural Gas	
Heat Rejection	Wet Cooling Towers		Wet Cooling Towers	
NO_x Control	DLN/SCR		DLN/SCR	
CO Control	Oxidation Catalyst		Oxidation Catalyst	
Particulate Control	Good Combustion Practice		Good Combustion Practice	
Technology Rating	Mature		Mature	
Permitting & Construction Schedule (Years from FNTP)	4		4	
ESTIMATED PERFORMANCE (See note 2)				
Base Load Performance @59 °F (Nominal)				
Net Plant Output, kW	357,200	359,900	410,600	412,100
Net Plant Heat Rate, Btu/kWh (HHV)	6,490	6,440	6,280	6,260
Heat Input, MMBtu/h (HHV)	2,320	2,320	2,580	2,580
Incremental Duct Fired Performance @ 59 °F (Nominal)				
Incremental Duct Fired Output, kW	N/A	82,600	N/A	98,600
Incremental Heat Rate, Btu/kWh (HHV)	N/A	8,370	N/A	8,420
Incremental Heat Input, MMBtu/h (HHV)	N/A	690	N/A	830
Minimum Load (Single Turbine at MECL) @ 59 °F (Nominal)				
Net Plant Output, kW	168,400	170,900	129,500	128,800
Net Plant Heat Rate, Btu/kWh (HHV)	7,740	7,630	7,970	8,010
Heat Input, MMBtu/h (HHV)	1,300	1,300	1,030	1,030

VECTREN 2019 IRP TECHNOLOGY ASSESSMENT
COMBINED CYCLE TECHNOLOGY ASSESSMENT PROJECT OPTIONS
PRELIMINARY - NOT FOR CONSTRUCTION
December 2019

PROJECT TYPE	**1x1 F Class CCGT - Unfired**	**1x1 F Class CCGT - Fired**	**1x1 G/H Class CCGT - Unfired**	**1x1 G/H Class CCGT - Fired**
BASE PLANT DESCRIPTION	Unfired	Fired	Unfired	Fired
Base Load Performance @ 20 °F (Winter)				
Net Plant Output, kW	357,100	360,900	415,100	417,400
Net Plant Heat Rate, Btu/kWh (HHV)	6,610	6,540	6,350	6,320
Heat Input, MMBtu/h (HHV)	2,360	2,360	2,640	2,640
Incremental Duct Fired Performance @ 20 °F (Winter)				
Incremental Duct Fired Output, kW	N/A	88,500	N/A	102,000
Incremental Heat Rate, Btu/kWh (HHV)	N/A	8,380	N/A	8,540
Incremental Heat Input, MMBtu/h (HHV)	N/A	740	N/A	870
Minimum Load (Single Turbine at MECL) @ 20 °F (Winter)				
Net Plant Output, kW	182,200	180,700	137,000	124,100
Net Plant Heat Rate, Btu/kWh (HHV)	7,610	7,670	7,850	8,660
Heat Input, MMBtu/h (HHV)	1,390	1,390	1,080	1,070
Base Load Performance @ 90 °F (Summer)				
Net Plant Output, kW	335,100	335,300	381,100	379,700
Net Plant Heat Rate, Btu/kWh (HHV)	6,540	6,540	6,340	6,370
Heat Input, MMBtu/h (HHV)	2,190	2,190	2,420	2,420
Incremental Duct Fired Performance @ 90 °F (Summer)				
Incremental Duct Fired Output, kW	N/A	80,600	N/A	95,000
Incremental Heat Rate, Btu/kWh (HHV)	N/A	8,220	N/A	8,200
Incremental Heat Input, MMBtu/h (HHV)	N/A	660	N/A	780
Minimum Load (Single Turbine at MECL) @ 90 °F (Summer)				
Net Plant Output, kW	164,900	161,800	147,000	142,100
Net Plant Heat Rate, Btu/kWh (HHV)	7,690	7,840	7,570	7,830
Heat Input, MMBtu/h (HHV)	1,270	1,270	1,110	1,110

VECTREN 2019 IRP TECHNOLOGY ASSESSMENT
COMBINED CYCLE TECHNOLOGY ASSESSMENT PROJECT OPTIONS
PRELIMINARY - NOT FOR CONSTRUCTION
December 2019

PROJECT TYPE	1x1 F Class CCGT - Unfired	1x1 F Class CCGT - Fired	1x1 G/H Class CCGT - Unfired	1x1 G/H Class CCGT - Fired
BASE PLANT DESCRIPTION	Unfired	Fired	Unfired	Fired
ESTIMATED CAPITAL AND O&M COSTS				
EPC Project Capital Costs, 2019 MM$ (w/o Owner's Costs)	**$351**	**$369**	**$400**	**$420**
Owner's Costs, 2019 MM$	**$125**	**$129**	**$136**	**$139**
Owner's Project Development	$3.5	$3.5	$3.5	$3.5
Owner's Operational Personnel Prior to COD	$1.7	$1.7	$1.7	$1.7
Owner's Engineer	$2.3	$2.3	$2.4	$2.4
Owner's Project Management	$5.9	$5.9	$6.1	$6.1
Owner's Legal Costs	$1.0	$1.0	$1.0	$1.0
Owner's Start-up Engineering and Commissioning	$5.7	$5.7	$5.6	$5.6
Land	$0.4	$0.4	$0.4	$0.4
Temporary Utilities	$1.6	$1.6	$1.7	$1.7
Permitting and Licensing Fees	$0.5	$0.5	$0.5	$0.5
Switchyard	$9.9	$9.9	$9.9	$9.9
Political Concessions & Area Development Fees	$0.5	$0.5	$0.5	$0.5
Startup/Testing (Fuel & Consumables)	$0.9	$0.9	$1.0	$1.0
Initial Fuel Inventory	$0.0	$0.0	$0.0	$0.0
Site Security	$0.8	$0.8	$0.8	$0.8
Operating Spare Parts	$6.0	$6.0	$6.5	$6.5
Water Supply Infrastructure (5 Mile Pipeline) (Note 13)	$15.0	$15.0	$15.0	$15.0
Natural Gas Supply Infrastructure	Excluded	Excluded	Excluded	Excluded
Transmission Interconnect	$1.4	$1.4	$1.6	$1.6
Transmission Upgrade Costs	Excluded	Excluded	Excluded	Excluded
Firm Gas Supply Reservation Charge	Provided by Owner	Provided by Owner	Provided by Owner	Provided by Owner
Permanent Plant Equipment and Furnishings	$1.3	$1.3	$1.3	$1.3
AFUDC (12.2% of EPC Project Capital Costs)	$42.8	$45.0	$48.8	$51.2
Builders Risk Insurance (0.45% of Construction Costs)	$1.6	$1.7	$1.8	$1.9
Owner's Contingency	$22.7	$23.7	$25.5	$26.6
Total Project Costs, 2019 MM$	**$476**	**$498**	**$536**	**$559**
EPC Cost Per UNFIRED kW, 2019 $/kW	**$982**	**$1,026**	**$974**	**$1,019**
Total Cost Per UNFIRED kW, 2019 $/kW	**$1,333**	**$1,384**	**$1,305**	**$1,357**
EPC Cost Per FIRED kW, 2019 $/kW	**N/A**	**$834**	**N/A**	**$822**
Total Cost Per FIRED kW, 2019 $/kW	**N/A**	**$1,125**	**N/A**	**$1,095**
FIXED O&M COSTS (See note 9)				
Fixed O&M Cost - LABOR, 2019 $MM/Yr	$2.8	$2.8	$2.8	$2.8
Fixed O&M Cost - OTHER, 2019 $MM/Yr	$1.8	$1.8	$2.1	$2.1

VECTREN 2019 IRP TECHNOLOGY ASSESSMENT
COMBINED CYCLE TECHNOLOGY ASSESSMENT PROJECT OPTIONS
PRELIMINARY - NOT FOR CONSTRUCTION
December 2019

PROJECT TYPE	1x1 F Class CCGT - Unfired	1x1 F Class CCGT - Fired	1x1 G/H Class CCGT - Unfired	1x1 G/H Class CCGT - Fired
BASE PLANT DESCRIPTION	Unfired	Fired	Unfired	Fired
LEVELIZED CAPITAL MAINTENANCE COSTS				
Major Maintenance Cost, 2019 $/GT-hr	$350	$350	$580	$580
Major Maintenance Cost, 2019 $/MWh	$0.98	$0.97	$1.41	$1.41
Catalyst Replacement Cost, 2019 $/MWh	$0.19	$0.19	$0.17	$0.17
NON-FUEL VARIABLE O&M COSTS (EXCLUDES MAJOR MAINTENANCE)				
Total Variable O&M Cost, Unfired 2019 $/MWh	$1.80	$1.74	$1.80	$1.68
Water Related O&M ($/MWh)	$0.39	$0.40	$0.36	$0.36
SCR Reagent, $/MWh	$0.20	$0.20	$0.20	$0.20
Other Consumables and Variable O&M ($/MWh)	$1.20	$1.10	$1.20	$1.10
Incremental Duct Fired Variable O&M, 2019 $/MWh (For Incremental Output Only)	N/A	$1.39	N/A	$1.40
ESTIMATED BASE LOAD OPERATING EMISSIONS: NATURAL GAS, lb/MMBtu (HHV)				
NO_X	0.01	0.01	0.007	0.007
SO_2	< 0.002	< 0.002	< 0.002	< 0.002
CO	0.00	0.00	0.004	0.004
CO_2	120.00	120.00	120	120

Notes

Note 1: New and clean performance assumed. All performance is based on NATURAL GAS operation. Min load ratings are based on OEM performance information at specified ambient conditions. Fuel oil conversion factors are included in the "Fuel Oil Conversion" tab in this workbook.
Note 2: Base O&M costs are based on performance at annual average conditions.
Note 3: Major maintenance $/hr holds for frame gas turbines where hours per start is >27.
Note 4: Startup time to stack emissions compliance is not the same as the start time for gas turbine MECL. Stack emissions compliance is expected to be limited by the temperature of the CO catalyst, which impacts VOC emissions.
Note 5: Capital costs include duct firing to 1,600°F.
Note 6: Outage and availability statistics are collected using the NERC Generating Availability Data System. Combined cycle data is based on North American units that came online in 2006 or later. Reporting period is 2011-2016.
Note 7: Cold start is >72 hours after shutdown. Hot start is <8 hours after shutdown.
Note 8: Startup times reflect unrestricted, conventional starts for all gas turbines. These start times assume the inclusion of terminal point desuperheaters, full bypass, and associated controls. Fast start packages are not included in CCGT plants.
Note 9: Fixed O&M assumes 22 FTE for 1x1 configurations.
Note 10: Variable O&M costs assume onsite demin treatment system.
Note 11: Emissions estimates are shown for steady state operation at annual average conditions. Estimates account for the impacts of SCR and CO catalysts.
Note 12: Estimated costs exclude decommissioning costs and salvage values.

VECTREN ENERGY 2019 GENERIC UNIT ASSESSMENT SUMMARY TABLE
COMBINED HEAT AND POWER TECHNOLOGY ASSESSMENT PROJECT OPTIONS
PRELIMINARY - NOT FOR CONSTRUCTION
December 2019

PROJECT TYPE	**Combined Heat and Power**	**Combined Heat and Power**
BASE PLANT DESCRIPTION	2x 9MW Reciprocating Engine (Wartsila 20V34SG)	1 x Titan 250 CTG w/ unfired HRSG
Number of Gas Turbines / Engines / Reactors	2	1
Number of HRSGs	1	1
Number of Steam Turbines	0	0
Steam Conditions (Main Steam / Reheat)	150 psig/366F (saturated)	150 psig/366F (saturated)
Main Steam Pressure	150 psig	150 psig
Steam Cycle Type	Topping Cycle	Topping Cycle
Capacity Factor (%)	85%	85%
Startup Time (Cold Start), hours	0.5	< 1.5 Hrs to Full Plant Load
Startup Time (Warm Start), hours	0.5	< 45 min to Full Plant Load
Startup Time (Hot Start), hours	0.5	< 45 min to Full Plant Load
Startup Time to MECL	0.5	< 45 min to Full Plant Load
Maximum Ramp Rate (Online), MW/min	4	2
Book Life, years	35	35
Equivalent Planned Outage Rate (%)	4%	6%
Equivalent Forced Outage Rate (%)	7%	8%
Equivalent Availability Factor (%)	94%	88%
Assumed Land Use (Acres)	1	1
Fuel Design	Natural Gas	Natural Gas
Heat Rejection	Remote Radiator	Remote Radiator
NO_x Control	SCR	Low NOx Combustion / SCR
SO_2 Control	N/A	N/A
CO_2 Control	N/A	N/A
Particulate Control	Good Combustion Practice	Good Combustion Practice
Technology Rating	Mature	Mature
Permitting & Construction Schedule (Years from FNTP)	3	3
ESTIMATED PERFORMANCE		
Base Load Performance @ (Annual Average)		
Net Plant Output, kW	N/A - See Below	N/A - See Below
Net Plant Heat Rate, Btu/kWh (HHV)	N/A - See Below	N/A - See Below
Heat Input, MMBtu/h (HHV)	N/A - See Below	N/A - See Below

VECTREN ENERGY 2019 GENERIC UNIT ASSESSMENT SUMMARY TABLE
COMBINED HEAT AND POWER TECHNOLOGY ASSESSMENT PROJECT OPTIONS
PRELIMINARY - NOT FOR CONSTRUCTION
December 2019

PROJECT TYPE	**Combined Heat and Power**	**Combined Heat and Power**
BASE PLANT DESCRIPTION	2x 9MW Reciprocating Engine (Wartsila 20V34SG)	1 x Titan 250 CTG w/ unfired HRSG
Minimum Load Operational Status @ (Annual Average)		
Net Plant Output, kW	N/A - See Below	N/A - See Below
Net Plant Heat Rate, Btu/kWh (HHV)	N/A - See Below	N/A - See Below
Heat Input, MMBtu/h (HHV)	N/A - See Below	N/A - See Below
CHP Base Load Performance @ (Winter)		
Net Plant Output, kW	17,940	21,670
Simple Cycle Heat Rate, Btu/kWh (HHV)	8,180	10,120
Plant Heat Rate, Btu/kWh (HHV)	6,830	6,420
Heat Input, MMBtu/h (HHV)	152	219
Plant Steam Output, pph	25,800	68,100
Plant Steam Output, MMBtu/h (HHV)	26	68
CHP Minimum Load Operational Status @ (Winter) (Single Unit)		
Net Plant Output, kW	4,530	10,860
Simple Cycle Heat Rate, Btu/kWh (HHV)	8,990	13,920
Plant Heat Rate, Btu/kWh (HHV)	7,010	7,410
Heat Input, MMBtu/h (HHV)	42	151
Plant Steam Output, pph	9,000	60,100
Plant Steam Output, MMBtu/h (HHV)	9	60
CHP Base Load Performance @ (Annual Average)		
Net Plant Output, kW	17,940	19,910
Simple Cycle Heat Rate, Btu/kWh (HHV)	8,180	10,390
Plant Heat Rate, Btu/kWh (HHV)	6,830	6,120
Heat Input, MMBtu/h (HHV)	152	207
Plant Steam Output, pph	25,800	72,300
Plant Steam Output, MMBtu/h (HHV)	26	72
CHP Minimum Load Operational Status @ (Annual Average) (Single Unit)		
Net Plant Output, kW	4,530	9,980
Simple Cycle Heat Rate, Btu/kWh (HHV)	8,990	14,220
Plant Heat Rate, Btu/kWh (HHV)	7,010	7,060
Heat Input, MMBtu/h (HHV)	42	142
Plant Steam Output, pph	9,000	60,700
Plant Steam Output, MMBtu/h (HHV)	9	61

VECTREN ENERGY 2019 GENERIC UNIT ASSESSMENT SUMMARY TABLE COMBINED HEAT AND POWER TECHNOLOGY ASSESSMENT PROJECT OPTIONS PRELIMINARY - NOT FOR CONSTRUCTION December 2019		
PROJECT TYPE	**Combined Heat and Power**	**Combined Heat and Power**
BASE PLANT DESCRIPTION	2x 9MW Reciprocating Engine (Wartsila 20V34SG)	1 x Titan 250 CTG w/ unfired HRSG
CHP Base Load Performance @ (Summer)		
Net Plant Output, kW	17,940	15,860
Simple Cycle Heat Rate, Btu/kWh (HHV)	8,180	11,260
Plant Heat Rate, Btu/kWh (HHV)	6,830	6,030
Heat Input, MMBtu/h (HHV)	152	179
Plant Steam Output, pph	25,800	70,600
Plant Steam Output, MMBtu/h (HHV)	26	71
CHP Minimum Load Operational Status @ (Summer) (Single Unit)		
Net Plant Output, kW	4,530	7,950
Simple Cycle Heat Rate, Btu/kWh (HHV)	8,990	16,170
Plant Heat Rate, Btu/kWh (HHV)	7,010	6,910
Heat Input, MMBtu/h (HHV)	42	128
Plant Steam Output, pph	9,000	62,500
Plant Steam Output, MMBtu/h (HHV)	9	63

VECTREN ENERGY 2019 GENERIC UNIT ASSESSMENT SUMMARY TABLE COMBINED HEAT AND POWER TECHNOLOGY ASSESSMENT PROJECT OPTIONS PRELIMINARY - NOT FOR CONSTRUCTION December 2019		
PROJECT TYPE	**Combined Heat and Power**	**Combined Heat and Power**
BASE PLANT DESCRIPTION	2x 9MW Reciprocating Engine (Wartsila 20V34SG)	1 x Titan 250 CTG w/ unfired HRSG
ESTIMATED CAPITAL AND O&M COSTS		
EPC Project Capital Costs, 2019 MM$ (w/o Owner's Costs)	**$54**	**$48**
Owner's Costs, 2019 MM$	**$22**	**$22**
Owner's Project Development	$0.3	$0.3
Owner's Operational Personnel Prior to COD	$0.3	$0.3
Owner's Engineer	$0.4	$0.4
Owner's Project Management	$0.8	$0.8
Owner's Legal Costs	$0.5	$0.5
Owner's Start-up Engineering and Commissioning	$0.2	$0.2
Land	$0.01	$0.01
Construction Power and Water	$0.5	$0.5
Permitting and Licensing Fees	$0.5	$0.5
Switchyard	N/A	N/A
Political Concessions & Area Development Fees	$0.3	$0.3
Startup/Testing (Fuel & Consumables)	$0.1	$0.3
Initial Fuel Inventory	$0.0	$0.0
Site Security	$0.2	$0.2
Operating Spare Parts	$0.3	$0.5
Water Supply Infrastructure (5 Mile Pipeline) (Note 6)	$7.5	$7.5
Natural Gas Supply Infrastructure	Excluded	Excluded
Transmission Interconnect	$0.1	$0.1
Transmission Upgrade Costs	Excluded	Excluded
Firm Gas Supply Reservation Charge	Provided by Owner	Provided by Owner
Permanent Plant Equipment and Furnishings	$0.0	$0.0
AFUDC (12.2% of EPC Project Capital Costs)	$6.6	$5.8
Builders Risk Insurance (0.45% of Construction Costs)	$0.3	$0.3
Owner's Contingency (5% for Screening Purposes)	$3.7	$3.3

VECTREN ENERGY 2019 GENERIC UNIT ASSESSMENT SUMMARY TABLE
COMBINED HEAT AND POWER TECHNOLOGY ASSESSMENT PROJECT OPTIONS
PRELIMINARY - NOT FOR CONSTRUCTION
December 2019

PROJECT TYPE	**Combined Heat and Power**	**Combined Heat and Power**
BASE PLANT DESCRIPTION	2x 9MW Reciprocating Engine (Wartsila 20V34SG)	1 x Titan 250 CTG w/ unfired HRSG
Total Project Costs, 2019 MM$	**$77**	**$69**
EPC Cost Per kW, 2019 $/kW	**$3,040**	**$3,010**
Total Cost Per kW, 2019 $/kW	**$4,290**	**$4,370**
FIXED O&M COSTS		
Fixed O&M Cost - LABOR, 2019$MM/Yr	$0.60	$0.60
Fixed O&M Cost - Other, 2019$MM/Yr	$0.15	$0.15
MAJOR MAINTENANCE COSTS		
Major Maintenance Cost, 2019$/MWh	$2.40	$8.70
NON-FUEL VARIABLE O&M COSTS (EXCLUDES MAJOR MAINTENANCE)		
Total Variable O&M Cost, 2019$/MWh	$5.93	$1.22
Water Related O&M ($/MWh)	$0.00	$0.00
SCR Related O&M ($/MWh)	$0.93	$0.32
Other Variable O&M ($/MWh)	$5.00	$0.90
ESTIMATED BASE LOAD OPERATING EMISSIONS, lb/MMBtu (HHV)		
NO_X	0.018	0.01
SO_2	< 0.002	< 0.002
CO	0.03	0.01
CO_2	120	120

Notes

Note 1: Combined heat and power (CHP) options assume that water treatment costs are the responsibility of the host and are not included in the O&M costs above.
Note 2: CHP start time shown is total system startup time. CTG or engine is capable of full load operation within ~10 minutes. Overall length of startup is primarily dependent upon startup rates recommended by HRSG manufacturer.

Note 3: CHP make-up water costs for the steam system will be dependent on Host condensate return percentage. DI water cost for water wash is negligible.

Note 4: LFG engine start times account for time required to heat engine jacket water appropriately to accommodate startup.
Note 5: Decommissioning costs and salvage values are excluded from analysis.

VECTREN ENERGY 2019 GENERIC UNIT ASSESSMENT SUMMARY TABLE
WASTE-TO-ENERGY TECHNOLOGY ASSESSMENT PROJECT OPTIONS
PRELIMINARY - NOT FOR CONSTRUCTION
December 2019

PROJECT TYPE	**Bubbling Fluidized Bed**	**Landfill Gas Engine**
BASE PLANT DESCRIPTION		3x Reciprocating Engine
Number of Gas Turbines / Engines / Reactors	N/A	3
Number of HRSGs	N/A	N/A
Number of Steam Turbines	1	N/A
Main Steam Pressure	1,400 psi-a	N/A
Steam Cycle Type	950°F / 950°F	N/A
Capacity Factor (%)	85%	10%
Startup Time (Cold Start), hours	12 Hours	6+ Hours
Startup Time (Warm Start), hours	Not Provided	1-2 Hours
Startup Time (Hot Start), hours	Not Provided	7 Minutes
Startup Time to MECL	Not Provided	5 Minutes
Maximum Ramp Rate (Online), MW/min	Not Provided	1
Book Life, years	30	30
Equivalent Planned Outage Rate (%)	2%	2%
Equivalent Forced Outage Rate (%)	10%	10%
Equivalent Availability Factor (%)	83%	83%
Fuel Design	Chipped Wood Biomass	Landfill Gas
Heat Rejection	Wet Cooling Tower	Fin Fan Heat Exchanger
NO_x Control	SNCR	Good Combustion Practice
SO_2 Control	Dry Sorbent Injection	N/A
CO_2 Control	Good Combustion Practice	N/A
Particulate Control	Baghouse	N/A
Technology Rating	Mature	Mature
Permitting & Construction Schedule (Years from FNTP)	4	2
ESTIMATED PERFORMANCE		
Base Load Performance @ (Annual Average)		
Net Plant Output, kW	50,000	4,500
Net Plant Heat Rate, Btu/kWh (HHV)	13,000	10,740
Heat Input, MMBtu/h (HHV)	650	48
Minimum Load Operational Status @ (Annual Average)		
Net Plant Output, kW	17,500	2,200
Net Plant Heat Rate, Btu/kWh (HHV)	15,500	11,910
Heat Input, MMBtu/h (HHV)	270	26

VECTREN ENERGY 2019 GENERIC UNIT ASSESSMENT SUMMARY TABLE WASTE-TO-ENERGY TECHNOLOGY ASSESSMENT PROJECT OPTIONS PRELIMINARY - NOT FOR CONSTRUCTION December 2019		
PROJECT TYPE	**Bubbling Fluidized Bed**	**Landfill Gas Engine**
BASE PLANT DESCRIPTION		3x Reciprocating Engine
ESTIMATED CAPITAL AND O&M COSTS		
EPC Project Capital Costs, 2019 MM$ (w/o Owner's Costs)	**$224**	**$14**
Owner's Costs, 2019 MM$	**$58**	**$5**
Owner's Project Development	$3.0	$0.3
Owner's Operational Personnel Prior to COD	$1.6	$0.0
Owner's Engineer	$1.0	$0.1
Owner's Project Management	$2.0	$0.1
Owner's Legal Costs	$1.0	$0.1
Owner's Start-up Engineering and Commissioning	$0.2	$0.1
Land	$1.0	$0.0
Construction Power and Water	$1.3	$0.2
Permitting and Licensing Fees	$1.0	$0.1
Switchyard	$6.0	$2.0
Political Concessions & Area Development Fees	$0.5	$0.1
Startup/Testing (Fuel & Consumables)	$1.5	$0.0
Initial Fuel Inventory	$4.3	$0.0
Site Security	$0.8	$0.1
Operating Spare Parts	$0.6	$0.0
Water Supply Infrastructure	Excluded	Excluded
Natural Gas Supply Infrastructure	Excluded (On-site)	Excluded (On-site)
Transmission Interconnect	$0.2	$0.0
Transmission Upgrade Costs	Excluded	Excluded
Firm Gas Supply Reservation Charge	Provided by Owner	Provided by Owner
Permanent Plant Equipment and Furnishings	$0.6	$0.0
AFUDC (12.2% of EPC Project Capital Costs)	$27.4	$1.8
Builders Risk Insurance (0.45% of Construction Costs)	$1.0	$0.1
Owner's Contingency (5% for Screening Purposes)	$2.8	$0.2
Total Project Costs, 2019 MM$	**$282**	**$20**
EPC Cost Per kW, 2019 $/kW	**$4,490**	**$3,190**
Total Cost Per kW, 2019 $/kW	**$5,640**	**$4,110**

VECTREN ENERGY 2019 GENERIC UNIT ASSESSMENT SUMMARY TABLE
WASTE-TO-ENERGY TECHNOLOGY ASSESSMENT PROJECT OPTIONS
PRELIMINARY - NOT FOR CONSTRUCTION
December 2019

PROJECT TYPE	**Bubbling Fluidized Bed**	**Landfill Gas Engine**
BASE PLANT DESCRIPTION		3x Reciprocating Engine
FIXED O&M COSTS		
Fixed O&M Cost - LABOR, 2019$MM/Yr	$3.60	$0.40
Fixed O&M Cost - Other, 2019$MM/Yr	$2.60	$0.10
MAJOR MAINTENANCE COSTS		
Major Maintenance Cost, 2019$/MWh	$4.28	$9.50
NON-FUEL VARIABLE O&M COSTS (EXCLUDES MAJOR MAINTENANCE)		
Total Variable O&M Cost, 2019$/MWh	$2.85	$7.62
Water Related O&M ($/MWh)	Included	$0.00
SCR Related O&M ($/MWh)	Included	$0.00
Other Variable O&M ($/MWh)	Included	$7.62
ESTIMATED BASE LOAD OPERATING EMISSIONS, lb/MMBtu (HHV)		
NO_X	0.10	0.15
SO_2	0.01	0.01
CO	0.08	1.27
CO_2	205	170

Notes

Note 1: Combined heat and power (CHP) options assume that water treatment costs are the responsibility of the host and are not included in the O&M costs above.

Note 2: CHP start time shown is total system startup time. CTG or engine is capable of full load operation within ~10 minutes. Overall length of startup is primarily dependent upon startup rates recommended by HRSG manufacturer.
Note 3: CHP make-up water costs for the steam system will be dependent on Host condensate return percentage. DI water cost for water wash is negligible.
Note 4: LFG engine start times account for time required to heat engine jacket water appropriately to accommodate startup.
Note 5: Decommissioning costs and salvage values are excluded from analysis.

VECTREN 2019 IRP TECHNOLOGY ASSESSMENT
RENEWABLE AND STORAGE TECHNOLOGY ASSESSMENT PROJECT OPTIONS
PRELIMINARY - NOT FOR CONSTRUCTION
December 2019

PROJECT TYPE	**Hydroelectric**	**Wind Energy**	**Wind Energy**	**Wind Energy**	**Wind Plus Storage**	**Solar Photovoltaic**	**Solar Photovoltaic**	**Solar Photovoltaic**
BASE PLANT DESCRIPTION	Low Head Hydroelectric	Southern IN	Northern IN	North Dakota	Indiana	Single Axis Tracking	Single Axis Tracking	Single Axis Tracking
Nominal Output, MW	50	200	200	200	50 MW Wind & 10 MW / 40 MWh Storage	10	50	100
Number of Turbines	1	58 x 3.45 MW	58 x 3.45 MW	58 x 3.45 MW	15 x 3.45 MW	N/A	N/A	N/A
Capacity Factor (%) (Notes 1,2)	40%	28%	38%	41%	38%	24.3%	24.2%	24.2%
Startup Time (Cold Start)		N/A	N/A	N/A	N/A	N/A	N/A	N/A
Book Life (Years)	40	30	30	30	30	30	30	30
Equivalent Planned Outage Rate (%)	11%	< 5%	< 5%	< 5%	< 5%	< 1%	< 1%	< 1%
Equivalent Forced Outage Rate (%)	< 5%	< 5%	< 5%	< 5%	< 5%	< 1%	< 1%	< 1%
Equivalent Availability Factor (%) (Note 6)	84%	95%	95%	95%	95%	99%	99%	99%
Assumed Land Use (Acres)	N/A	44	44	44	44	80	400	800
Fuel Design	Elevated Water	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Heat Rejection	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total System Cycles	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Interconnection Voltage Assumption	230 kV	230 kV	230 kV	230 kV	230 kV	34.5kV	230 kV	230 kV
PV Inverter Loading Ratio (DC/AC)	N/A	N/A	N/A	N/A	N/A	1.40	1.40	1.40
PV Degradation (%/yr) (Note 7)	N/A	N/A	N/A	N/A	N/A	First year: 2% After 1st Year: 0.5% per year	First year: 2% After 1st Year: 0.5% per year	First year: 2% After 1st Year: 0.5% per year
Storage System Initial Overbuild (%)	N/A	N/A	N/A	N/A	18%	N/A	N/A	N/A
Storage System Augmentation (%/yr)	N/A	N/A	N/A	N/A	2.5%	N/A	N/A	N/A
Storage System AC Roundtrip Efficiency (%)	N/A	N/A	N/A	N/A	85%	N/A	N/A	N/A
Technology Rating	Mature	Mature	Mature	Mature	Mature	Mature	Mature	Mature
Permitting & Construction Schedule (Years from FNTP)	7	2.5	2.5	2.5	2.5	2	2	2
ESTIMATED PERFORMANCE								
Base Load Performance @ (Annual Average)								
Net Plant Output, kW	50,000	200,000	200,000	200,000	50,000	10,000	50,000	100,000
Net Plant Heat Rate, Btu/kWh (HHV)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Heat Input, MMBtu/h (HHV)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
ESTIMATED CAPITAL AND O&M COSTS								
Project Capital Costs, 2019 MM$ (w/o Owner's Costs)	**$210**	**$230**	**$230**	**$230**	**$73**	**$16**	**$73**	**$145.9**
Wind Capital Cost Breakdown								
Engineering	N/A	$1.05	$1.05	$1.05	$0.26	N/A	N/A	N/A
Equipment and Materials	N/A	$160	$160	$160	$40	N/A	N/A	N/A
Turbine Towers	N/A	Incl	Incl	Incl	Incl	N/A	N/A	N/A
Turbine Blades	N/A	Incl	Incl	Incl	Incl	N/A	N/A	N/A
Turbine Hubs	N/A	Incl	Incl	Incl	Incl	N/A	N/A	N/A
Nacelle and nacelle components	N/A	Incl	Incl	Incl	Incl	N/A	N/A	N/A
SCADA Equipment	N/A	Incl	Incl	Incl	Incl	N/A	N/A	N/A
Construction	N/A	$69	$69	$69	$17	N/A	N/A	N/A
Turbine Foundation and Erection	N/A	Incl	Incl	Incl	Incl	N/A	N/A	N/A
BOP Costs	N/A	Incl	Incl	Incl	Incl	N/A	N/A	N/A
Collector Bus	N/A	Incl	Incl	Incl	Incl	N/A	N/A	N/A
Indirects and Fees	N/A	Incl	Incl	Incl	Incl	N/A	N/A	N/A
EPC Contingency	N/A	Incl	Incl	Incl	Incl	N/A	N/A	N/A
PV Capital Cost Breakdown								
Engineering	N/A	N/A	N/A	N/A	N/A	$1.2	$1.2	$1.5
Equipment and Materials	N/A	N/A	N/A	N/A	N/A			
Modules	N/A	N/A	N/A	N/A	N/A	$5.2	$25.8	$51.6
Inverters	N/A	N/A	N/A	N/A	N/A	$0.6	$3.1	$6.2
Racking	N/A	N/A	N/A	N/A	N/A	$1.7	$8.4	$16.8
Construction (Note 16)	N/A	N/A	N/A	N/A	N/A	$5.1	$25.7	$51.4
Indirects and Fees	N/A	N/A	N/A	N/A	N/A	$1.5	$7.1	$14.0
EPC Contingency	N/A	N/A	N/A	N/A	N/A	$0.5	$2.1	$4.2
	N/A							
Battery Storage Capital Cost Breakdown								
Batteries	N/A	N/A	N/A	N/A	$8	N/A	N/A	N/A
Inverters	N/A	N/A	N/A	N/A	$1	N/A	N/A	N/A
BOP	N/A	N/A	N/A	N/A	$1	N/A	N/A	N/A
Construction and Indirects	N/A	N/A	N/A	N/A	$6	N/A	N/A	N/A
Owner's Costs, 2019 MM$	**$93**	**$66**	**$66**	**$66**	**$18.9**	**$9**	**$17**	**$27**
Owner's Project Development	Allowance Included	Allowance Included	Allowance Included	Allowance Included	Allowance Included	Allowance Included	Allowance Included	Allowance Included
Owner's Engineer	Allowance Included	Allowance Included	Allowance Included	Allowance Included	Allowance Included	Allowance Included	Allowance Included	Allowance Included
Owner's Project Management	Allowance Included	Allowance Included	Allowance Included	Allowance Included	Allowance Included	Allowance Included	Allowance Included	Allowance Included
Startup / Testing / Warranties	Allowance Included	Allowance Included	Allowance Included	Allowance Included	Allowance Included	Allowance Included	Included in EPC	Included in EPC
Land (Note 11)	Excluded - Assumes Existing Dam	Excluded - Assumes Lease	Excluded - Assumes Lease	Excluded - Assumes Lease	Excluded - Assumes Lease	Excluded - Assumes Lease	Excluded - Assumes Lease	Excluded - Assumes Lease
Transmission Upgrade Costs	Excluded	Excluded	Excluded	Excluded	Excluded	Excluded	Excluded	Excluded
Permitting and Licensing Fees	Included	Included	Included	Included	Included	Included in EPC	Included in EPC	Included in EPC
Switchyard / Substation (Notes 8,9,12)	$2.0 M Allowance Included	$5.3 M Allowance Included	$5.3 M Allowance Included	$5.3 M Allowance Included	$5.3 M Allowance Included	$5.3M Allowance Included	$5.3M Allowance Included	$1.0M Allowance Included
AFUDC (Note 17)	$25.6	$23.2	$23.2	$23.2	$7.4	$1.3	$5.9	$11.7
Builder's Risk Insurance	Allowance Included	Allowance Included	Allowance Included	Allowance Included	Allowance Included	Allowance Included	Allowance Included	Allowance Included
Owner's Contingency	Allowance Included	Allowance Included	Allowance Included	Allowance Included	Allowance Included	Allowance Included	Allowance Included	Allowance Included
Total Project Costs, 2019 MM$	**$303**	**$296**	**$296**	**$296**	**$92**	**$25**	**$90**	**$173**
EPC Cost Per kW, 2019 $/kW (plus $/kWh for Storage)	**$4,200**	**$1,150**	**$1,150**	**$1,150**	**$1460 / $390**	**$1,580**	**$1,470**	**$1,460**
Total Cost Per kW, 2019 $/kW (plus $/kWh for Storage)	**$6,050**	**$1,480**	**$1,480**	**$1,480**	**$1840 / $650**	**$2,500**	**$1,810**	**$1,730**

VECTREN 2019 IRP TECHNOLOGY ASSESSMENT
RENEWABLE AND STORAGE TECHNOLOGY ASSESSMENT PROJECT OPTIONS
PRELIMINARY - NOT FOR CONSTRUCTION
December 2019

PROJECT TYPE	**Hydroelectric**	**Wind Energy**	**Wind Energy**	**Wind Energy**	**Wind Plus Storage**	**Solar Photovoltaic**	**Solar Photovoltaic**	**Solar Photovoltaic**
BASE PLANT DESCRIPTION	Low Head Hydroelectric	Southern IN	Northern IN	North Dakota	Indiana	Single Axis Tracking	Single Axis Tracking	Single Axis Tracking
Nominal Output, MW	50	200	200	200	50 MW Wind & 10 MW / 40 MWh Storage	10	50	100
Fixed O&M Cost - TOTAL, 2019$MM/Yr (Notes 3-5)	**$4.6**	**$8.0**	**$8.0**	**$8.0**	**$2.2**	**$0.3**	**$1.3**	**$2.44**
Annual Fixed Labor Cost, 2019$MM/Yr	Included in FOM	$0.6	$0.6	$0.6	$0.2	$0.0	$0.0	$0.00
Equipment Maintenance Cost, 2019$MM/Yr	Included in FOM	$4.8	$4.8	$4.8	$1.4	$0.1	$0.4	$0.70
BOP and Other Cost, 2019$MM/Yr	Included in FOM	$1.8	$1.8	$1.8	$0.5	$0.1	$0.4	$0.85
Land Lease Allowance, 2019$MM/Yr (Notes 10,11,14)	Included in FOM	$0.8	$0.8	$0.8	$0.2	$0.0	$0.2	$0.48
Property Tax Allowance, 2019$MM/Yr (Note 14)	Included in FOM	$0.0	$0.0	$0.0	$0.0	0	$0.0	$0.00
Capital Replacement Allowance, 2019$/MWh (Notes 3-5)	Included in FOM	% of OPEX; See Table	% of OPEX; See Table	% of OPEX; See Table	% of OPEX; See Table	$0.0	$0.2	$0.42
Variable O&M Cost, 2019$/MWh (excl. major maint.) (Note 4)	Included in FOM	Included in FOM	Included in FOM	Included in FOM	$14.5 (Storage MWh Only)	Included in FOM	Included in FOM	Included in FOM
ESTIMATED BASE LOAD OPERATING EMISSIONS, lb/MMBtu (HHV)								
NO_x	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SO_2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CO_2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Notes
1. Wind capacity factor represents Net Capacity Factor (NCF), which accounts for typical system losses. Capacity factor is based on Vestas V125-3.45 MW turbines with 87 meter hub height and 7.0 m/s average wind speed. Offshore capacity factor is based on estimates from publicly available studies.
2. Solar capacity factor accounts for typical losses. Fixed tilt systems assumes 20 degree tilt.
3. Capital maintenance allowances for onshore wind options are not included in the annual FOM above. A supplemental table in the report shows capital allowances estimated as percentages of annual operating expenses for a 30 year life. Offshore wind O&M estimates, based on publicly available documents, include levelized capital maintenance.

4. Battery FOM assumes the site is remotely controlled. Capital costs assume the system is oversized to accommodate normal degradation, so no battery replacement fund is included. Variable O&M accounts for the parasitic power draw of the system, including HVAC and efficiency losses.
5. PV O&M estimates assume fixed contracts for all maintenance activities. It is assumed the system is remotely controlled. Capital maintenance assumes an inverter replacement allowance levelized over the first 15 years. Inverter replacement is not included in the Solar + Storage option because of 15 year project life.
6. NERC GADS performance statistics are not available for PV, battery storage, and wind technologies. Availability estimates are based on vendor correspondence and industry publications.
7. PV degradation based on typical warranty information for polycrystalline products. Assuming factory recommended maintenance is performed, PV performance is estimated to degrade ~2% in the first year and 0.5% each remaining year.
8. Battery system assumes interconnection at distribution voltage and therefore excludes GSU and switchyard.
9. EPC costs for wind include 34.5 kV collection system and GSU to 230 kV. Owner's costs include 3 position ring bus switchyard for interconnection at 230kV. EPC cost for offshore wind include HVDC line and onshore converter. Owner's costs include 3 position ring bus switchyard for interconnection at 230kV.
10. Offshore wind project assumes cost for BOEM ocean lease is included in fixed O&M.
11. Onshore wind and PV projects assume that land is leased and therefore land costs are included in O&M, not capital costs. Onshore wind assumes one acre per turbine. PV assumes seven acres per MW for fixed tilt and eight acres per MW for tracking options.
12. PV scope for EPC includes 34.5 kV collector bus and circuit breaker. Owner costs include allowance for interconnection at 34.5 kV. PV costs updated in March 2019 to reflect potential impacts of tariffs on PV panels and steel.
13. Battery storage costs are shown as $/kW and as $/kWh per industry norms.
14: Land lease and property estimates are assumed allowances.
15: Estimated Costs exclude decommissioning costs and salvage values.
16. Construction line item for PV includes Labor, Construction Materials, and miscellaneous BOP Equipment
17. AFUDC of 12.2% used for the hydro option, 10.1% for the wind options, and 8% for the solar and storage options. AFUDC percentage is based on project schedule.

VECTREN 2019 IRP TECHNOLOGY ASSESSMENT
RENEWABLE AND STORAGE TECHNOLOGY ASSESSMENT PROJECT OPTIONS
PRELIMINARY - NOT FOR CONSTRUCTION
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PROJECT TYPE	**Solar Plus Storage**	**Battery Storage**	**Battery Storage**	**Battery Storage**	**Battery Storage**	**Battery Storage**	**Battery Storage**
BASE PLANT DESCRIPTION	Single Axis Tracking	Lithium Ion	Lithium Ion	Flow Battery	Flow Battery	Flow Battery	Flow Battery
Nominal Output, MW	50 MW PV & 10 MW / 40 MWh Storage	10 MW / 40 MWh	50 MW / 200 MWh	10 MW / 60 MWh	10 MW / 80 MWh	50 MW / 300 MWh	50 MW / 400 MWh
Number of Turbines	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Capacity Factor (%) (Notes 1,2)	24.2%	17%	17%	25%	33%	25%	33%
Startup Time (Cold Start)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Book Life (Years)	15	15	15	20	20	20	20
Equivalent Planned Outage Rate (%)	< 3%	< 3%	< 3%	< 3%	< 3%	< 3%	< 3%
Equivalent Forced Outage Rate (%)	< 3%	< 3%	< 3%	< 3%	< 3%	< 3%	< 3%
Equivalent Availability Factor (%) (Note 6)	97%	97%	97%	97%	97%	97%	97%
Assumed Land Use (Acres)	402	5	8	20	20	20	20
Fuel Design	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Heat Rejection	N/A	Air-cooled HVAC	Air-cooled HVAC	Air-cooled chiller	Air-cooled chiller	Air-cooled chiller	Air-cooled chiller
Total System Cycles	N/A	5,500	5,500	7,200	7,200	7,200	7,200
Interconnection Voltage Assumption	230 kV	230 kV	230 kV	230 kV	230 kV	230 kV	230 kV
PV Inverter Loading Ratio (DC/AC)	1.40	N/A	N/A	N/A	N/A	N/A	N/A
PV Degradation (%/yr) (Note 7)	First year: 2% After 1st Year: 0.5% per year	N/A	N/A	N/A	N/A	N/A	N/A
Storage System Initial Overbuild (%)	18%	18%	18%	0%	0%	0%	0%
Storage System Augmentation (%/yr)	2.5%	2.5%	2.5%	0%	0%	0%	0%
Storage System AC Roundtrip Efficiency (%)	85%	85%	85%	68%	68%	68%	68%
Technology Rating	Mature	Mature	Mature	Developing	Developing	Developing	Developing
Permitting & Construction Schedule (Years from FNTP)	2	2	2	2	2	2	2
ESTIMATED PERFORMANCE							
Base Load Performance @ (Annual Average)							
Net Plant Output, kW	50,000	10,000 kW / 40,000 kWh	50,000 kW / 200,000 kWh	10,000 kW / 60,000 kWh	10,000 kW / 80,000 kWh	50,000 kW / 300,000 kWh	50,000 kW / 400,000 kWh
Net Plant Heat Rate, Btu/kWh (HHV)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Heat Input, MMBtu/h (HHV)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
ESTIMATED CAPITAL AND O&M COSTS							
Project Capital Costs, 2019 MM$ (w/o Owner's Costs)	**$88.8**	**$16.5**	**$63.1**	**$35.8**	**$44.6**	**$162.8**	**$205.5**
Wind Capital Cost Breakdown							
Engineering	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Equipment and Materials	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Turbine Towers	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Turbine Blades	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Turbine Hubs	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nacelle and nacelle components	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SCADA Equipment	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Construction	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Turbine Foundation and Erection	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BOP Costs	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Collector Bus	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Indirects and Fees	N/A	N/A	N/A	N/A	N/A	N/A	N/A
EPC Contingency	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PV Capital Cost Breakdown							
Engineering	$1.2	N/A	N/A	N/A	N/A	N/A	N/A
Equipment and Materials		N/A	N/A	N/A	N/A	N/A	N/A
Modules	$25.8	N/A	N/A	N/A	N/A	N/A	N/A
Inverters	$3.1	N/A	N/A	N/A	N/A	N/A	N/A
Racking	$8.4	N/A	N/A	N/A	N/A	N/A	N/A
Construction (Note 16)	$25.7	N/A	N/A	N/A	N/A	N/A	N/A
Indirects and Fees	$7.1	N/A	N/A	N/A	N/A	N/A	N/A
EPC Contingency	$2.1	N/A	N/A	N/A	N/A	N/A	N/A
Battery Storage Capital Cost Breakdown							
Batteries	$8	$8	$40	$26	$34	$128	$170
Inverters	$1	$1	$3	$1	$1	$3	$3
BOP	$1	$2	$2	$1	$1	$5	$5
Construction and Indirects	$6	$6	$17	$9	$9	$27	$27
Owner's Costs, 2019 MM$	**$19**	**$9.6**	**$16**	**$16**	**$17**	**$33**	**$36**
Owner's Project Development	Allowance Included	Allowance Included	Allowance Included	Allowance Included	Allowance Included	Allowance Included	Allowance Included
Owner's Engineer	Allowance Included	Allowance Included	Allowance Included	Allowance Included	Allowance Included	Allowance Included	Allowance Included
Owner's Project Management	Allowance Included	Allowance Included	Allowance Included	Allowance Included	Allowance Included	Allowance Included	Allowance Included
Startup / Testing / Warranties	Included in EPC	Allowance Included	Allowance Included	Allowance Included	Allowance Included	Allowance Included	Allowance Included
Land (Note 11)	Excluded - Assumes Lease	Excluded - Assumes Lease	Excluded - Assumes Lease	Excluded - Assumes Lease	Excluded - Assumes Lease	Excluded - Assumes Lease	Excluded - Assumes Lease
Transmission Upgrade Costs	Excluded	Excluded	Excluded	Excluded	Excluded	Excluded	Excluded
Permitting and Licensing Fees	Included in EPC	Allowance Included	Allowance Included	Allowance Included	Allowance Included	Allowance Included	Allowance Included
Switchyard / Substation (Notes 8,9,12)	$1.0M Allowance Included	$5.3M Allowance Included	$5.3M Allowance Included	$5.3M Allowance Included	$5.3M Allowance Included	$5.3M Allowance Included	$5.3M Allowance Included

VECTREN 2019 IRP TECHNOLOGY ASSESSMENT
RENEWABLE AND STORAGE TECHNOLOGY ASSESSMENT PROJECT OPTIONS
PRELIMINARY - NOT FOR CONSTRUCTION
December 2019

PROJECT TYPE	Solar Plus Storage	Battery Storage	Battery Storage	Battery Storage	Battery Storage	Battery Storage	Battery Storage
BASE PLANT DESCRIPTION	Single Axis Tracking	Lithium Ion	Lithium Ion	Flow Battery	Flow Battery	Flow Battery	Flow Battery
Nominal Output, MW	50 MW PV & 10 MW / 40 MWh Storage	10 MW / 40 MWh	50 MW / 200 MWh	10 MW / 60 MWh	10 MW / 80 MWh	50 MW / 300 MWh	50 MW / 400 MWh
AFUDC (Note 17)	$7.1	$1.3	$5.0	$2.9	$3.6	$13.0	$16.4
Builder's Risk Insurance	Allowance Included	Allowance Included	Allowance Included	Allowance Included	Allowance Included	Allowance Included	Allowance Included
Owner's Contingency	Allowance Included	Allowance Included	Allowance Included	Allowance Included	Allowance Included	Allowance Included	Allowance Included
Total Project Costs, 2019 MM$	**$108**	**$26**	**$79**	**$51**	**$61**	**$195**	**$242**
EPC Cost Per kW, 2019 $/kW (plus $/kWh for Storage)	**$1,780**	**$1650 / $410**	**$1260 / $320**	**$3580 / $600**	**$4460 / $560**	**$3260 / $540**	**$4110 / $510**
Total Cost Per kW, 2019 $/kW (plus $/kWh for Storage)	**$2,160**	**$2610 / $650**	**$1580 / $390**	**$5150 / $860**	**$6140 / $770**	**$3910 / $650**	**$4830 / $600**
Fixed O&M Cost - TOTAL, 2019$MM/Yr (Notes 3-5)	**$1.5**	**$0.3**	**$0.7**	**$1.9**	**$1.9**	**$2.1**	**$2.1**
Annual Fixed Labor Cost, 2019$MM/Yr	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Equipment Maintenance Cost, 2019$MM/Yr	$0.6	$0.2	$0.5	$1.9	$1.9	$1.9	$1.9
BOP and Other Cost, 2019$MM/Yr	$0.4	Included	Included	Included	Included	Included	Included
Land Lease Allowance, 2019$MM/Yr (Notes 10,11,14)	$0.2	$0.003	$0.005	$0.01	$0.01	$0.01	$0.01
Property Tax Allowance, 2019$MM/Yr (Note 14)	$0.0	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Capital Replacement Allowance, 2019$/MWh (Notes 3-5)	$0.3	$0.04	$0.20	$0.1	$0.1	$0.2	$0.2
Variable O&M Cost, 2019$/MWh (excl. major maint.) (Note 4)	$14.5 (Storage MWh Only)	$14.50	$14.50	Included in FOM	Included in FOM	Included in FOM	Included in FOM
ESTIMATED BASE LOAD OPERATING EMISSIONS, lb/MMBtu (HHV)							
NO_X	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SO_2	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CO	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CO_2	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Notes

1. Wind capacity factor represents Net Capacity Factor (NCF), which accounts for typical system losses. Capacity factor is based on Vestas V125-3.45 MW turbines with 87 meter hub height and 7.0 m/s average wind speed. Offshore capacity factor is based on estimates from publicly available studies.
2. Solar capacity factor accounts for typical losses. Fixed tilt systems assumes 20 degree tilt.
3. Capital maintenance allowances for onshore wind options are not included in the annual FOM above. A supplemental table in the report shows capital allowances estimated as percentages of annual operating expenses for a 30 year life. Offshore wind O&M estimates, based on publicly available documents, include levelized capital maintenance.
4. Battery FOM assumes the site is remotely controlled. Capital costs assume the system is oversized to accommodate normal degradation, so no battery replacement fund is included. Variable O&M accounts for the parasitic power draw of the system, including HVAC and efficiency losses.
5. PV O&M estimates assume fixed contracts for all maintenance activities. It is assumed the system is remotely controlled. Capital maintenance assumes an inverter replacement allowance levelized over the first 15 years. Inverter replacement is not included in the Solar + Storage option because of 15 year project life.
6. NERC GADS performance statistics are not available for PV, battery storage, and wind technologies. Availability estimates are based on vendor correspondence and industry publications.
7. PV degradation based on typical warranty information for polycrystalline products. Assuming factory recommended maintenance is performed, PV performance is estimated to degrade ~2% in the first year and 0.5% each remaining year.
8. Battery system assumes interconnection at distribution voltage and therefore excludes GSU and switchyard.
9. EPC costs for wind include 34.5 kV collection system and GSU to 230 kV. Owner's costs include 3 position ring bus switchyard for interconnection at 230kV. EPC cost for offshore wind include HVDC line and onshore converter. Owner's costs include 3 position ring bus switchyard for interconnection at 230kV.
10. Offshore wind project assumes cost for BOEM ocean lease is included in fixed O&M.
11. Onshore wind and PV projects assume that land is leased and therefore land costs are included in O&M, not capital costs. Onshore wind assumes one acre per turbine. PV assumes seven acres per MW for fixed tilt and eight acres per MW for tracking options.
12. PV scope for EPC includes 34.5 kV collector bus and circuit breaker. Owner costs include allowance for interconnection at 34.5 kV. PV costs updated in March 2019 to reflect potential impacts of tariffs on PV panels and steel.
13. Battery storage costs are shown as $/kW and as $/kWh per industry norms.
14: Land lease and property estimates are assumed allowances.
15: Estimated Costs exclude decommissioning costs and salvage values.
16. Construction line item for PV includes Labor, Construction Materials, and miscellaneous BOP Equipment
17. AFUDC of 12.2% used for the hydro option, 10.1% for the wind options, and 8% for the solar and storage options. AFUDC percentage is based on project schedule.

VECTREN 2019 IRP TECHNOLOGY ASSESSMENT
COAL TECHNOLOGY ASSESSMENT PROJECT OPTIONS
PRELIMINARY - NOT FOR CONSTRUCTION
December 2019

PROJECT TYPE	Supercritical Pulverized Coal with Carbon Capture	Ultra-Supercritical Pulverized Coal with Carbon Capture
BASE PLANT DESCRIPTION		
Nominal Output	500 MW Net with CCS	750 MW Net with CCS
Number of Gas Turbines	N/A	N/A
Number of Boilers/Reactors	1	1
Number of Steam Turbines	1	1
Steam Conditions (Main Steam / Reheat)	1050 F/1050F	1100 F/1100F
Main Steam Pressure	3675 psia	3694 psia
Steam Cycle Type	Supercritical	Ultra-Supercritical
Capacity Factor (%)	70%	70%
Startup Time (Cold Start)	10 Hours	10 Hours
Startup Time (Warm Start)	6 Hours	6 Hours
Startup Time (Hot Start)	4 Hours	4 Hours
Book Life (Years)	33	33
Equivalent Planned Outage Rate (%)	9.0%	8.8%
Equivalent Forced Outage Rate (%)	10.9%	8.8%
Equivalent Availability Factor (%)	79.5%	80.8%
Fuel Design	Bituminous Coal	Bituminous Coal
Heat Rejection	Wet Cooling Tower	Wet Cooling Tower
NO_x Control	Low NOx burners / SCR	Low NOx burners / SCR
SO_2 Control	Integrated WFGD and DFGD	Integrated WFGD and DFGD
Acid Gas Control	Integrated WFGD and DFGD	Integrated WFGD and DFGD
CO_2 Control	Advanced Amine	Advanced Amine
Particulate Control	Baghouse	Baghouse
Ash Disposal	Landfill	Landfill
Technology Rating	Mature	Mature
Permitting & Construction Schedule (Years from FNTP)	6.5 Years	6.5 Years
ESTIMATED PERFORMANCE		
Base Load Performance @ (Annual Average) w/ Carbon Capture		
Net Plant Output, kW	505,750	747,100
Net Plant Heat Rate, Btu/kWh (HHV)	11,290	10,480
Heat Input, MMBtu/h (HHV)	5,710	7,830
Minimum Load Operational Status @ (Annual Average)		
Net Plant Output, kW	177,010	298,840
Net Plant Heat Rate, Btu/kWh (HHV)	13,410	12,240
Heat Input, MMBtu/h (HHV)	2,370	3,660

VECTREN 2019 IRP TECHNOLOGY ASSESSMENT
COAL TECHNOLOGY ASSESSMENT PROJECT OPTIONS
PRELIMINARY - NOT FOR CONSTRUCTION
December 2019

PROJECT TYPE	Supercritical Pulverized Coal with Carbon Capture	Ultra-Supercritical Pulverized Coal with Carbon Capture
ESTIMATED CAPITAL AND O&M COSTS		
EPC Project Capital Costs, 2019 MM$ (w/o Owner's Costs)	**$2,609**	**$3,523**
Owner's Costs, 2019 MM$	**$612**	**$780**
Owner's Project Development	$7.5	$7.5
Owner's Operational Personnel Prior to COD	$7.7	$7.7
Owner's Engineer	$11.5	$11.5
Owner's Project Management	$10.0	$10.0
Owner's Legal Costs	$3.0	$3.0
Owner's Start-up Engineering	$0.4	$0.4
Land	$5.0	$5.0
Operator Training	$0.6	$0.6
Construction Power and Water	$3.6	$3.6
Permitting and Licensing Fees	$4.0	$4.0
Switchyard	$10.1	$10.1
Political Concessions & Area Development Fees	$2.5	$2.5
Startup/Testing (Fuel & Consumables)	$30.1	$30.1
Initial Fuel Inventory	$16.8	$16.8
Site Security	$0.6	$0.6
Operating Spare Parts	$8.2	$8.2
Water Supply Infrastructure	Included in Project Capital	Included in Project Capital
Natural Gas Supply Infrastructure	N/A	N/A
Transmission Interconnect	$2.0	$3.0
Transmission Upgrade Costs	Excluded	Excluded
Firm Gas Supply Reservation Charge	Provided by Owner	Provided by Owner
Permanent Plant Equipment and Furnishings	$4.6	$4.6
AFUDC (12.2% of EPC Project Capital Costs)	$318.3	$429.8
Builders Risk Insurance (0.45% of Construction Costs)	$11.7	$15.9
Owner's Contingency (5% for Screening Purposes)	$153	$205
Total Project Costs, 2019 MM$	**$3,220**	**$4,302**
EPC Cost Per kW, 2019 $/kW	**$5,158**	**$4,715**
Total Cost Per kW, 2019 $/kW	**$6,370**	**$5,760**

VECTREN 2019 IRP TECHNOLOGY ASSESSMENT COAL TECHNOLOGY ASSESSMENT PROJECT OPTIONS PRELIMINARY - NOT FOR CONSTRUCTION December 2019		
PROJECT TYPE	**Supercritical Pulverized Coal with Carbon Capture**	**Ultra-Supercritical Pulverized Coal with Carbon Capture**
CO_2 Transportation and Geologic Sequestration (See note 4)		
50 Mile Pipeline Cost, 2019 MM$	$122	$122
CO_2 Pipeline Maintenance ($/MWh)	$3.52	$3.52
CO_2 Storage Cost ($/MWh)	$9.14	$9.14
Fixed O&M Cost, 2019$/kW-Yr	$29.10	$29.10
Fixed O&M Cost, 2019 $MM/Yr	$14.70	$21.70
Major Maintenance Cost, 2019$/MWh	$5.20	$5.20
Variable O&M Cost, 2019$/MWh (excl. major maint.)	$11.20	$11.20
ESTIMATED BASE LOAD OPERATING EMISSIONS (NO CCS), lb/MMBtu (HHV)		
NO_X	0.02	0.02
SO_2	0.02	0.02
CO	0.15	0.15
CO_2	100	100

Notes
Note 1: PC cost and performance are based on net performance inclusive of carbon capture.
Note 2: The PC unit assumes that cooler tower blowdown is recycled in the wet FGD.
Note 3: The PC unit assumes a spray dry absorber will be used to control acid gases. FGD purge will be recycled in the SDA.
Note 4: Carbon transportation and sequestration assumes 50 mile pipeline to a suitable subterranean reservoir.
Note 5: Outage and availability statistics are collected using the NERC Generating Availability Data System. Reporting period is those units that reported evenings between 2013-2017.

Attachment 3.1 Stakeholder Materials

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VECTREN PUBLIC STAKEHOLDER MEETING

AUGUST 15, 2019

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WELCOME, INTRODUCTION TO CENTERPOINT, AND SAFETY SHARE

LYNNAE WILSON

INDIANA ELECTRIC CHIEF BUSINESS OFFICER

SAFETY SHARE

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Know your exits

- Whenever you are entering a public area or a guest in a facility such as this, always know your exits. Take note of the signs
- There are two emergency exits, immediately behind me, Additionally, there are exit doors directly behind you – once through the door, to the left is the main entrance into the building. Should the main entrance be blocked there is an exit to the right of this room through a set of doors leading to the loading dock area

Visualize for safety

- When you enter a new space, visualize that an emergency – like a fire, bad weather, or an earthquake – could happen there and consider how you can respond
- The best way is to prepare to respond to an emergency before it happens. Few people can think clearly and logically in a crisis, so it is important to do so in advance, when you have time to be thorough

  Fire

  - Evacuate the building and move to the back of the Vectren parking lot, near the YWCA

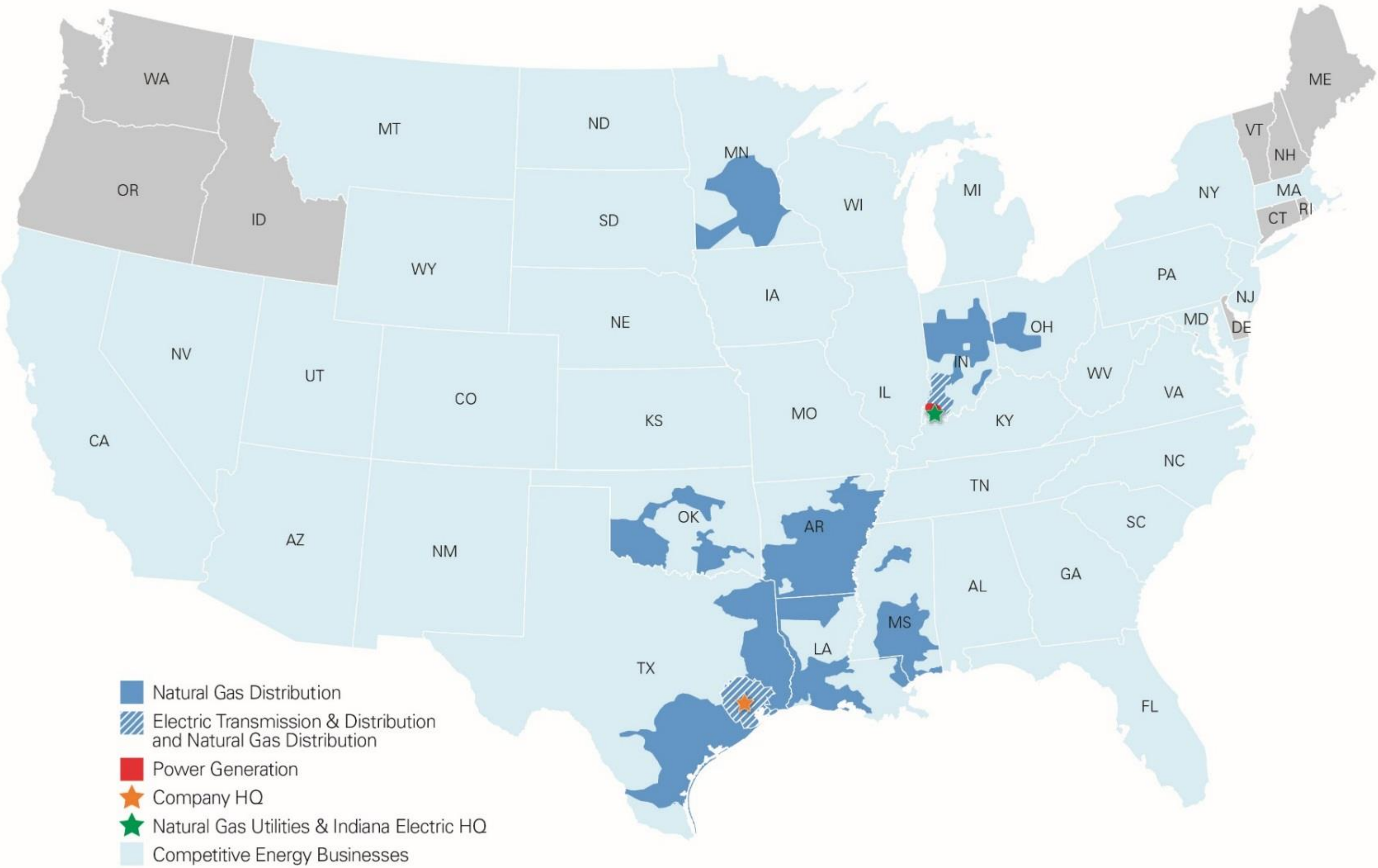
  Bad Weather

  - During a tornado warning, stay away from windows, glass doors, and outside walls
  - Move in an orderly fashion to the stairwell, just outside of the lobby in the main entrance way

  Earthquake

  - Move under the desk where you are sitting, facing away from glass, and cover your head and face
  - Once shaking has subsided, move in an orderly fashion towards the nearest exit and move to the back of the Vectren parking lot, near the YWCA

OUR BUSINESSES



AGENDA

Time		
9:00 a.m.	Sign-in/Refreshments	
9:30 a.m.	Welcome, Safety Message	Lynnae Wilson, CenterPoint Energy Indiana Electric Chief Business Officer
9:45 a.m.	2019/2020 IRP Process	Matt Rice, Vectren Manager of Resource Planning and Gary Vicinus, Managing Director for Utilities, Pace Global
10:35 a.m.	Break	
10:45 a.m.	Objectives & Measures Workshop	Gary Vicinus, Managing Director for Utilities, Pace Global
11:30 a.m.	Lunch	
12:15 p.m.	All-Source RFP	Matt Lind, Resource Planning & Market Assessments Business Lead, Burns and McDonnell
1:00 p.m.	Environmental Compliance Update	Angila Retherford, CenterPoint Energy, Vice President Environmental Affairs and Corporate Responsibility
1:35 p.m.	Break	
1:45 p.m.	Draft Base Case Market Inputs and Scenarios Workshop	Gary Vicinus, Managing Director for Utilities, Pace Global
2:30 p.m.	Stakeholder Questions and Feedback	Moderated by Gary Vicinus, Managing Director for Utilities, Pace Global
3:00 p.m.	Adjourn	

MEETING GUIDELINES

1. Please hold most questions until the end of each presentation. Time will be allotted for questions following each presentation. (Clarifying questions about the slides are fine throughout)
2. For those on the webinar, we will open the (currently muted) phone lines for questions within the allotted time frame. You may also type in questions via the chat feature. Only questions sent to 'All-Entire Audience' will be seen and answered during the session.
3. At the end of the presentation, we will open up the floor for "clarifying questions," thoughts, ideas, and suggestions.
4. There will be a parking lot for items to be addressed at a later time.
5. Vectren does not authorize the use of cameras or video recording devices of any kind during this meeting.
6. Questions asked at this meeting will be answered here or later.
7. We will do our best to capture notes but request that you provide written feedback (concepts, inputs, methodology, etc.) at IRP@CenterPointEnergy.com following the meeting. Additional questions can also be sent to this e-mail address.

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2019/2020 IRP PROCESS

MATT RICE

VECTREN MANAGER OF RESOURCE PLANNING

DIRECTOR’S REPORT FEEDBACK

Improvement Opportunities	Positive Comments
Include lower and higher boundary scenarios to create a wider range of portfolios	Significant improvements in all aspects of the IRP
Model a wide range of portfolios	Use of state-of-the art models
Strategist model did not consider enough options simultaneously	A collegial stakeholder process with a concerted efforts to broaden stakeholder participation
Update risk analysis methodology to be less qualitative and more encompassing of known risks	Appropriate use of short, mid, and long term breaks in forecasts
Explore other options for modeling EE cost options and make greater use of a Market Potential Study (MPS)	Being credible and well-reasoned, with narratives that were clear
More consideration given to Warrick unit 4 in scenario development	Maintaining optionality in the plan
Clearly define risk analysis methodology	Commendable use of multiple fuel prices
Clearly define Energy Efficiency Methodology	Top management participation

ADDITIONAL DIRECTOR'S REPORT GUIDANCE

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The director had five specific requests of all utilities that should be incorporated into IRPs

- Greater use of tables
- Easier comparisons for scenario assumptions
- List of technical modeling constraints
- Expanded use of graphics
- Solicit stakeholder inputs and improve the exploratory nature of IRPs

IURC ORDER 45052

- Vectren selected a Combined Cycle Gas Turbine (CCGT) that was too large for a small utility
  - Did not adequately consider flexibility to change paths, adding stranded asset risks
  - Did not consider fuel or geographic diversity
- Risk analysis did not consider the full range of portfolios
  - Did not fully explore options at the Brown plant (conversion or scrubber alternatives)
  - Need to more fully consider customer-generator opportunities
  - Did not fully consider energy and capacity purchases
  - Did not consider smaller gas plant options in the risk analysis
- Vectren's analysis disadvantaged renewable resources
  - Vectren did not make a serious effort to determine the price and availability of renewables
  - The RFP was too restrictive
- Vectren did not fully respond to the Director's report critiques in updated CPCN analysis
  - Did not update the risk modeling
  - Did not consider the full range of gas prices (including methane regulation)

Other Items to Note

- Acknowledged that Vectren needs to act swiftly to develop our 2019 IRP to meet the 2023 constraints
- DSM was compared on a consistent and comparable basis with supply side alternatives

VECTREN COMMITMENTS FOR 2019/2020 IRP

- Will strive to make every encounter meaningful for stakeholders and for us
- Will provide a data release schedule and provide modeling data ahead of filing for evaluation
- The IRP process informs the selection of the preferred portfolio
- Utilize an All-Source RFP to gather market pricing & availability data
- Use one model for consistency in optimization, simulated dispatch, and probabilistic functions
- Attempt to model more resources simultaneously
- Will include a balanced, less qualitative risk score card. Draft to be shared at the first public stakeholder meeting
- Work with stakeholders on portfolio development
- Will test a wide range of portfolios in scenario modeling and ultimately in the risk analysis
- Will conduct a sensitivity analysis
- Exhaustive look at existing resource options
- The IRP will include information presented for multiple audiences (technical and non-technical)

KEY DIFFERENCES FROM 2016 APPROACH

2016	2019/2020
Utilized technology assessment information	All-Source RFP, supplemented with technology assessment information
Discussed objectives, risks, and provided example of potential metrics. Showed scorecard and final metrics in the last stakeholder meeting	Will show objectives, metrics, and gather feedback on scorecard early in the process
Built 15 portfolios for the risk analysis, including continuing use of coal plants, least cost portfolios, diversified portfolios, and stakeholder portfolios	Work with stakeholders to build a wide range of portfolios to be tested in the risk analysis. Utilize models to develop least cost portfolios for various portfolio strategies
Other than the continue coal portfolio, alternatives such as gas conversion or repower options did not ultimately make it into the risk analysis	More exhaustive look at viability of existing units, and include in the risk analysis
Utilized scenario modeling to create computer generated portfolios. Essentially used as a screening tool for the risk analysis	Utilize scenarios to evaluate regulatory risk, with simulated dispatch for a wide range of portfolios
No sensitivity analysis	Will include a sensitivity analysis on various risks, utilizing data from probabilistic modeling. EE Sensitivity.
Modeled 8 blocks of EE up to 2% of sales. Costs based on EIA penetration model. EE selection was binary (selected for full period or not)	Will model EE bins of varying sizes and timeframes. Ties directly to MPS with costs based in empirical data and historical experience
Did not provide modeling data until after IRP was filed	Will provide modeling data throughout the process
Utilized two IRP models (Strategist & Aurora)	Moving to Aurora for all IRP modeling

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PROPOSED 2019/2020 IRP PROCESS

Stakeholder input is provided on a timely basis throughout the process, with meetings held in August, October, December, and March

- Conduct an All Source RFP
- Create Objectives, Risk Perspectives and Scorecard Development
- Create Base Case Assumptions and Scenario Development
- Portfolio Development Based on Various Strategies, Utilizing Optimization to Create a Wide Range of Portfolios and Refine with All Source RFP Data
- Portfolio Testing in Scenarios, Focused on Potential Regulatory Risks
- Portfolio Testing Using Probabilistic Modeling of 200 Potential Futures
- Utilize the Probabilistic Modeling to Conduct Sensitivity Analysis
- Populate the Risk Scorecard that was Developed Early in the Process and Evaluate Portfolios
- Select the Preferred Portfolio

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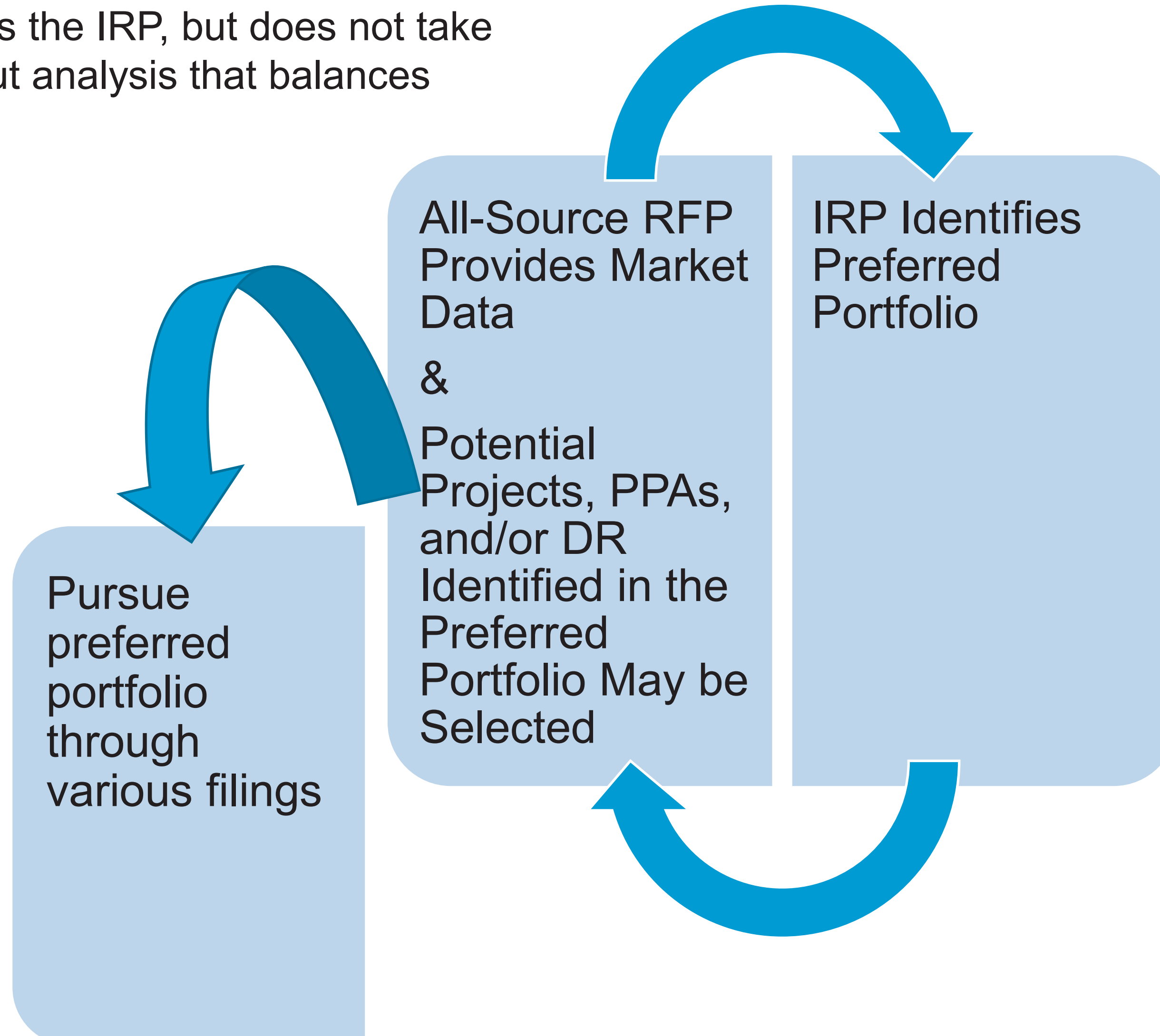
ROLE OF THE ALL-SOURCE RFP

The All-Source RFP informs the IRP, but does not take the place of well thought out analysis that balances multiple objectives

- Average delivered cost by resource will inform modeling
- Resources to be modeled on a tiered basis
- The full IRP analysis, including risk analysis, will test a diverse set of resource mixes and will ultimately identify a preferred portfolio
- Vectren will pursue resources consistent with those identified in the preferred portfolio



KEY VENDORS

RFP

- Burns and McDonnell
  - Draft RFP
  - Post
  - Interpret and align bids
  - Bid risk assessment
  - Convert into modeling inputs
  - Further evaluation on viable projects
  - Transmission analysis where needed

IRP

- Pace
  - Moderation of stakeholder meetings
  - Strategy (assist with stakeholder engagement, scenario, portfolio, objectives, & metrics development)
  - Deterministic modeling (determined scenarios)
  - Probabilistic modeling
  - Sensitivity analysis
  - Risk assessment and scorecard

File May 1, 2020

2019/2020 STAKEHOLDER PROCESS

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August 15, 2019	October 10, 2019	December 12, 2019	March 19, 2020
• 2019/2020 IRP Process • Objectives and Measures • All-Source RFP • Environmental Update • Draft Base Case Market Inputs & Scenarios	• RFP Update • Draft Resource costs • Sales and Demand Forecast • DSM MPS/ Modeling Inputs • Scenario Modeling Inputs • Portfolio Development	• Draft Portfolios • Draft Base Case Modeling Results • All-Source RFP Results and Final Modeling Inputs • Probabilistic Modeling Approach and Assumptions	• Final Base Case Modeling • Probabilistic Modeling Results • Risk Analysis Results • Preview the Preferred Portfolio

FEEDBACK AND DISCUSSION

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OBJECTIVES & MEASURES

GARY VICINUS

MANAGING DIRECTOR FOR UTILITIES, PACE GLOBAL

IRP OBJECTIVES & MEASURES

The purpose of the IRP is to evaluate Vectren's current energy resource portfolio and a range of alternative future portfolios to meet customers' electrical energy needs in an affordable, system-wide manner

In addition, the IRP process evaluates portfolios in terms of environmental stewardship, market and price risk, and future flexibility, system flexibility to provide backup resources, reliability, and resource diversity

Each objective is important and worthy of balanced consideration in the IRP process, taking into account uncertainty. Some objectives are better captured in portfolio construction than as a portfolio measure

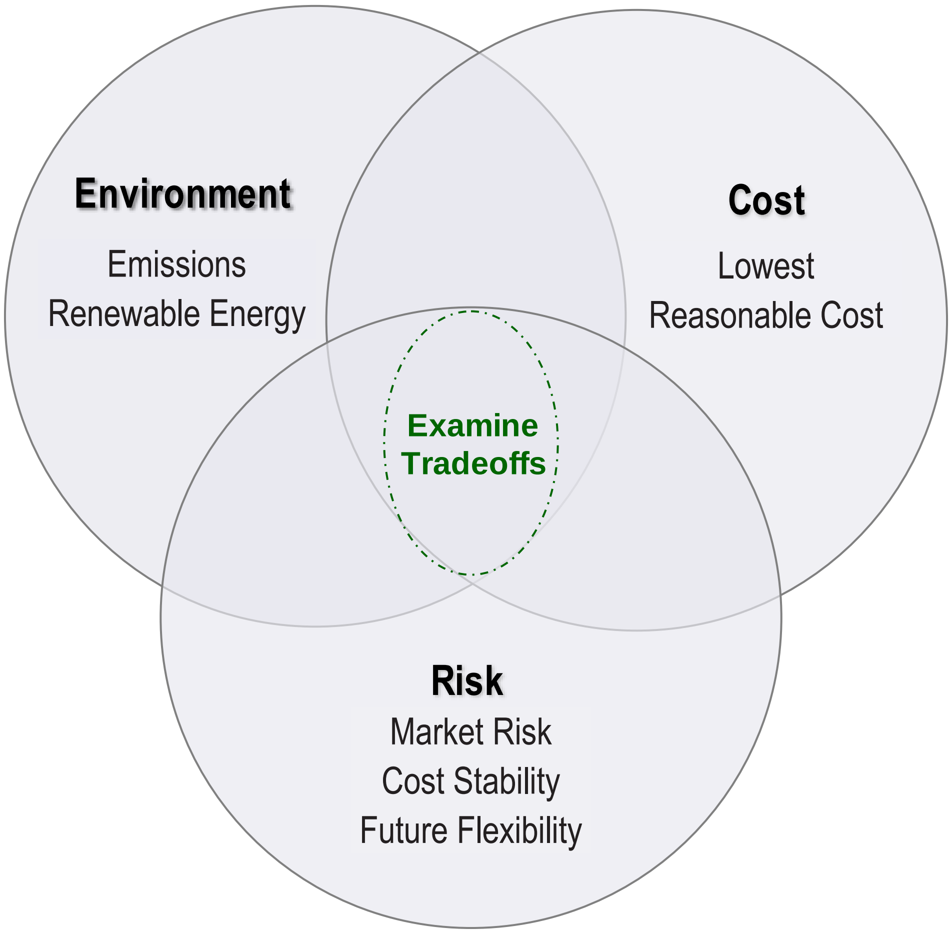
The measures allow the analysis to compare portfolio performance and potential risk on an equal basis

Quantitative IRP Objectives
Affordability
Environmental Risk Minimization
Price Risk Minimization
Market Risk Minimization
Future Flexibility

Qualitative IRP Objectives
Resource Diversity
System Flexibility

EACH PORTFOLIO WILL HAVE TRADEOFFS

Customer Perspective



IRP OBJECTIVES & MEASURES

For each resource portfolio, the objectives are tracked and measured to evaluate portfolio performance in the base case, in four alternative scenarios, and across a wide range of possible future market conditions. All measures of portfolio performance are based on probabilistic modeling of 200 futures

Objective	Measure	Unit
Affordability	20-Year NPVRR	$
Price Risk Minimization	95th percentile value of NPVRR	$
Environmental Risk Minimization	CO_2 Emissions	tons
Market Risk Minimization	Energy Market Purchases or Sales outside of a +/- 15% Band	%
	Capacity Market Purchases or Sales outside of a +/- 15% Band	%
Future Flexibility	MWh of impairment by asset	MWh

SCREENING PORTFOLIO PERFORMANCE

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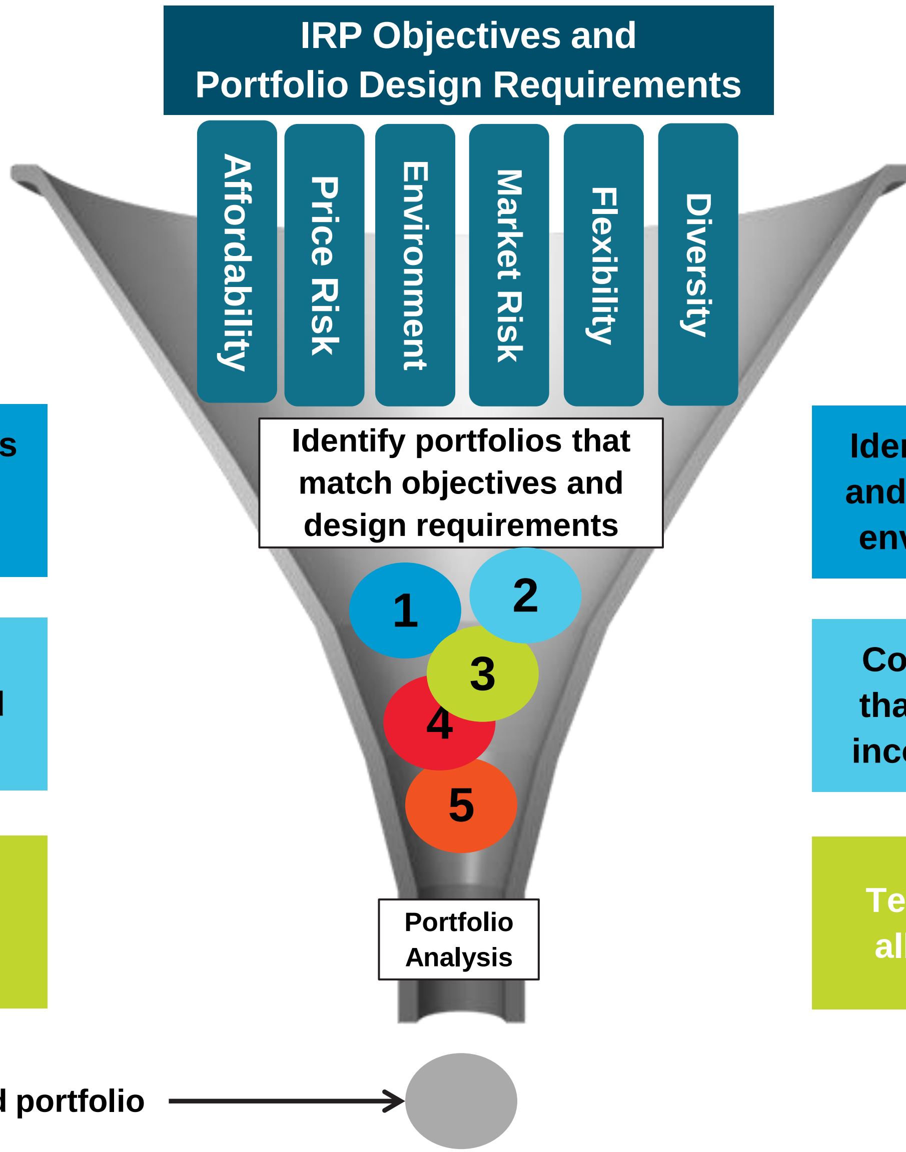

Task

Screen portfolio options for objectives and design requirements

Combine individual options into integrated portfolios

Perform risk analysis

Select preferred portfolio

Approach

Identify design requirements and rank options by cost and environmental performance

Construct portfolio options that meet requirements and incorporate strategy options

Test each portfolio against all objectives & measures

FEEDBACK AND DISCUSSION

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ALL-SOURCE RFP UPDATE

MATT LIND,

RESOURCE PLANNING & MARKET ASSESSMENTS BUSINESS LEAD, BURNS AND MCDONNELL

OVERVIEW

- 2016 IRP:
  - Identified capacity and energy shortfall beginning in 2023
  - Potential need of ~700 MW accredited capacity
- 2019/2020 IRP:
  - Must examine existing resources alongside alternatives
  - Potentially a similar need
- 2019 All-Source RFP:
  - Feed IRP inputs
  - Identify potential cost effective resources

ALL-SOURCE RFP KEY DATES

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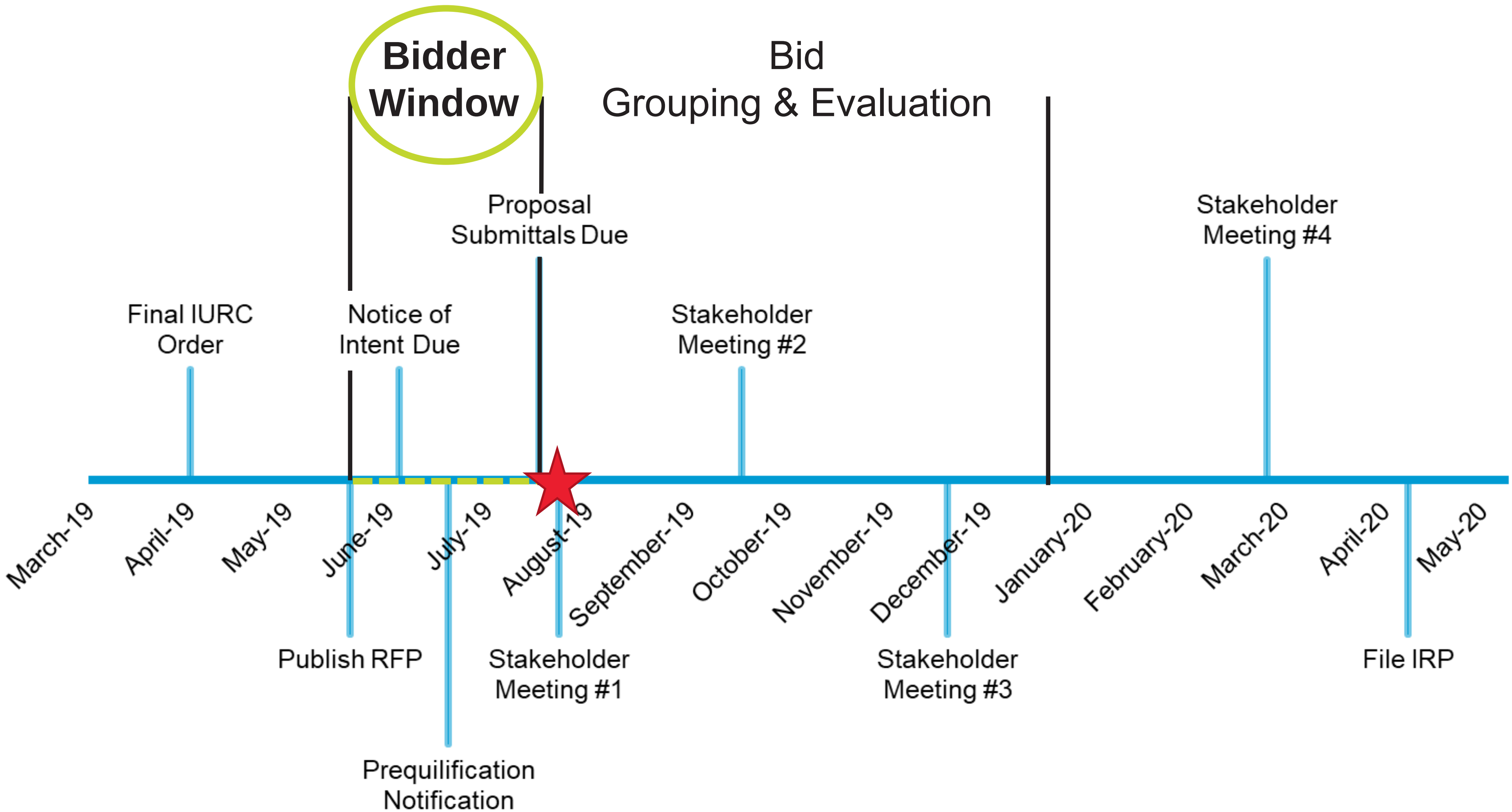
Event	Anticipated Date*
All-Source RFP Issued	Wednesday, June 12, 2019
Notice of Intent (NOI), All-Source RFP NDA, and Respondent Pre-Qualification Application Due	5:00 p.m. CDT Thursday, June 27, 2019
Respondents Notified of Results of Pre-Qualification Application Review	5:00 p.m. CDT ~~Wednesday, July 3, 2019~~ Friday, July 12, 2019
Proposal Submittal Due Date	**5:00 p.m. CDT** **~~Wednesday, July 31, 2019~~** **Friday, August 9, 2019**
Initial Proposal Review and Evaluation Period	August - September 2019
Interconnection Evaluation	August - October 2019
Congestion Evaluation	4th Quarter, 2019
Inputs to IRP	4th Quarter, 2019

*Negotiation schedule for smaller projects can be expedited at Vectren's discretion

TIMELINE


Bidder Window
Bid Grouping & Evaluation
Proposal Submittals Due
Stakeholder Meeting #4
Final IURC Order
Notice of Intent Due
Stakeholder Meeting #2
March-19
April-19
May-19
June-19
July-19
August-19
September-19
October-19
November-19
December-19
January-20
February-20
March-20
April-20
May-20
Publish RFP
Stakeholder Meeting #1
Stakeholder Meeting #3
File IRP
Prequilification Notification

ALL-SOURCE RFP PUBLICATION & DISTRIBUTION

VECTREN
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- Ad published in Megawatt Daily (~20,000 recipients)
- North American Energy Markets Association (NAEMA) distribution (150 members)
- Published in June 2019 Midwest Energy Efficiency Alliance (MEEA) Minute (161 members)
- Included on Vectren.com
- Sent to participants in Vectren's 2017 RFP
- BMcD RFP contact list (>450 industry contacts)
- Vectren stakeholders & industry contacts
- Interviews with Evansville Courier & Press

REQUEST FOR PROPOSALS

Vectren Energy Delivery (Vectren), a subsidiary of CenterPoint Energy, is issuing this

All-Source

Request for Proposals (RFP) targeting

10 to 700 MW

of capacity and unit-contingent energy to meet the needs of its customers.

Bids are due by Wednesday, July 31, 2019. The RFP documents, schedule, and other RFP information can be found at: http://VectrenRFP.rfpmanager.biz/

Vectren has retained Burns & McDonnell to act as its agent in managing the RFP process. All RFP inquiries and communications are to be made via e-mail: VectrenRFP@burnsmcd.com

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BURNS McDONNELL

WEBSITE: HTTP://VECTRENRFP.RFPMANAGER.BIZ/

VECTREN
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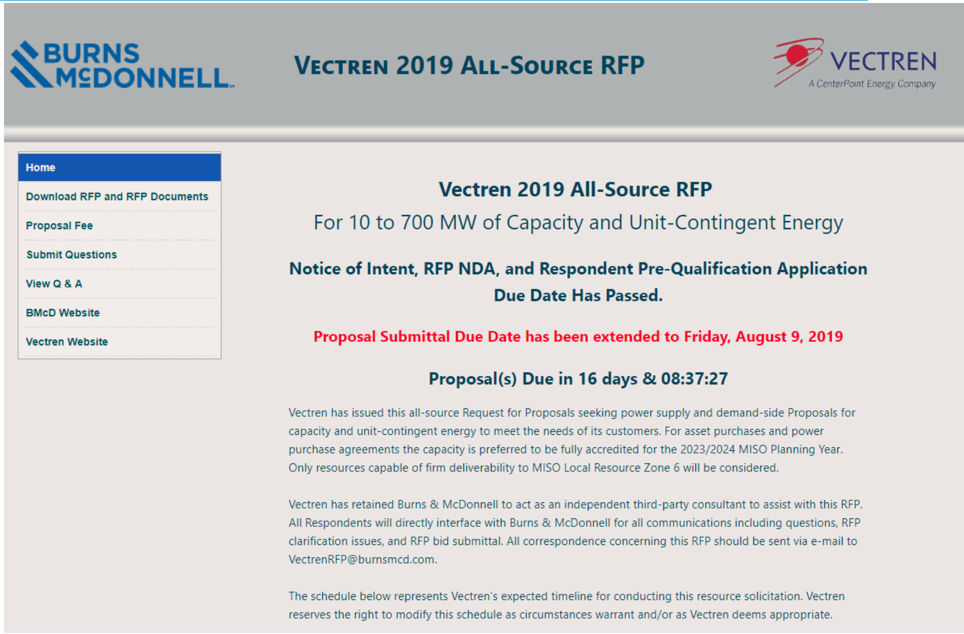
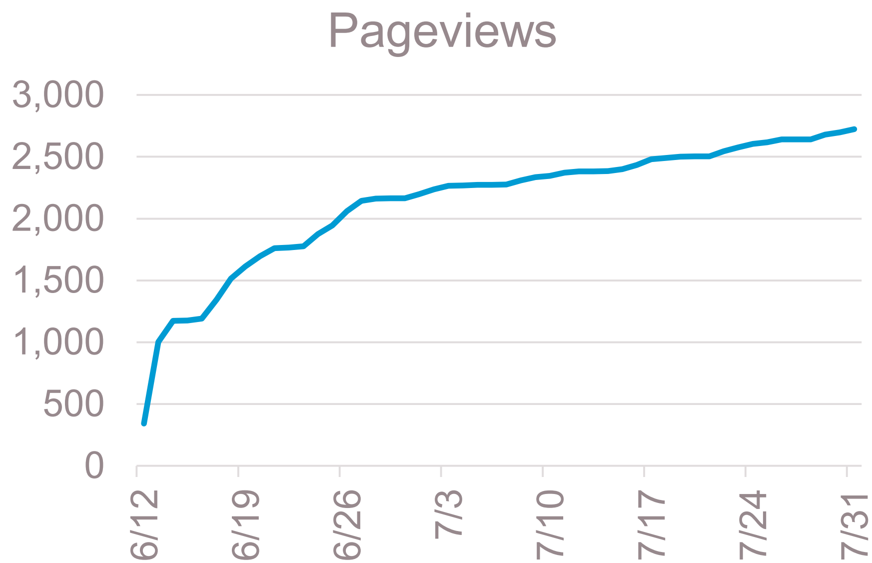
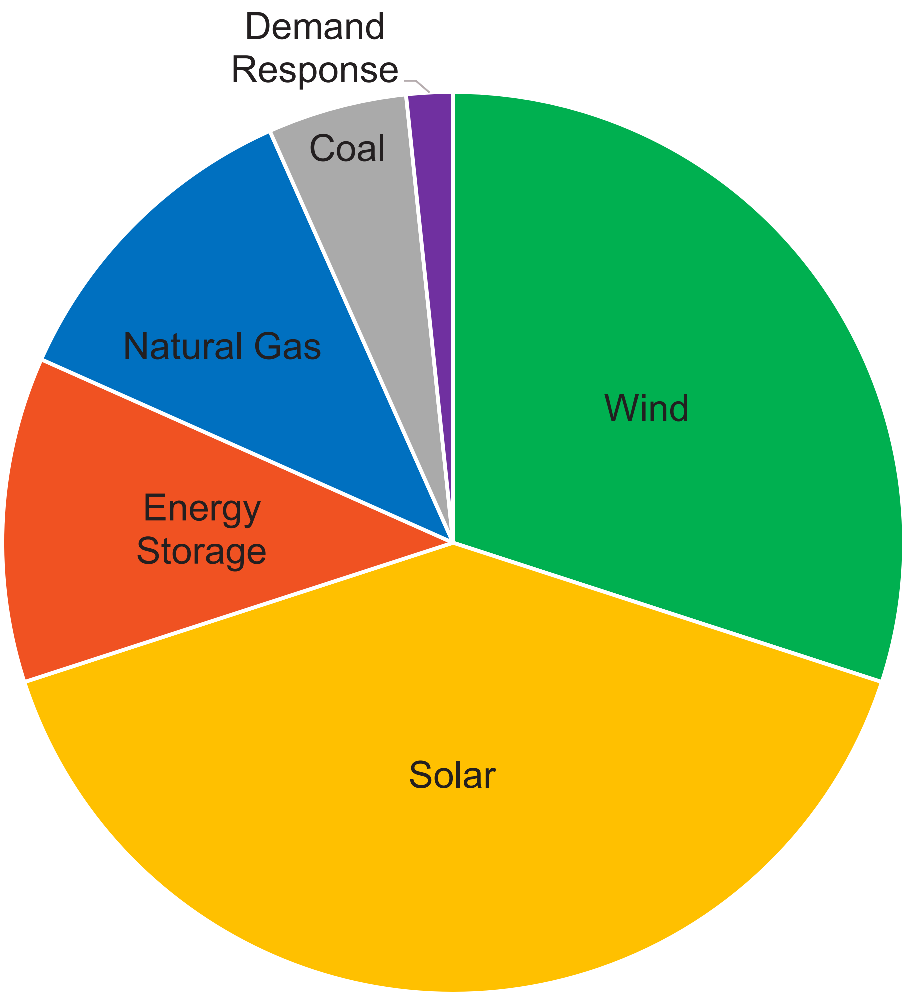
- RFP document downloads
  - 142 unique people
  - 107 companies
- Website visits (June 12th-July 31st)
  - ~800 users
  - ~3,000 pageviews
- Question & Answers posted





ALL-SOURCE RFP PARTICIPATION

- 32 companies submitted Notice of Intent (NOI)



TYPES OF RESOURCES CONSIDERED

- Open, non-limiting All-Source RFP
  - Asset purchase or power purchase agreement (PPA)
    - Existing or planned dispatchable generation
    - Existing or planned utility scale renewable resources
    - Existing or planned utility scale storage facilities, either stand-alone or paired with renewables
  - Load modifying resource (LMR)/Demand Resource (DR)
    - In Local Resource Zone 6 (LRZ6)
    - Proposals outside of Vectren's service territory are only eligible for capacity

PROPOSAL REQUIREMENTS

VECTREN
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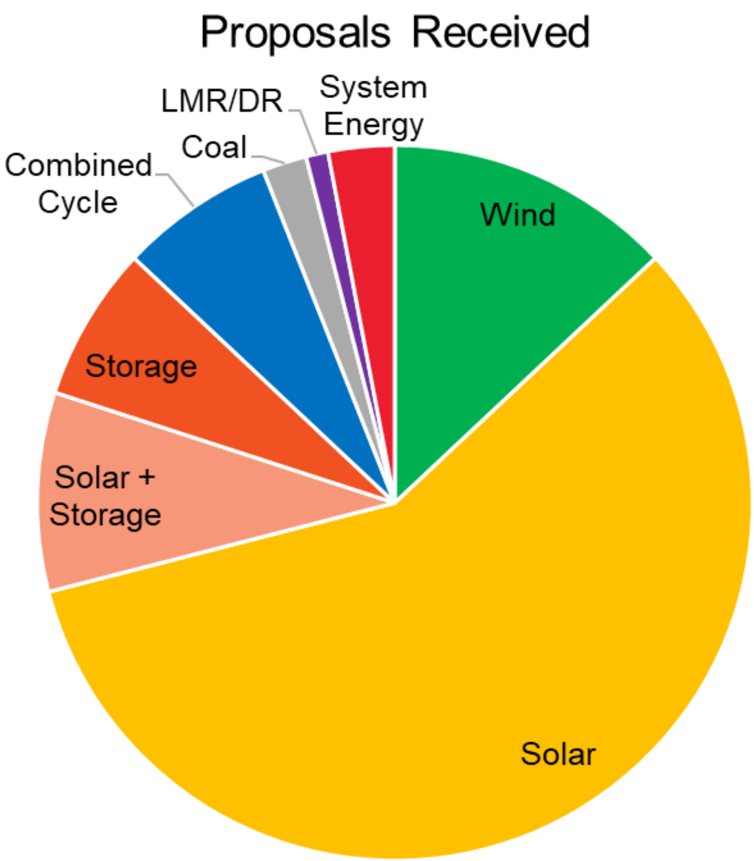
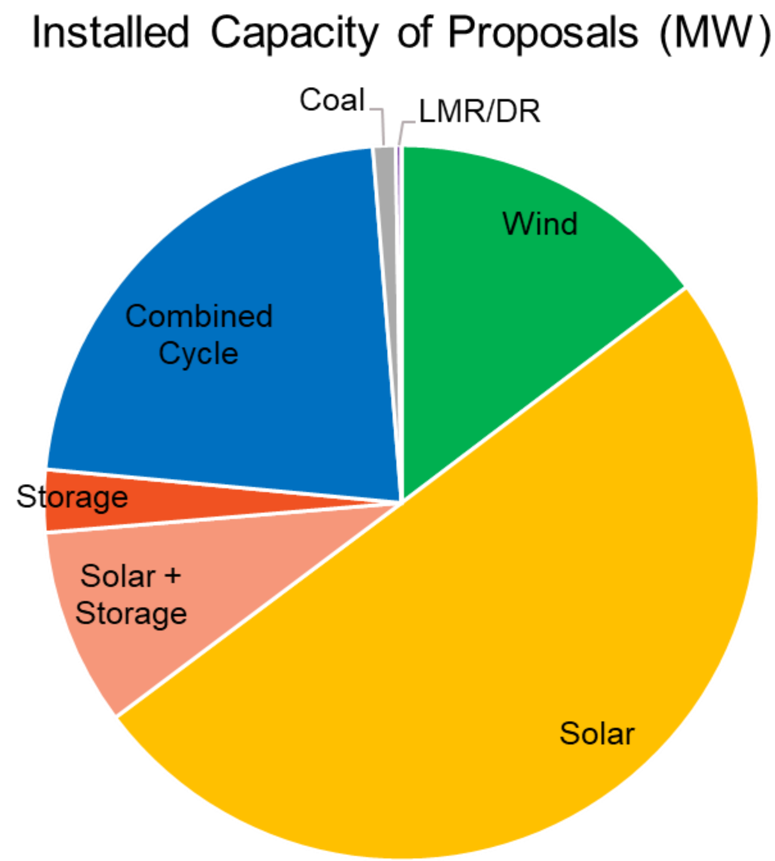
- MISO accredited or accreditable capacity (including Zonal Resource Credits) of no less than 10 MW to MISO LRZ 6
- Submittal forms (NOI, NDA, Pre-Qualification Application)
- 1-year pricing guarantee (from Proposal Submittal Due Date)
- Credit worthy bidders
- Respondent information and experience
- Facility information (Appendix D)
- Remaining life of at least 5 years from acquisition date for asset purchase

PRELIMINARY* RFP STATISTICS

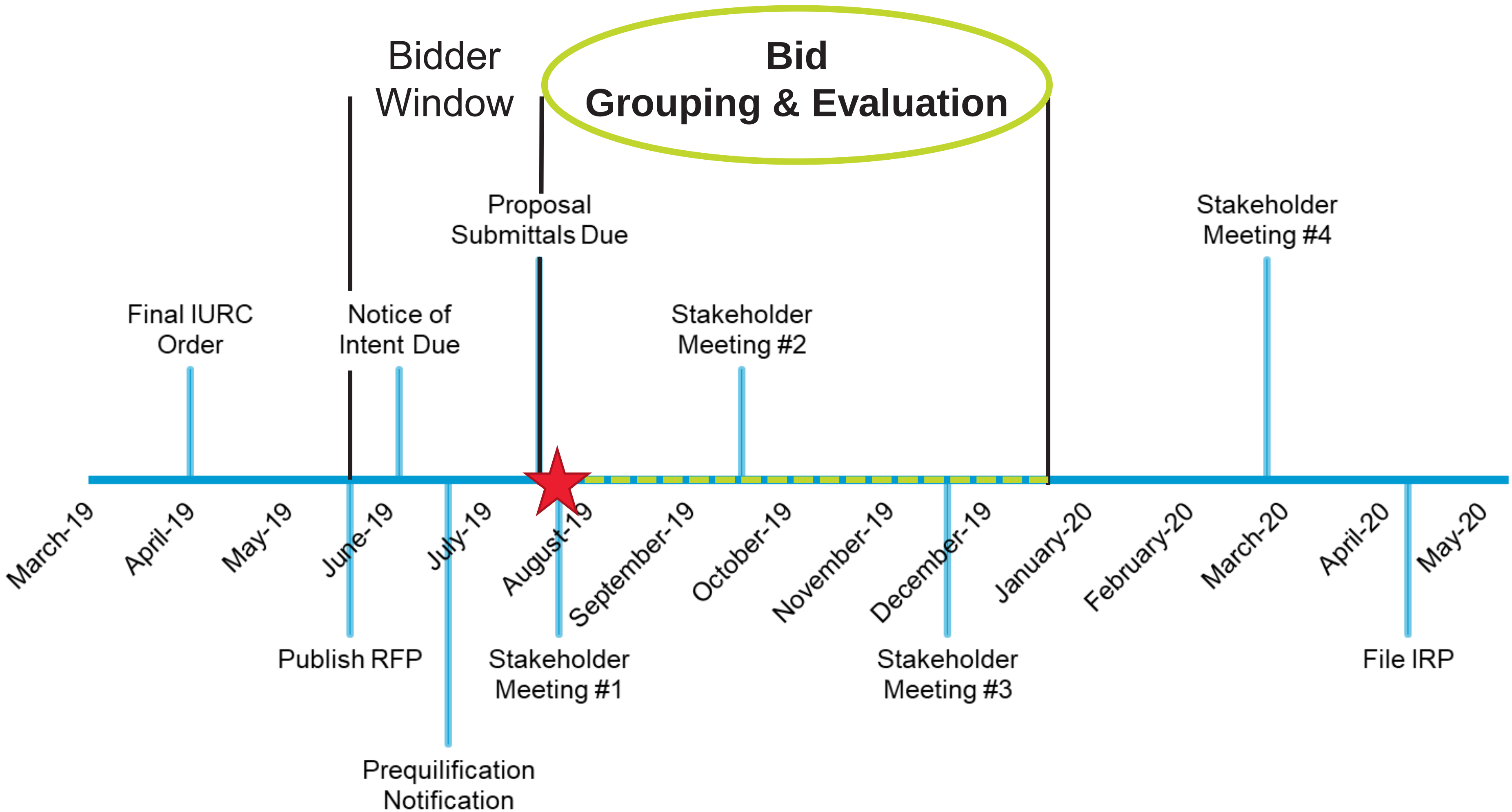
- 100 Proposals from 22 Respondents (4/5 in Indiana, 2/3 are PPA)





*Proposals received 4 business days ago. Follow-up and clarification process with respondents is ongoing.

TIMELINE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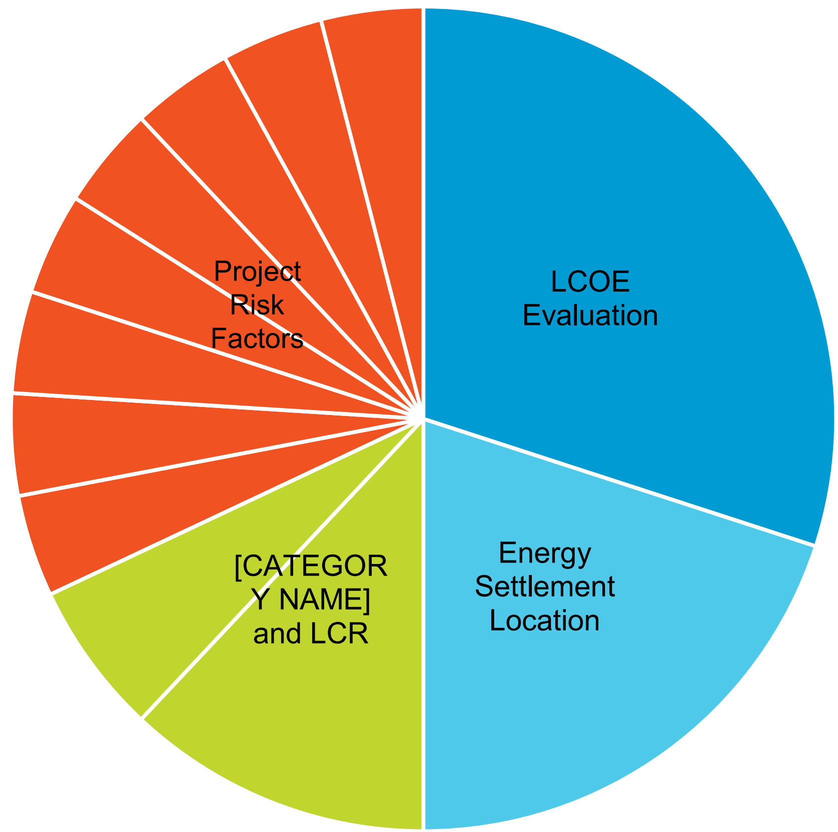
PROPOSAL EVALUATION

- Proposals will be grouped with similar proposals and scored relative to other bids within the same grouping
  - The preferred resource mix will be identified by the IRP analysis
  - All-Source RFP evaluation will rank order available resources within each grouping

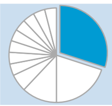
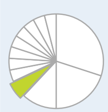
Rank	Illustrative Resource Groupings						
	Solar	Wind	Storage	Coal	Gas	Demand Response	etc.
1							
2							
3							
4							
5							
6							
7							
8							

500 Total Points*

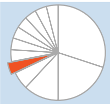
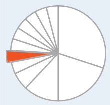
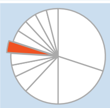
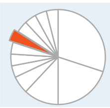
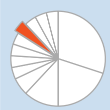
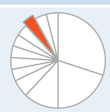
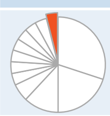


*Vectren reserves the right to add up to 100 points to Proposals located in Southern Indiana (generally defined as the following counties within Vectren's service territory; Dubois, Gibson, Pike, Posey, Spencer, Vanderburgh, and Warrick), as local resources provide multiple benefits: VAR support, economic development, less future congestion risk, etc.

EVALUATION SUMMARY

Scoring Criteria Name	Points		Scoring Method	Definition	Importance
LCOE Evaluation	150		Curve	$/MWh calculation within asset class	An LCOE evaluation comparing similar resource groups will help to show which Project(s) may provide lower cost energy to Vectren's customers.
Energy Settlement Location	100		Binary	Proposals that include all costs to have energy financially settled or directly delivered to Vectren's load node (SIGE.SIGW)	Having financial settlement or direct delivery to Vectren's load node provides Project's true resource cost to Vectren's customers, eliminating risks/costs associated with the delivery of energy.
Interconnection and Development Status	60		Binary	Executed a pro-forma MISO Service Agreement and Interconnection Construction Services Agreement (12 points) Completed a MISO Facilities Study (12 points) Completed a MISO System Impact Study (12 points) Achieved site control and completed zoning requirements (12 points) EPC Contract awarded (12 points)	These points are for completion of various critical milestones in the interconnection and development process. Projects which are further through the interconnection and development process will receive more points as cost certainty improves.
Local Clearing Area Requirement	30		Binary	Physically and electrically located in LRZ 6	Being located in LRZ 6 provides greater certainty that asset capacity can be deliverable to Vectren and fall within LCR requirements through entire life or contract term.

EVALUATION SUMMARY

Scoring Criteria Name	Points		Scoring Method	Definition	Importance
Credit and Financial Plan	20		Curve	Vectren will be reviewing the credit rating and financing capabilities in relation to a Bidder's Project	Projects which lack the financial wherewithal to ensure development pose a significant risk to Vectren and their customers.
Development Experience	20		Curve	Scored based on 1,500 MW of relevant development experience	Relevant technology experience is important when looking at asset purchases or PPA's for facilities which are not in service. A Bidder's track record of project completion is a benefit to the Project's scoring.
Sole Ownership/ Partial Owner	20		Binary	Being a sole owner would allow full site and dispatch rights/preferences	Being able to solely own, operate, and maintain a Project lowers risks for Vectren and their customers.
Ownership Structure (Purchase/PPA)	20		Binary	Vectren has a preference for ownership	Owning an asset and having control with regards to dispatch, maintenance, and operation of the facility lowers risks for Vectren and their customers.
Operational Control	20		Binary	Dispatch parameters used for the scheduling of energy into MISO and approval for maintenance outage periods	Operational control provides the ability to make prudent operational decisions when it makes economic sense for Vectren's customers.
Fuel Risk	20		Binary	Sites having firm and reliable fuel supply	Having fuel restrictions or a lack of reliable fuel could effect the operation of the Project and be a risk to the owner/off taker.
Delivery Date	20		Curve	For each year prior or after MISO PY 2023/2024, 25% of the points will be deducted	To the extent resources are brought on-line before potential Vectren unit retirements, Vectren customers could pay for duplicative capacity and/or energy; while there may be reasons to proceed with such projects, in recognition of their incremental costs, it is appropriate for such projects to not score as well in terms of timing.
Site Control	20		Binary	Proper rights to the site in which the facility will be located	Without proper permitting and permissions from the owner, there is a risk that the project may not move forward or could experience significant delays.

LMR/DR - PROPOSAL EVALUATION

- Proposals will be grouped with similar proposals and scored relative to other bids within the same grouping
  - The preferred resource mix will be identified by the IRP analysis
  - All-Source RFP evaluation will rank order available resources within each grouping

Rank	Illustrative Resource Groupings						
1	Solar	Wind	Storage	Coal	Gas	Demand Response	etc.
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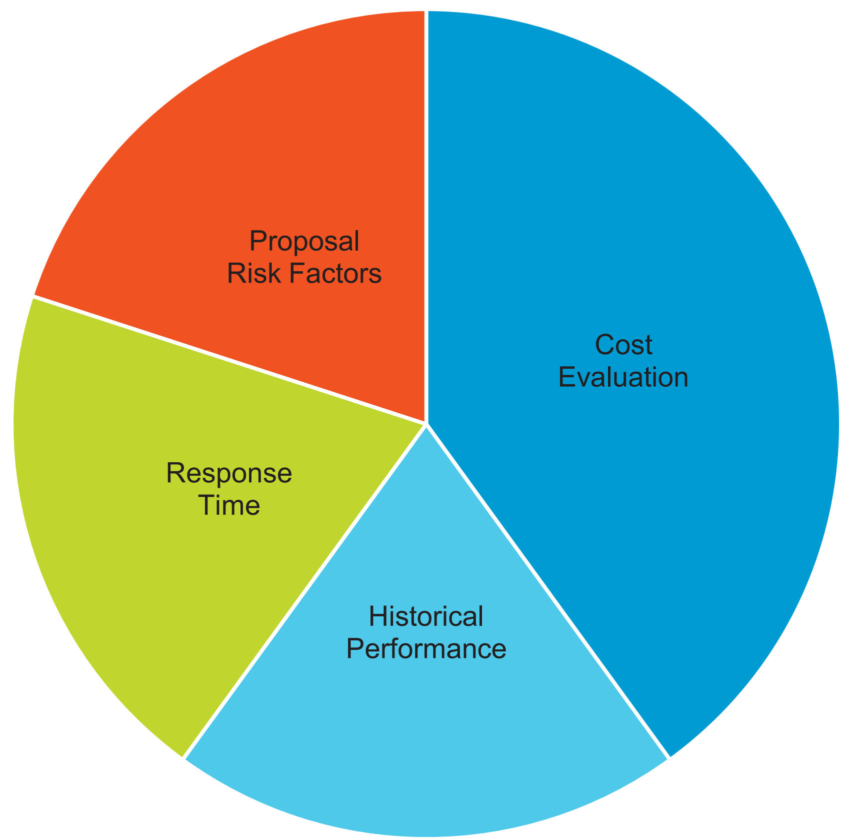
500 Total Points*



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LMR/DR - EVALUATION SUMMARY

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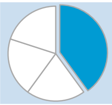
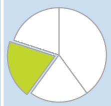
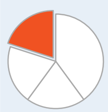
Scoring Criteria Name	Points		Scoring Method	Definition	Importance
Cost Evaluation	200		Curve	$/MW calculation to determine scoring based on rank order	The cost of the Project will have the most impact on Vectren's ability to provide low cost energy to its customers.
Historical Performance	100		Range	Scored based on the length of time the Project has provided demand response services without receiving a non-performance penalty	Historical data can show a track record of performance which can be a benefit to the Project's scoring.
Response Time	100		Range	Scored based on the time it takes the LMR/DR to reach load reduction target after receiving notification	Fast response time allows the LMR/DR to take advantage of specific control signals
Proposal Risk Factors	100		Binary	Scored based on the amount of material risk identified	Risk factors may cause concern for the reliability or cost of delivery. Risks associated with a specific Proposal will be considered during the evaluation process.

FEEDBACK AND DISCUSSION

VECTREN
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ENVIRONMENTAL COMPLIANCE UPDATE

ANGILA RETHERFORD

VICE-PRESIDENT ENVIRONMENTAL AFFAIRS AND CORPORATE RESPONSIBILITY

REVIEW ENVIRONMENTAL CONTROLS

Unit	In Service Date	Installed Generating Capacity	SO_2 Control	NO_x Control	Soot Control	Hg Control	H_2SO_4 Control
Culley 2*	1966	90 MW	Scrubber (1995)	Low NO_x (1995)	ESP (1972)	Organosulfide Injection (2015)	
Culley 3	1973	270 MW	Scrubber (1995)	SCR (2003)	Fabric Filter (2006)	Organosulfide Injection (2015)	Sorbent Injection System (2016)
Brown 1	1979	250 MW	Scrubber (1979)	SCR (2005)	Fabric Filter (2004)	Organosulfide Injection (2015)	Sorbent Injection System (2015)
Brown 2	1986	250 MW	Scrubber (1986)	SCR (2004)	ESP (1986)	Organosulfide Injection (2015)	Sorbent Injection System (2016)
Warrick 4	1970	150 MW	Scrubber (2009)	SCR (2004)	ESP (1970)	Organosulfide Injection	Lime Injection

COAL COMBUSTION RESIDUALS RULE

- Final Rule issued April 2015
- Allows continued beneficial reuse of coal combustion residuals
  - Majority of Vectren's fly ash beneficially reused in cement application
  - Scrubber by-product at Culley and Warrick beneficially reused in synthetic gypsum application
- Rule established operating criteria and assessments as well as closure and post-closure care standards
- Groundwater monitoring requirements are underway
- "Phase 1, Part 1" rule was published on July 30, 2018
  - Requires closure of surface impoundments effective October 2020 for impoundments that fail uppermost aquifer location restriction or groundwater protection standard

COAL COMBUSTION RESIDUALS RULE

- D.C. Circuit Court decision on August 2018 declared all unlined impoundments an unacceptable risk under CERCLA
  - IDEM interprets D.C. Circuit Court as requiring enhanced focus on mitigating and/or eliminating horizontal infiltration of groundwater through impounded ash
- Evaluating closure-by-removal for Culley East Ash Pond and planning for a closure-by-removal with beneficial reuse for Brown Ash Pond
- Timing for commencement of closure activities based upon results of groundwater monitoring, alternative disposal capacity, and construction of new impoundment or other water storage and treatment system
- Same closure strategy assumed under all scenarios

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EFFLUENT LIMITATION GUIDELINES

- On September 30, 2015, the EPA finalized its new Effluent Limitation Guidelines (ELGs) for power plant wastewaters, including ash handling and scrubber wastewaters
- The ELGs prohibit discharge of water used to handle fly ash and bottom ash, thereby mandating dry handling of fly ash and bottom ash
  - Vectren has previously converted its generating units to dry fly ash handling, however we currently anticipate additional modifications to the existing dry fly ash handling system at Brown to comply with the ELGs
- ELG Postponement Rule published September 2017
  - Delayed initial compliance deadline for Bottom Ash Transport Water by two years, to November 2020
  - Compliance deadline for Fly Ash Transport Water remains November 2018, however the rule provides that utilities can seek an alternative compliance schedule through the water discharge permit renewal process

EFFLUENT LIMITATION GUIDELINES CONT.

- The ELG rules provide an alternative compliance date of December 2023 for generating units that agree to a more stringent set of discharge limits, which could include retirement
- While we continue to work on engineering solutions to reduce potential compliance costs, the following technologies are in process or being evaluated for ELG compliance for Vectren plants:
  - Culley
    - Includes dry bottom ash conversion, scrubber wastewater treatment and ash landfill construction
    - Converting to dry bottom ash Fall 2020
    - FGD Wastewater conversion to Zero Liquid Discharge (ZLD) estimated late 2022
  - Brown
    - Includes dry fly ash system upgrades, dry bottom ash conversion, an ash landfill and a new lined process pond or tank system
    - The existing Brown scrubbers are closed loop, and are not required to meet ELG wastewater discharge limits for scrubber wastewater discharges; Any new scrubber retrofits would be required to comply with applicable scrubber wastewater discharges

CLEAN WATER ACT 316B

- In May 2014 EPA finalized its Clean Water Act §316(b) rule which requires that power plants use the best technology available to prevent and/or mitigate adverse environmental impacts to fish and aquatic species
- The final rule did not mandate cooling water tower retrofits
- The Brown plant currently uses closed loop technology
- Vectren submitted the multi-year studies for F.B. Culley as required under the rule and the NPDES permit
- For purposes of IRP modeling, Vectren has assumed intake screen modifications for the Culley plant and assumed a 2024 deadline for compliance

AFFORDABLE CLEAN ENERGY (ACE) RULE

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- Rule finalized in June 2019. Repealed & replaced the Clean Power Plan (CPP)
- Rule establishes standards for states to use when developing plans to limit CO_2 at coal-fired power plants
- Establishes heat rate improvement, or efficiency improvement, targets as the best system of emissions reductions for CO_2
  - These heat rate targets to be set on a unit by unit basis; Averaging not allowed
  - Vectren currently reviewing technology alternatives available for each unit
- State Implementation Plans are due September 2022 with compliance planned to begin within 24 months of submission
- For purposes of base case assumptions, Vectren assumed that ACE will be upheld upon judicial review

FEEDBACK AND DISCUSSION

DRAFT BASE CASE MARKET INPUTS AND SCENARIOS WORKSHOP

GARY VICINUS

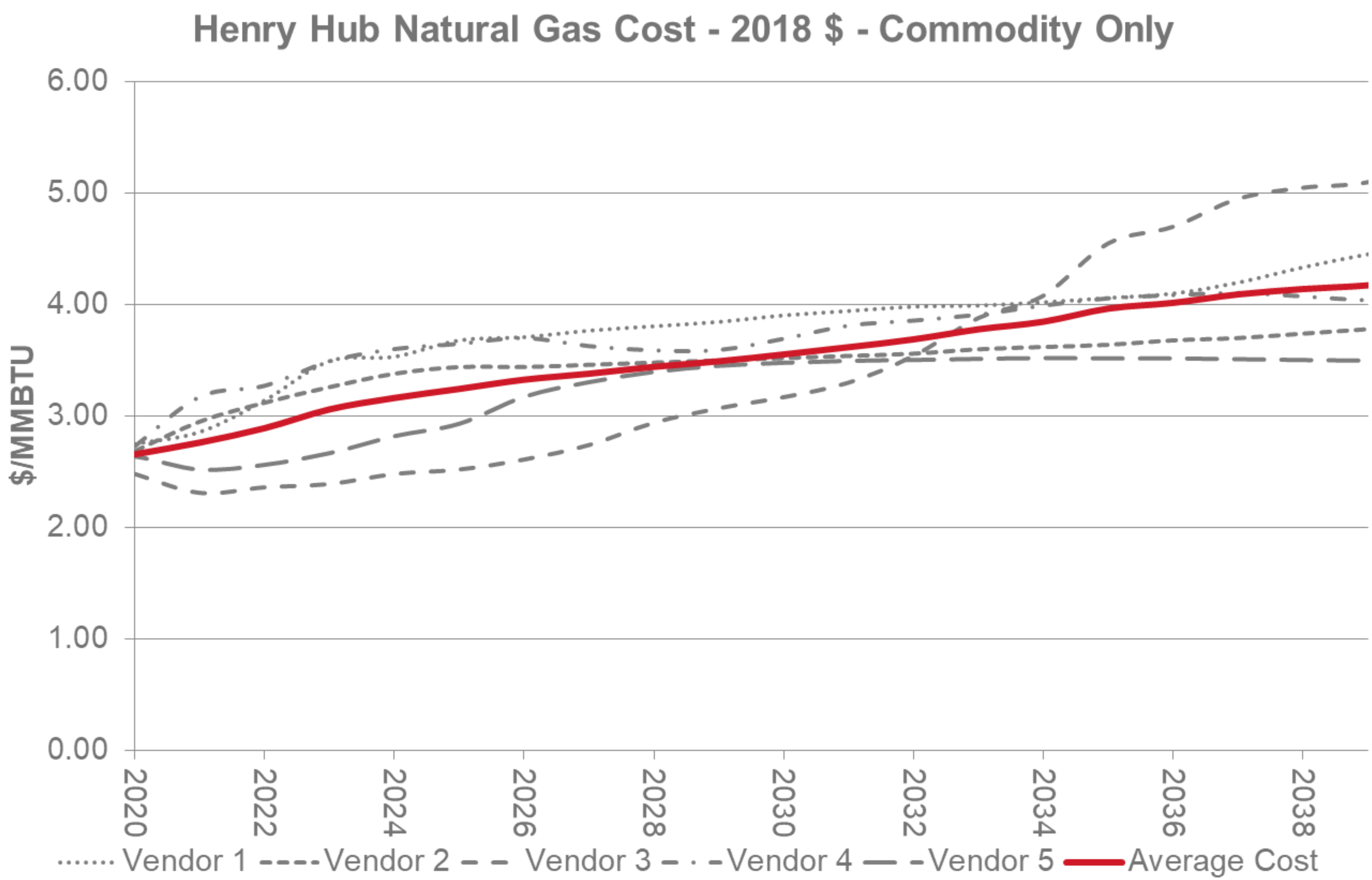
MANAGING DIRECTOR FOR UTILITIES, PACE GLOBAL

BASE CASE INPUTS

Vectren surveyed and incorporated a wide array of sources in developing its base case assumptions, which reflect a current consensus view of key drivers in power and fuel markets

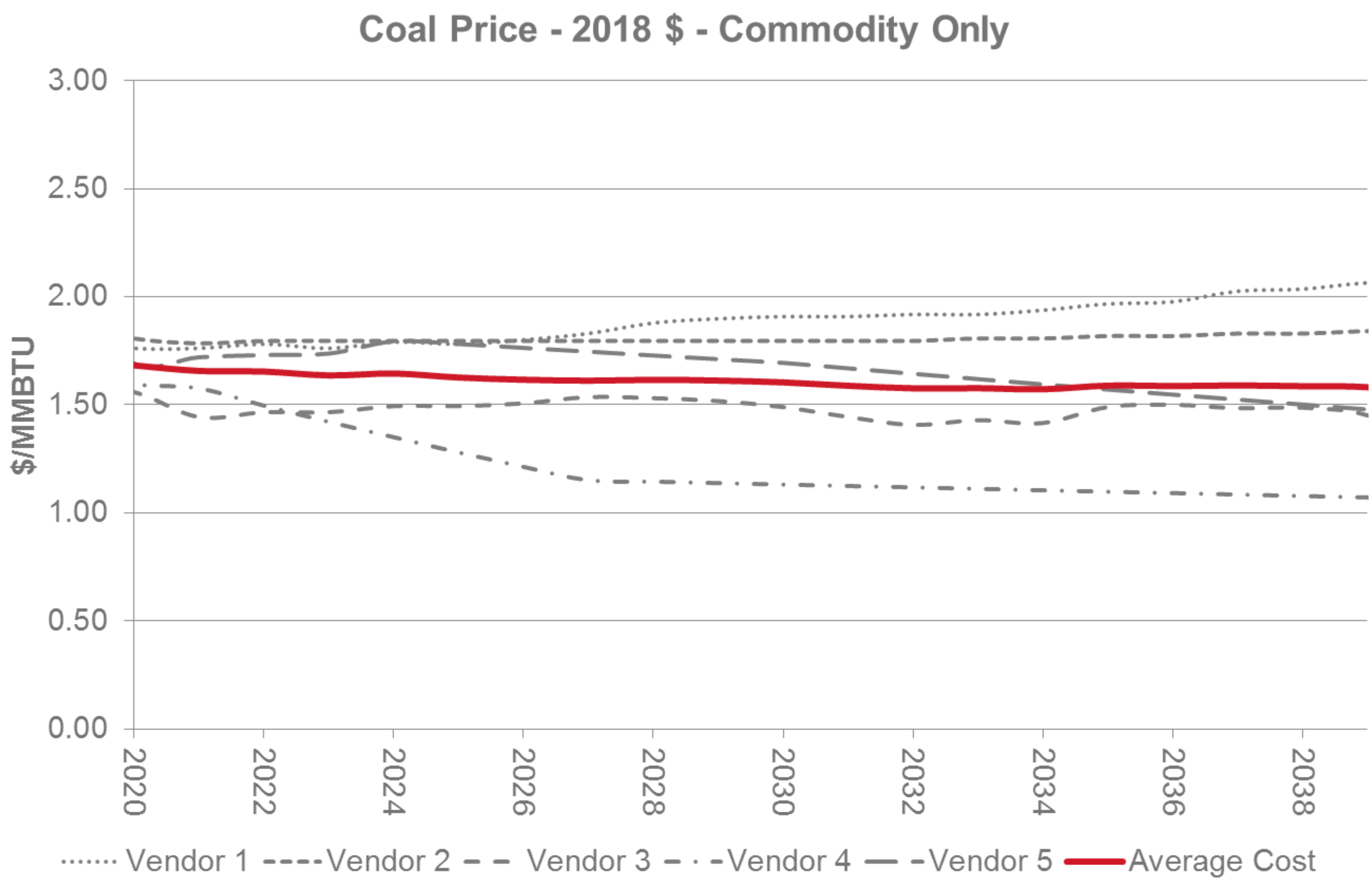
- Base case assumptions include forecasts of the following key drivers:
  - Vectren and MISO energy and demand (load)
  - Henry Hub and delivered natural gas prices
  - Illinois Basin minemouth and delivered coal prices
  - Capital costs for various generation technologies
- On- and off-peak power prices are an output of scenario assumptions
- Vectren uses a consensus base case view, by averaging forecasts from several sources where applicable

BASE CASE CONSENSUS FUEL FORECASTS



Note: Vendors used were PIRA, Wood Mackenzie, Pace, ABB, & EVA

BASE CASE CONSENSUS FUEL FORECASTS



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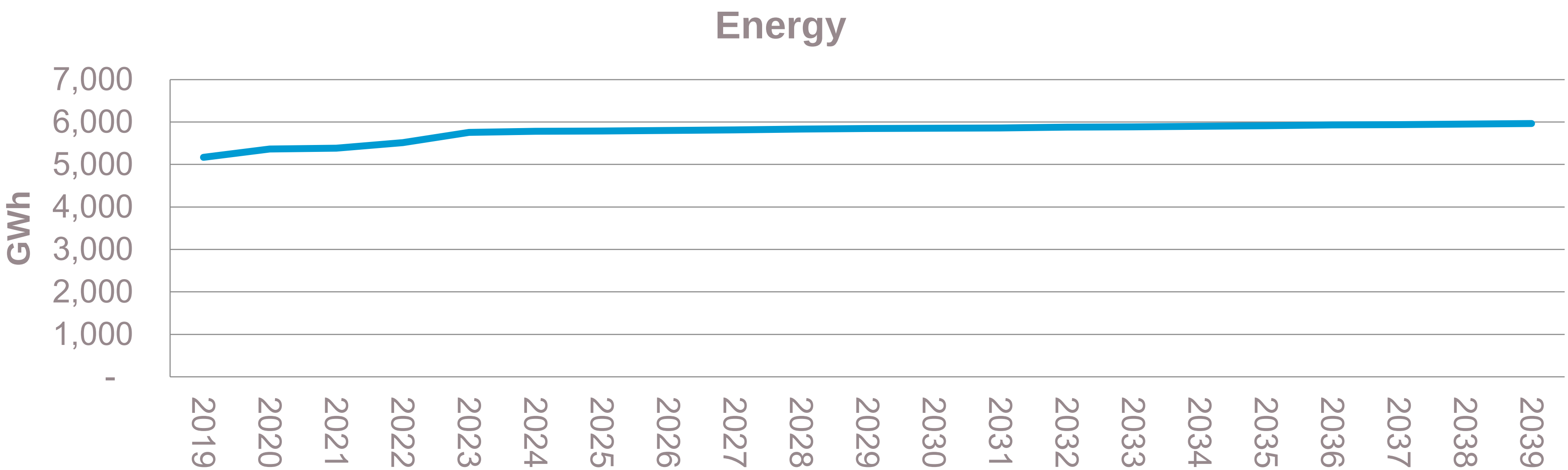
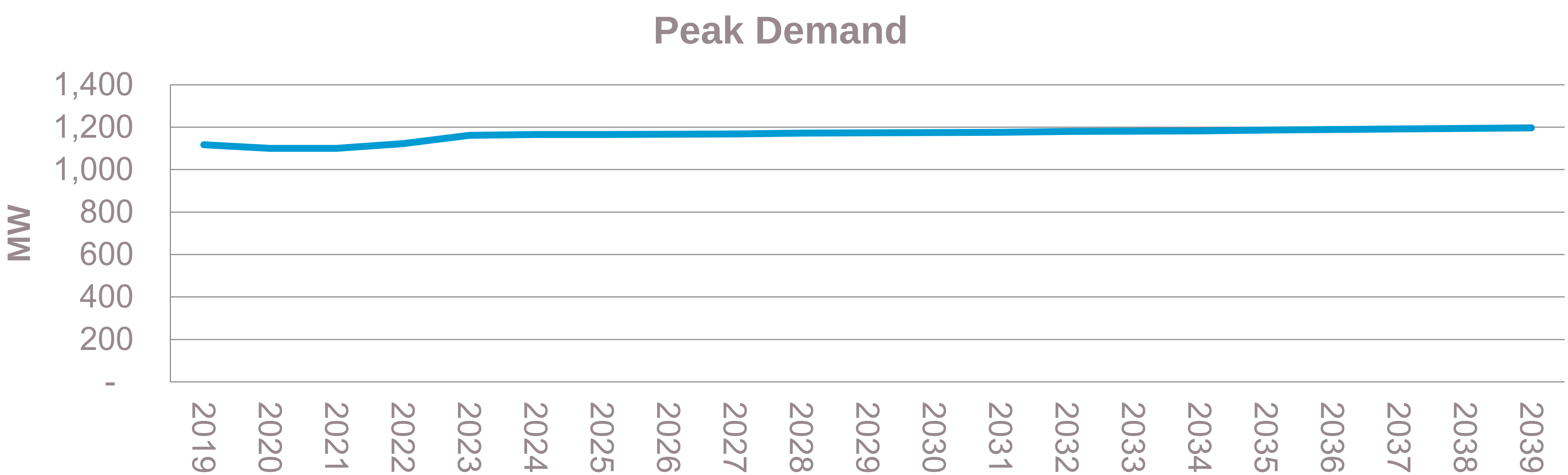
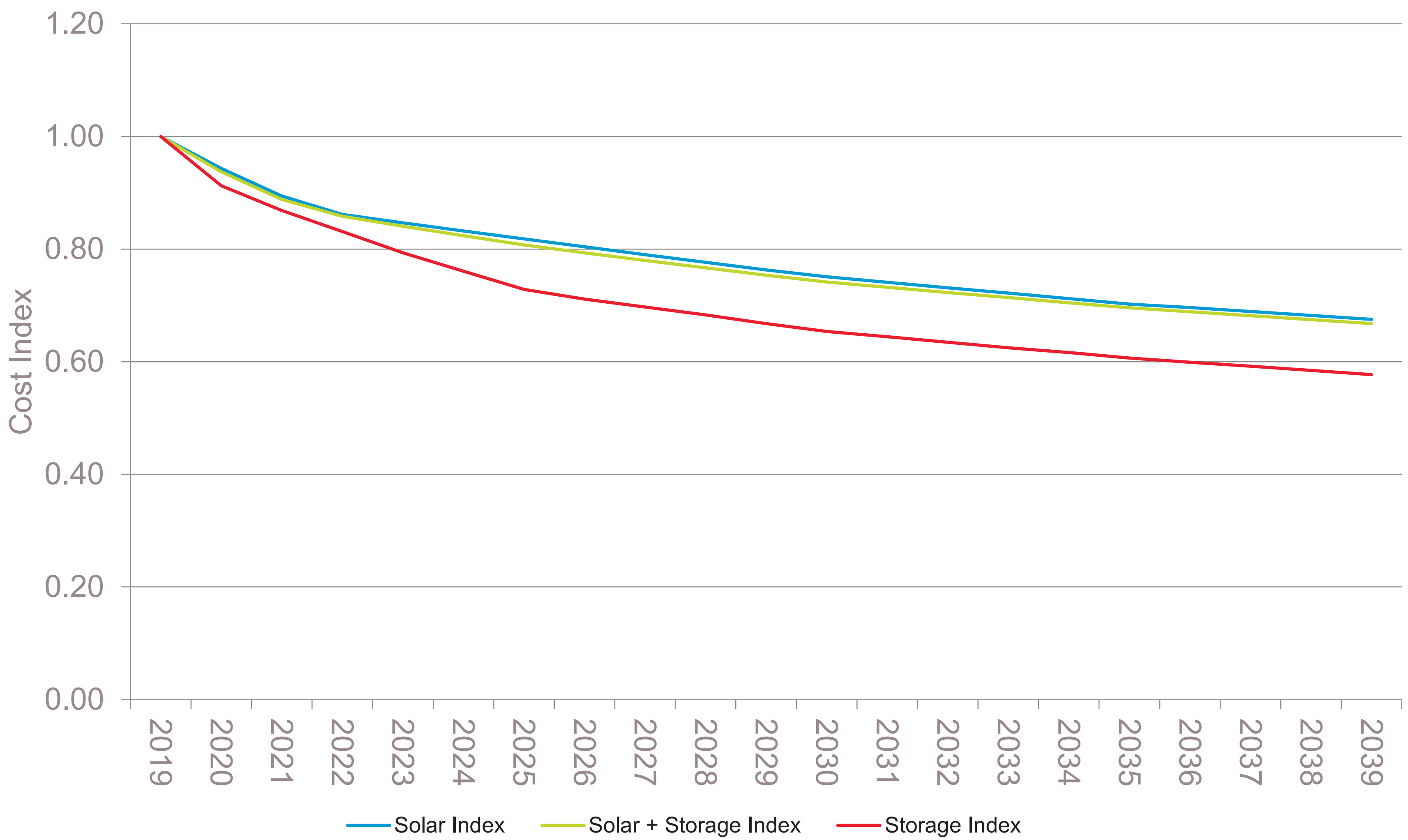
BASE CASE LOAD (PRELIMINARY – FORECAST IS CURRENTLY BEING UPDATED)





BASE CASE RENEWABLES AND STORAGE LONG TERM COST CURVES



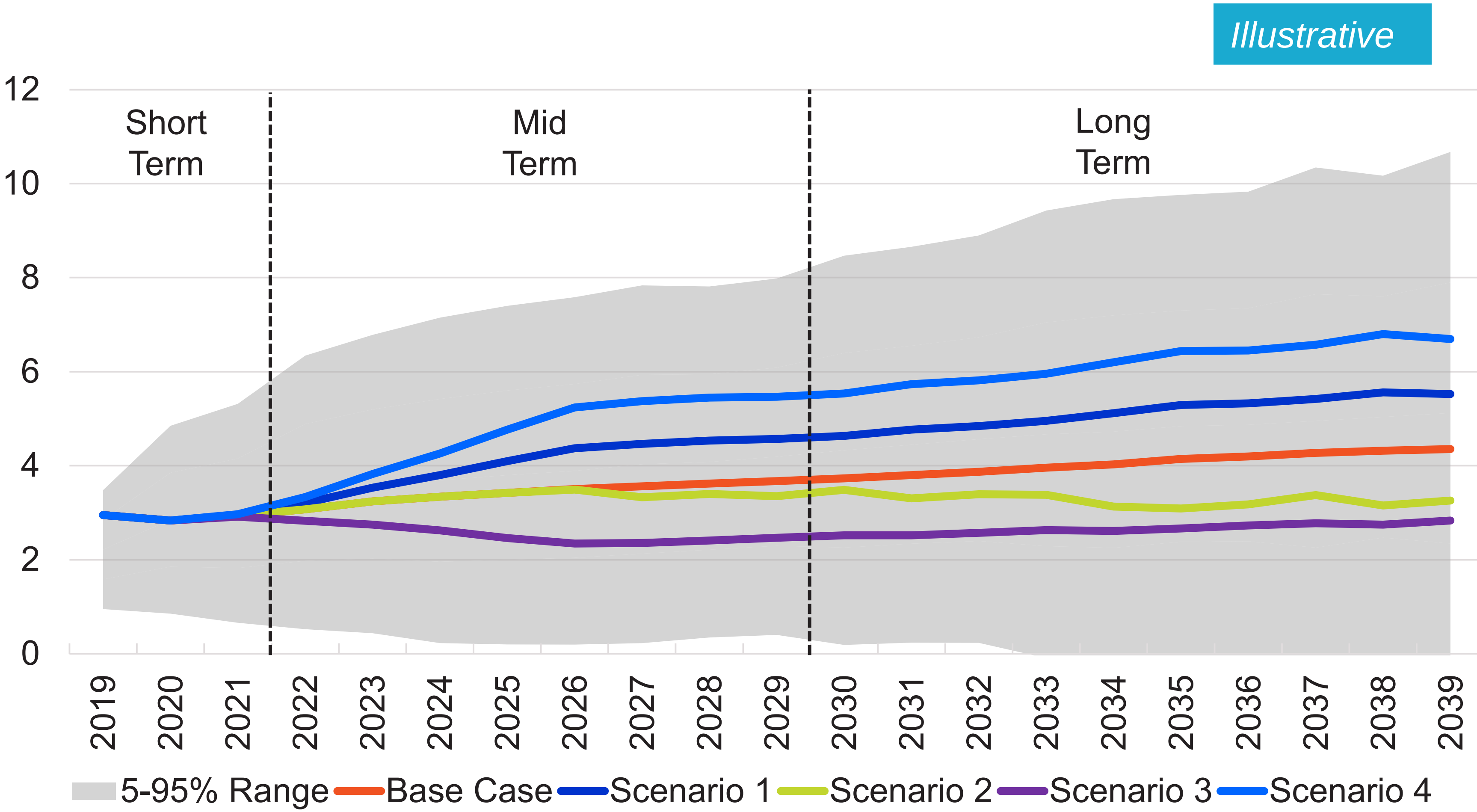
SCENARIO DEVELOPMENT

Vectren worked with Pace to develop a base case and four alternative, internally consistent scenarios (potential futures), to test which portfolios are optimal over a wide range of future market and regulatory conditions.

- Subjecting portfolios to a range of deterministic scenarios can test portfolio performance in key risk areas important to management and stakeholders alike
- Portfolios would still be run through a stochastic risk analysis to measure performance across a large number of future scenarios
- Scenarios include a low regulatory case, a high technology case, an 80% CO_2 reduction by 2050 case, and high regulatory case. Each is described in the following pages with narratives of the major drivers that characterize the scenario
- The framework was developed to ensure internal consistency with the scenario by first developing directional changes for each variable (load, gas prices, coal prices, carbon prices, and capital costs) relative to the base case forecast in the near, mid and long term

CenterPoint Energy
Cause No. 45501
Petitioner's Exhibit 4
MAR WP1 (Public)

RANGE OF BOUNDARY CONDITIONS



DRAFT SCENARIOS

Vectren will utilize scenario based modeling to evaluate various regulatory constructs. The base case is considered the most likely future. The alternative scenarios are shown as higher than, lower than, or the same as the base case.

Increasing Regulation

	CO2	Gas Reg.	Water Reg.	Economy	Load	Gas Price	Coal Price	Renewables and Storage Cost	EE Cost
Base Case	ACE		ELG	Base	Base	Base	Base	Base	Base
Low Reg.	ACE Delay**		ELG Light*	Higher	Higher	Higher	Base	Base	Base
High Tech	Low CO2 Tax		ELG	Higher	Higher	Lower	Lower	Lower	Lower
80% CO2 Reduction by 2050	Cap and Trade	Methane	ELG	Lower	Lower	Base	Lower	Higher	Higher
High Reg.	High CO2 Tax	Fracking Ban	ELG	Lower	Lower	Higher	Lower	Higher	Higher

*No bottom ash conversion required based on size of the unit and delay requirement for 2 years
**ACE Delayed for 3 years

SCENARIO NARRATIVES

VECTREN
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Base Case

- The base case is the “most likely” case, built with commodity forecasts based on industry expert averages
- Load forecast is being developed by Itron and will be submitted to MISO this fall
- The ACE (Affordable Clean Energy) rule, which was finalized as the replacement of the Clean Power Plan, has been promulgated and is included in the base case
- All other scenarios reference the base case (individual uncertainties are at the same levels or are higher or lower than the base case)
- In the base case:
  - Coal prices remain relatively flat over the 20 year forecast horizon in constant dollars
  - Natural gas prices move upward in real dollars to 2039
  - Energy and Demand increase moderately through 2039
  - Capital costs generally decline slightly for fossil resources and decline more for wind and approximately 35% or more for solar and storage resources

SCENARIO NARRATIVES

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Low Regulatory

- In the low regulatory scenario, there is a delay of the ACE rule for three years due to legal challenges, but ultimately remains in place. Indiana implements a lenient interpretation of the rule. ELG is partially repealed with bottom ash conversations not required for some smaller units and is delayed for two years (this does not apply to FB Culley 3)
- Fewer regulations lead to a better economy and higher load
- Gas prices edge up slightly with increased demand
- Coal prices continue to remain at base levels as demand for coal continues to decline nationally due to investor pressure and demand for cleaner alternatives
- Technology costs continue to decline at base case levels
- EE costs net to the base level. There is downward pressure with fewer codes and standards being implemented, leaving some low hanging fruit, but upward pressure with increasing load, netting to no change from the base level

SCENARIO NARRATIVES

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High Technology

- This scenario assumes that technology costs decline faster than in the base case, allowing renewables and battery storage to be more competitive
- A low CO_2 tax is implemented. The economic outlook is better than in the base case as lower technology costs and lower energy prices offset the impact of the CO_2 tax
- Increased demand for natural gas is more than met with advances in key technologies that unlock more shale gas, increasing supply and lowering gas prices relative to the base case
- Less demand for coal results in lower prices relative to the base case
- Utility-sponsored energy efficiency costs rise early in the forecast but ultimately fall back to below base levels due to technology advances, allowing for new and innovative ways to partner with customers to save energy
- As technology costs fall, customers begin to move towards electrification, driving more electric vehicles and higher adoption of rooftop solar/energy storage and trend towards highly efficient electric heat pumps in new homes

SCENARIO NARRATIVES

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80% CO_2 Reduction by 2050 (aka 2 degrees scenario)

- This scenario assumes a carbon regulation mandating 80% reduction of CO_2 from 2005 levels by 2050 is implemented. A glide path would be set using a cap and trade system similar to the CPP, gradually ratcheting down CO_2 emissions and driving CO_2 allowance costs up
- Load decreases as the costs for energy and backup power increase and as the energy mix transitions
- In this scenario, regulations on methane emissions initially drive up gas prices, but are partially offset by increased supply. The price of natural gas is slightly higher in the mid term, then decreases back to base levels by the end of the forecast
- There is less demand for coal, driving prices lower than the base case; however, some large and efficient coal plants remain as large fleets are able to comply with the regulation on a fleet wide basis
- Renewables and battery storage technology are widely implemented to help meet the mandated CO_2 reductions, increasing prices relative to the base case
- Market based solutions are implemented to lower CO_2. Innovation occurs, but is offset by more codes and standards with no incentives, energy efficiency costs rise as a result

SCENARIO NARRATIVES

High Regulatory

- The social cost of carbon is implemented via a high CO_2 tax early in the scenario
- A fracking ban is imposed, driving up the cost of natural gas as supply dramatically shrinks
- Tighter regulations are implemented in all aspects coal production and use. As these costs are imposed, prices for coal decrease
- High regulation costs are a drag on the economy and load decreases relative to the base case
- As renewables and battery storage are widely implemented to avoid paying high CO_2 prices, prices are driven up
- Utility-sponsored energy efficiency costs are higher as more codes and standards are implemented, leaving less low hanging fruit

FEEDBACK AND DISCUSSION

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STAKEHOLDER PROCESS RECAP AND Q&A

STAKEHOLDER PROCESS RECAP

August 15, 2019	October 10, 2019	December 12, 2019	March 19, 2020
• 2019/2020 IRP Process • Objectives and Measures • All-Source RFP • Environmental Update • Draft Base Case Market Inputs & Scenarios	• All-Source RFP Update • Draft Tech Assessment Forecasts • Sales and Demand Forecast • DSM MPS/ Modeling Inputs • Scenario Modeling Inputs • Portfolio Development	• Draft Portfolios • Draft Base Case Modeling Results • All-Source RFP Results and Final Modeling Inputs • Probabilistic Modeling Approach and Assumptions	• Final Base Case Modeling • Probabilistic Modeling Results • Risk Analysis Results • Preview the Preferred Portfolio

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Q&A

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APPENDIX

DEFINITIONS

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Term	Definition
ACE	Affordable Clean Energy (ACE) Rule, establishes emission guidelines for states to develop plans to address greenhouse gas emissions from existing coal-fired power plants
All-Source RFP	Request for proposals, regardless of source (renewable, thermal, storage, demand response)
Aurora	Electric modeling forecasting and analysis software. Allows for model consistency in capacity expansion, chronological dispatch, and stochastic functions
Base Case	The most expected future scenario that is designed to include a current consensus view of key drivers in power and fuel markets
Baseload	The minimum level of demand on an electrical grid over a span of time
Cap and Trade	Emissions trading program aimed at reducing pollution
Capacity	The maximum output of electricity that a generator can produce under ideal conditions (megawatts)
CCGT	A combined-cycle power plant uses both a gas and a steam turbine together to produce up to 50 percent more electricity from the same fuel than a traditional simple-cycle plant. The waste heat from the gas turbine is routed to the nearby steam turbine, which generates extra power
CERCLA	The Comprehensive Environmental Response, Compensation, and Liability Act (Commonly known as Superfund)
CO2	Carbon dioxide
CPCN	A Certificate of Public Convenience and Necessity is required to be granted by the Commission for significant generation projects
CPP	Clean Power Plan
Deterministic Modeling	Simulated dispatch of a portfolio in a determined future. Often computer generated portfolios are created by optimizing on cost to the customer

DEFINITIONS CONT.

Term	Definition
DSM	Demand side management includes both Energy Efficiency and Demand Response programs to reduce customer demand for electricity
EE	Energy Efficiency
ELG	Effluent Limitation Guidelines are U.S. national standards for wastewater discharges to surface waters and publicly owned treatment works
Energy	Amount of electricity (megawatt-hours) produced over a specific time period
EPA	Environmental Protection Agency
GW	Giga watt (1,000 million watt), unit of electric power
Henry Hub	Point of interconnection of interstate and intrastate natural gas pipelines as well as other related infrastructure in Erath, Louisiana
Installed Capacity (ICAP)	Refers to generating capacity after ambient weather adjustments and before forced outages adjustments
Intermittent	An intermittent energy source is any source of energy that is not continuously available for conversion into electricity and outside direct control
IRP	Integrated Resource Plan is a comprehensive plan to meet customer load expectations
IURC	The Indiana Utility Regulatory Commission is the public utilities commission of the State of Indiana. The commission regulates electric, natural gas, telecommunications, steam, water and sewer utilities
LCOE	Levelized Cost of Energy, A measure that looks at cost and energy production over the life of an asset so different resources can be compared. Does not account for capacity value.

DEFINITIONS CONT.

Term	Definition
LMR	Load Modifying Resource
Local Clearing Requirement (LCR)	Capacity needs to be fulfilled by local resource zone
LRZ6	MISO Local Resource Zone 6
Mine Mouth	At the mine location
MISO	Midcontinent Independent System Operator, an Independent System Operator (ISO) and Regional Transmission Organization(RTO) providing open-access transmission service and monitoring the high-voltage transmission system in the Midwest United States and Manitoba, Canada and a southern United States region which includes much of Arkansas, Mississippi, and Louisiana. MISO also operates one of the world's largest real-time energy markets
MPS	Market potential study - Determines the total market size (value/volume) for a DSM at a give period of time
MW	Mega watt (million watt), unit of electric power
Name Plate Capacity	The intended full-load sustained output of a generation facility
NDA	Non-Disclosure Agreement
NOI	Notice of Intent

DEFINITIONS CONT.

Term	Definition
NPDES	National Pollutant Discharge Elimination System
OMS	Organization of MISO States, was established to represent the collective interests of state and local utility regulators in the Midcontinent Independent System Operator (MISO) region and facilitate informed and efficient participation in related issues.
Peaking	Power plants that generally run only when there is a high demand, known as peak demand, for electricity
Planning Reserve Margin Requirement	Total capacity obligation each load serving entity needs to meet
Portfolio	A group of resources to meet customer load
PPA	Purchase power agreement
Preferred Portfolio	The IRP rule requires that utilities select the portfolio that performs the best, with consideration for cost, risk, reliability, and sustainability
Probabilistic modeling	Simulate dispatch of portfolios for a number of randomly generated potential future states, capturing performance measures
RA (Resource Adequacy)	RA is a regulatory construct developed to ensure that there will be sufficient resources available to serve electric demand under all but the most extreme conditions
Resource	Supply side (generation) or demand side (Energy Efficiency, Demand Response, Load Shifting programs) to meet planning reserve margin requirements

DEFINITIONS CONT.

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Term	Definition
Scenario	Potential future State-of-the-World designed to test portfolio performance in key risk areas important to management and stakeholders alike
Sensitivity Analysis	Analysis to determine what risk factors portfolios are most sensitive to
Strategist	Strategic planning software application typically used for IRP analyses
Technology Assessment	An analysis that provides overnight and all-in costs and technical specifications for generation and storage resources
Unforced Capacity (UCAP)	A unit's generating capacity adjusted down for forced outage rates (thermal resources) or expected output during peak load (intermittent resources)
VAR Support	Unit by which reactive power is expressed in an AC electric power system
ZLD	Zero Liquid Discharge

Vectren 2019 IRP
1st Stakeholder Meeting Minutes Q&A
August 15, 2019, 9 am – 3 pm CDT

Lynnae Wilson (CenterPoint Energy Indiana Electric Chief Business Officer) – Welcome, Safety Message, Introduction to CenterPoint Energy/ Vectren, Personal background and Vectren team introductions, Updates and Goals for this 2019 IRP

> Subject matter experts in the room: Natalie Hedde, Angie Casbon-Scheller, Justin Joiner, Christine Keck, Bob Heidorn, Wayne Games, Matt Rice, Ryan Wilhelmus, Rina Harris, Nick Kessler, Laurie Thornton, Jason Stephenson, Cas Swiz, Steve Rawlinson, Tom Bailey, Roland Rosario.

Gary Vicinus (Moderator, Managing Director for Utilities, Pace Global) – General Introduction to this IRP Process, Introductions for approximately 40 stakeholders in the room, List of affiliations include:

Country Mark
Deaconess Health Systems
EQ Research
Hallador Energy/Sunrise Coal
IBEW Local 702
IURC
NIPSCO
Orion Renewable Energy Group LLC
OUCC
Sierra Club
SUFG
Tr-State Creation Care
Valley Watch
Whole Sun Designs Inc.

More than 30 stakeholders attended on the phone. Those registered included representatives from:

Advanced Energy Economy
AECOM
AEMA
AEP
Applied Economics Clinic
Boardwalk Pipeline
CAC
Development Partners Group
Energy Futures Group
Enerwise Global Technologies, LLC d/b/a CPower; and Advanced Energy Management Alliance
Hoosier Energy
Indiana Distributed Energy Alliance

IPL
IURC
Lewis Kappes
MEEA
Morton Solar & Electric
Orion Renewable Energy Group LLC
OUCC
Sierra Club
St. Joe
Vote Solar

Matt Rice (Vectren Manager of Resource Planning) – Discussed the feedback received since the 2016 IRP, the 2019/2020 IRP process, and the role of the all source request for proposals.

- Slide 8 Director's Report Feedback:
  - Question: What was the suggestion given consideration for Warrick 4, and what does it mean to maintain optionality?
    - Response: In the 2016 IRP, we hard coded an assumption in for Warrick 4 shutdown. With respect to Warrick 4 the Director's report comment referred to evaluating running the unit longer or shutting it down sooner. While not addressed in the meeting, in 2016 the Director provided praise for building scenario inputs in the short, mid, and long term, thus maintaining optionality.
  - Follow-up: After the smelter shutdown, there was higher risk to Warrick 4. So why was there an extension to the Warrick 4 agreement?
    - Response: The agreement was extended through 2023. Please see Wayne Games for more questions. While not stated in the meeting, the extension supported ALCOA's decision to reopen its smelter.
- Slide 13 Proposed 2019/2020 IRP Process:
  - Question: Will you provide preparatory material, list of potential strategies, etc. ahead of the next meeting?
    - Response: Yes, we will post the presentation and potential strategies one week ahead of next meeting. Below is a list of potential strategies for you to think about it in advance.
      - Minimize CO2
      - Minimize cost
      - Continue to run existing plants
      - Maximize Energy Efficiency (EE) and renewables
      - Balanced/Diverse mix of resources (don't put all of your eggs in one basket),
  - Question: Regarding Slide 8 (Director's Report Feedback), how will scoring be done this time?
    - Response: We will cover details in the Objectives and Measures section today.
  - Statement: Please differentiate among stakeholders. Additionally, I have a concern about the loss of industrial load and support for the community, particularly low income customers.
    - Response: There are many different stakeholders, and we try to make this IRP process relevant to all stakeholders. Tom Bailey can speak to economic development, and we have scenarios with higher load. We hear your concern on

price impact, and we'll address those concerns during Objectives & Measures discussion.

- Slide 14 Role of the All-Source RFP:
  - Question: Please explain how resources will be modeled on a tiered basis?
    - Response: We will group resources by cost and by like-resources.
  - Question: How much modeling of RFP responses has Pace and Vectren done to-date?
    - Response: None, as we are still gathering inputs. RFP bids just came in last week so there's been very little analysis to-date.
  - Question: CenterPoint has a vested interest in using natural gas. How do you not bias toward natural gas in this plan?
    - Response: Portfolios will be evaluated based on tradeoffs presented in the scorecard, which we will talk about today. Vectren has no preconceived notion of what the portfolio will be. We are taking an unbiased approach to selecting resources.
- Slide 15 Key Vendors:
  - Question: Since bids are done, doesn't that limit us?
    - Response: No, we will use the RFP as an input into the IRP. We are looking for your input on how we evaluate portfolios of resources.
  - Question: Will RFP data be made available to all stakeholders, and can we learn the total number and type of bids?
    - Response: We will summarize data. We must protect confidential information, but we will work with some groups to try and find a way to show certain groups, like the OUCC, bid information. We will provide some summary data later today, and we will continue to provide more detailed information as analysis is completed.
- Slide 16 2019/2020 Stakeholder Process:
  - Question: We have an ongoing concern with use of Aurora for IRP purposes. It is not possible to export input/output files according to Energy Exemplar, and costs are large even for a read-only model. Additionally, we cannot see the manual without having a license.
    - Response: We will provide all of the inputs, outputs, and talk about the constraints. We have also determined that the cost for a read only license is $5k. For those who obtain the license, we will provide modeling files for review. We will follow up about the owner's manual.
  - Follow-up: Still concerned about costs and would like to know if stakeholders can log-in using existing license.
    - Response: We can have a follow-up conversation and can discuss options. We chose Aurora based on capabilities, feedback, internal consistency, and run-times on the cloud.
  - Follow-up statement: We appreciate working with Vectren on how to gain access to data within Aurora, which will allow for a meaningful stakeholder process, no further questions here but we want to comment that this is critical.
    - Response: Vectren will work hard to provide useful information.
  - Statement: I am responding to the gentleman that said he has a concern about the loss of industrial load and support for the community, particularly low income customers. I have a concern that you will only try to encourage industrial growth. There are many businesses that we should be attracting.
    - Response: Vectren works to attract all types of customers.

<u>Gary Vicinus</u> – Discussed Objectives & Measures and gathered stakeholder feedback:

- Slide 23 Feedback and Discussion:

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- Question: The concept of affordability is inclusive of all costs over time, including externalities. Clarify the concept of affordability.
  - Response: Cost is inclusive of relevant costs associated with portfolios. In the scenarios, we'll talk about costs of regulation (e.g., social cost of carbon in one scenario) where some of the costs considered go beyond direct cost of generation.
- Follow-up: Do we account for environmental and health impacts?
  - Response: In the high regulatory scenario, health impacts are one of the considerations that go into the social cost of carbon.
- Question: Where does the 15% band come from [for the Market Risk Minimization metric]?
  - Response: It was selected as a placeholder but we will continue to review to determine if it is reasonable, including looking at historical data.
- Question: How are you measuring impairment; how would it be calculated?
  - Response: We will run 200 iterations and track plant-level economics. We can determine how many scenarios would have shut down a unit for economics and track the number of MWhs over time that unit would have produced. The methodology for assessing potential asset impairment remains under review.
- Question: By only looking at CO2 emissions at a plant level, aren't we missing local impacts (ground level ozone, PM) and upstream impacts (methane fugitive emissions, flaring, etc.)?
  - Response: Would you have a suggestion for a better metric?
    - Response: You could use CO2-equivalent instead of CO2.
- Statement: It seems like MWh impairment is more of a price risk. Maybe this measure should be capital exposed rather than MWh.
- Question: I echo his questions and am also concerned that Market Risk measures. Would that bias toward excess sales/purchases?
  - Response: Just the opposite is the case. Excess sales and purchases above or below a band would be detrimental to portfolio performance.
- Statement: You should track other emissions within the modeling.
  - Response: CO2 isn't the only thing we'll track in the model. It is important to get the big picture, beyond the scorecard. We are going to be capturing a wide range of outputs from future scenarios going forward, including the implications of methane.
- Statement: It will be hard to quantify costs to methane emissions.
  - Response: It will be a challenge, and we'll bring our estimates to the next meeting and you will have a chance to comment if our inputs seem reasonable or not.
- Statement: CO2 emitted now is worse than CO2 emitted 20 years from now (as demonstrated by CCL models), so consider a NPV of CO2.
- Question: How do we incorporate feedback from initial steps to optimize the preferred portfolio? Are you considering feedback loops in determining the best or optimal portfolio?
  - Response: Can you clarify what you mean in "best" vs "optimal" portfolio?
  - Question: Yes, let's say we have 150 portfolios. How do you use something like Artificial Intelligence to improve the portfolio selection?
  - Response: IRPs are done every 3 years, which is in a way a feedback loop. We'd be interested in how to implement this within an IRP. If you have comments that you would like to send to us, we would be happy to look at it.
- Question: Are you measuring environmental harm from mining/ fracking? Also, if renewables costs are expensive, why does Vectren have the highest rates in the state despite using fossil generation?

-
    -
        - Response: Renewables costs may be more or less expensive. The RFP process provide inputs that will provide useful information regarding the cost of renewables. Also, fracking will be captured in the scenario analysis.
    - Question: Are you looking at measuring other GHGs (methane) and water pollution on a lifecycle basis? If so, where does that fit?
        - Response: We'll take into consideration CO2-equivalent and also will measure the impact of methane emissions regulations. If we don't answer your question within the scenario discussion, you will have a chance to ask again at the end of the day.
    - Question: Where is the optimal nexus of the Venn diagram on Slide 20 (Each Portfolio Will have Tradeoffs) to explore tradeoffs vs synergies?
        - Response: We are not just exploring tradeoffs but also synergies, which should point towards the optimal solution.
    - Statement: I have a concern with weighting metrics.
        - Response: We have presented the metrics, and we will talk about how we plan to evaluate the metrics over time.
    - Statement: On slide 72 (Definitions Cont.) the definition of optimal portfolio includes consideration for sustainability. My comment is that fossil fuel is inherently unsustainable.
    - Question: Why did Vectren not do an open source RFP last IRP (2016)?
        - Response: The traditional approach for an IRP is to utilize a technology assessment. There is a very large cost difference between a technology assessment [a study of costs and operating characteristics of various resources] and a RFP. Also, it's only recently that IRPs have begun to incorporate the use of RFPs.
    - Question: Is 15% on slide 21 (IRP Objectives and Measures) based on expected load or expected purchases and sales?
        - Response: It's based on a range around expected purchases/ sales with +/- 15% from those levels.

Matt Lind – Discussed the Request For Proposals (RFP) methodology, scoring, role, and provided high level statistics for Vectren's RFP.

- Slide 25 [RFP] Overview:
    - Question: Are you considering existing resources with alternatives? Does that include the OVEC contract? I'm concerned about ratepayers being impacted by extra cost now that FirstEnergy has pulled out of that contract. Also, is Vectren involved in the decision on coal ash ponds?
        - Response: FirstEnergy is not out of the contract yet.
    - Question: Is it covered in the IRP?
        - Response: To the extent all resources are considered, yes.
- Slide 32 Proposal Requirements:
    - Question: Why set the limit at 10 MW when you already have two 2 MW projects.
        - Response: Those two 2 MW projects are pilot projects.
    - Question: Will you share the bidder list, and will there be an opportunity to bid in again later on?
        - Response: We will share a list with bidder names. We do not plan to obtain bids again for this IRP.
    - Question: Were there any bidders that came too late or any that were rejected because they were unacceptable?
        - Response: At this point no bids have been rejected because they were deemed unacceptable. We accepted bids from all that provided bids on time with an NOI and NDA.
    - Question: Were bidders allowed to offer in existing resources in the RFP?
        - Response: Yes.

  - Question: Did you provide information on your existing situation?
    - Response: No.
  - Question: Why was the RFP deadline extended?
    - Response: We did not get responses back regarding credit review to bidders within our stated timeframe on the RFP, so we extended the due date proportionately.
  - Question: Can you tell us how many respondents NIPSCO had to its RFP?
    - Response: We believe somewhere close to 90 proposals.
- Slide 33 Preliminary RFP Statistics:
  - Question: How big is the solar portion of the pie to the right?
    - Response: Solar is about 19,500 MW, but there is double counting here (multiple PPA vs build options).
  - Question: Is this nameplate capacity or accredited capacity?
    - Response: This is ICAP (nameplate), not UCAP (accredited).
  - Question: Did Vectren or its related companies submit proposals to the RFP.
    - Response: No.
- Slide 37 [RFP] Evaluation Summary:
  - Question: I'm afraid that the way you are conducting this RFP process won't allow the most affordable options to rise to the top.
    - Response: The RFP at this point is providing information about the cost of each resource and will feed IRP modeling. The IRP will be the process that picks the preferred portfolio mix. Gas is not competing with solar and wind within the RFP scoring. Like groups of resources will be grouped so that solar resources are competing with solar within the RFP and gas is competing with gas.
- Slide 40 Feedback and Discussion:
  - Question: Why do projects within your service territory get 100 points? I would like to get more clarity about how this may hamper projects not within this area.
    - Response: Potential local points are additive to the 500 points. It is not a given that they will be applied. It is an option to apply 100 additional points based on a preference for local resources and the benefits that local resources provide to transmission reliability, lower congestion risk, and economic development. In terms of the local preference, we will provide the criteria at a later date. If we apply it, we will give rational.
  - Question: I have a concern over delivery date, why penalize based on early delivery (before 2023/24 date)?
    - Response: To the extent capacity is needed early, we'll capture that in the IRP process.
  - Question: Fuel sources have to compete with one another in this process. Is that what is being done in the IRP?
    - Response: Yes. The resources compete with one another within the IRP.
  - Question: You mentioned that there is an Import/Export limit on resources, who sets the value and what is the limit?
    - Response MISO does an annual (public) LOLE study that determines I/E limits for Local Resource Zone-6. Currently about 70% of Vectren resources need to be located within MISO zone 6.
  - Question: Will point scoring be an input in any way or via weighting in the Aurora Model?
    - Response: No.
  - Follow-up: How are local vs. non-local resources going to be evaluated?
    - Response: Cost information from bids will be evaluated in Aurora based on the cost to deliver energy to Vectren's load node. Burns and McDonnel will also do an evaluation of congestion costs for RFP scoring.
  - Follow-up: I'm still unclear on RFP scoring and how it relates to the IRP.

- Response: The IRP will identify a preferred resource mix [portfolio] and then we may go back to the RFP proposals for best offers within each resource category.
- Question: I'm concerned about options from the RFP. Two nearby dams can provide approximately 700 MWs of hydroelectric power. So why is hydro not in bids?
  - Response: No hydro bids were received. Within IRP modeling, we will supplement bid information with technology assessment information for resources where we did not receive a bid, including hydro.

Angila Retherford – Discussed the current regulatory environment as it pertains to generation, including, but not limited to, CCR, ELG, the Clean Water Act 316B, and ACE.

- Slide 48 Affordable Clean Energy (ACE) Rule:
  - Question: What is the conversion rate that you are using for CO2?
    - Response: We will have to verify, but it is around 26x. We will clarify at the next meeting.
  - Question: Are you talking about CO2-equivalence as a measured life-cycle or at the stack?
    - Response: At the stack, but we will get closer to life-cycle with one of our scenarios.
  - Question: How do you justify the ACE rule will stand for 20 years?
    - Response: The ACE is the current regulation for CO2 and is therefore included as the base case. Your question is focused around a base case. We're going to construct scenarios around more stringent regulations. This is a business as usual scenario.
  - Question: Have you evaluated compliance costs for 100% solar?
    - Response: No, but we would need to also consider upstream environmental costs of renewable energy the same as we consider them for fossil.
  - Question: Are you accounting for methane leaks in Vectren's system?
    - Response: Not in terms of the distribution system, but the high reg scenario will capture higher methane costs for regulations.

Gary Vicinus – Discussed base case inputs and draft scenarios and asked for feedback.

- Slide 53 Base Case Consensus Fuel Forecasts [Coal]:
  - Question: Can you provide delivered coal prices to compare to these forecasts?
    - Response: Yes. We will provide delivered historic prices compared to these projections. Note that delivered prices are included in modeling.
  - Question: Some coal plants are designated as "must-run" due to take-or-pay coal contracts. Do you designate your plants under must run status? Is that how any of your coal contracts are set up?
    - Response: No, we do not designate our plants as must run unless there is a reliability issue and our system operator tells us we need to run a plant. It is not a function of coal supply contracts.
  - Question: Gary mentioned both coal and gas have a $1/MMBtu difference [between the high and low inputs], but in absolute terms these are very different. Comment?
    - Response: These consensus forecasts are showing a difference of about a $1/MMBtu. The distinction though is that one is off of a three dollar base and the other is off of about a dollar and a half base.
  - Question: Is Vectren's gas price similar to Henry Hub?
    - Response: We're showing commodity only, but we'll factor in transportation costs.
  - Question: 4/5 vendors gas forecasts were close. One was quite different. Do you know why?

        - Response: One of the benefits of a consensus forecast is that it is a best guess, but the drawback is you can't always look at underlying assumptions. Vectren's view is that these are all credible vendor forecasts.
- Slide 55 Base Case Renewables and Storage Long Term Cost Curves:
    - Question: Am I interpreting this chart correctly, that solar cost will decline ~30% and storage ~40%?
        - Response: Yes.
    - Question: Are capital cost decline indices a combo of NREL, B&M, and Pace?
        - Response: Yes.
    - Comment: At some point technology advances are less important to cost because of other costs, like land, become larger.
        - Response: Absolutely correct.
    - Question: We've historically underestimated solar costs. How do you account for that? Will you consider a steeper decline curve.
        - Response: We will evaluate bid costs and assess if these curves still make sense. Additionally, a steeper decline curve will be assessed in the high technology scenario.
- Slide 58 Draft Scenarios:
    - Question: How did you determine Economy? What is higher and lower and how did you determine?
        - Response: These are all in relation to the Base Case.
    - Follow-up: Please look at the Economy again. It may not be valid that a High Regulation case leads to Lower-than-Base-Case economy.
        - Response: Perfectly valid concerns. That is why we want your input.
    - Question: What are the ACE rule implications?
        - Response: ACE means there is greater investment to increase efficiency to meet targets in the rule.
    - Comment: I want to echo the concern that correlates High Reg with Low Economy. I think that it is a false assumption. There is a bipartisan bill in congress that has been analyzed using REMI analysis that says High Reg (carbon dividend, specifically) would in fact *improve* the economy.
        - Response: That is the kind of input that we are looking for. We will look into the study/bill that you suggest.
    - Question: Where is the 100% clean energy scenario? NIPSCO, Xcel, others have committed to 100% renewable.
        - Response: There is a distinction between scenario and strategy. You described a strategy. Here, we're looking at scenarios, but portfolio construction can be designed to achieve 100% renewable energy. You could construct a scenario with a high 80-100% renewable portfolio standard.
- Slide 62 Scenario Narratives [80% CO2 Reduction by 2050 (aka 2 degrees scenario)]:
    - Comment: I disagree in the 80% scenario that you'd see that battery storage prices would increase with more demand, just like computer prices didn't increase with greater demand.
        - Response: We will consider, but we need to make sure to capture boundary conditions within scenarios. These are not cast in stone. We appreciate your input.
- Slide 63 Scenario Narratives:
    - Comment: Please don't set boundaries to disadvantage renewables.
        - Response: Remember that we'll also expose the portfolios not only to these scenarios but also 200 iterations.
    - Question: The base case is supposed to be most likely, so the idea that in the Base Case that the ACE rule will last 20 years is not realistic. Also, I don't think we would

raise solar prices due to higher regulatory restrictions, particularly over 30 years to 2050.
        - Response: Fair point, that feedback is valuable. Keep in mind that when you see higher, this is higher relative to the base case. In other words, the costs will decline more slowly.
    - Comment: Again, Base Case assumption of ACE rule is unrealistic.
        - Response: The most likely future is probably a misnomer, but it is the rule on the books. Don't focus too much on this since we are modeling lots of other scenarios. Ignoring the CO2 law on the books that exists now is problematic from a process standpoint.

Open Q&A Session

- Question: I have a question on the October 10th meeting on what portfolios are vs. strategies.
    - Response: We will be looking for your input on strategies for portfolio development.
- Question: How reliable are your coal plants?
    - Response: There are a couple of ways to measure reliability. Capacity factor is around 60-65% over last 4-5 years. Our forced outage rate is around 4.5%.
- Question: Can you confirm that each tiered resource modeled in Aurora will consist of the average price of the prices from each tier, and will each tier consist of the sum of MWs within that tier, and will all tiers compete with one other simultaneously? Will the price of each tier simply be the average or will there be adders of any kind from congestion layered on top of them.
    - Response: Within each category there will be tiers to the extent that there are multiple proposals represented within that tier. Not in every case (e.g., DR, which had one response), but yes - we'll capture in the tiers various cost levels that may include congestion. We'll revisit in next meeting. To add with our own experience, we have a wind PPA that sits in the northern part of the state. So when the transmission system is loaded, we have to pay MISO to get that energy. The congestion component based on where these plants are is a big deal. We will do the best we can to capture the costs that our customers are going to see.
- Question: How are you using stakeholder input in IRP process; will it be tangibly used?
    - Response: We will be transparent in how we use or not use stakeholder inputs. If we chose not to use a suggestion, we will tell you why.
- Question: How do Objectives & Measures work, and will they be weighted?
    - Response: At this point nothing is weighted. We are looking at tradeoffs for portfolios. The balanced scorecard is a tool to understand tradeoffs. At the end of the day, the scorecard is not going to produce a score and rank order portfolios. It is a tool to understand where the differences lie and how each portfolio meets these multiple objectives. We can place an emphasis on certain measures but that is in the realm of judgement. We can't take ultimate decision-making out of management's hands and reduce it down to a formula. The tradeoffs have to be considered fully by management, with transparency of the body of evidence of performance and implications among tradeoffs.
- Comment: We received a serious warning one year ago from the IPCC. I appreciate your expertise, and we need your knowledge and skills. But I also want you to inject a morale urgency into your decision-making to ensure we're creating a pathway to respond to the warnings of climate experts. We would like to see you indicate which portfolios meet the IPCC standards.

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VECTREN PUBLIC STAKEHOLDER MEETING

OCTOBER 10, 2019

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WELCOME AND SAFETY SHARE

LYNNAE WILSON

INDIANA ELECTRIC CHIEF BUSINESS OFFICER

SAFETY SHARE

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Tips to Avoid Distractions While Driving

- Make adjustments before your get underway. Address vehicle systems like your GPS, seats, mirrors, climate controls and sound systems before hitting the road. Decide on your route and check traffic conditions ahead of time.
- Snack smart. If possible, eat meals or snacks before or after your trip, not while driving. On the road, avoid messy foods that can be difficult to manage.
- Secure children and pets before getting underway. If they need your attention, pull off the road safely to care for them. Reaching into the backseat can cause you to lose control of the vehicle.
- Put aside your electronic distractions. Don’t use cell phones while driving – handheld or hands-free – except in absolute emergencies. Never use text messaging, email functions, video games or the internet with a wireless device, including those built into the vehicle, while driving.
- If another activity demands your attention, instead of trying to attempt it while driving, pull off the road and stop your vehicle in a safe place. To avoid temptation, power down or stow devices before heading out.
- As a general rule, if you cannot devote your full attention to driving because of some other activity, it’s a distraction. Take care of it before or after your trip, not while behind the wheel.

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2019/2020 STAKEHOLDER PROCESS

August 15, 2019

- 2019/2020 IRP Process
- Objectives and Measures
- All-Source RFP
- Environmental Update
- Draft Base Case Market Inputs & Scenarios

October 10, 2019

- RFP Update
- Draft Resource Costs
- Sales and Demand Forecast
- DSM MPS/ Modeling Inputs
- Scenario Modeling Inputs
- Portfolio Development

December 13, 2019[1]

- Draft Portfolios
- Draft Base Case Modeling Results
- All-Source RFP Results and Final Modeling Inputs
- Probabilistic Modeling Approach and Assumptions

March 19, 2020

- Final Base Case Modeling
- Probabilistic Modeling Results
- Risk Analysis Results
- Preview the Preferred Portfolio

1 Snow date is December 19, 2019

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AGENDA

Time		
9:00 a.m.	Sign-in/Refreshments	
9:30 a.m.	Welcome, Safety Message	Lynnae Wilson, CenterPoint Energy Indiana Electric Chief Business Officer
9:40 a.m.	Follow-up Information Since Our Last Stakeholder Meeting	Matt Rice, Vectren Manager of Resource Planning and Gary Vicinus, Managing Director for Utilities, Pace Global
10:10 a.m.	MISO Considerations	Justin Joiner, Vectren Director Power Supply Services
10:40 a.m.	Break	
10:50 a.m.	Scenario Modeling Inputs	Gary Vicinus, Managing Director for Utilities, Pace Global
11:30 a.m.	Lunch	
12:00 p.m.	Long-term Base Energy and Demand Forecast	Mike Russo, Senior Forecasting Analyst, Itron
12:30 p.m.	Existing Resource Overview	Wayne Games, Vectren Vice President Power Generation Operations
1:00 p.m.	Potential New Resources and MISO Accreditation	Matt Lind, Resource Planning & Market Assessments Business Lead, Burns and McDonnell
1:40 p.m.	Break	
1:50 p.m.	DSM Modeling in the IRP	Jeffrey Huber, Managing Director, GDS Associates
2:20 p.m.	Portfolio Development Workshop	Moderated by Gary Vicinus, Managing Director for Utilities, Pace Global
3: 00 p.m.	Adjourn	

MEETING GUIDELINES

1. Please hold most questions until the end of each presentation. Time will be allotted for questions following each presentation. (Clarifying questions about the slides are fine throughout)
2. For those on the webinar, please place your phone and computer on mute. We will open the phone lines for questions within the allotted time frame. You may also type in questions via the chat feature. Only questions sent to 'All-Entire Audience' will be seen and answered during the session.
3. There will be a parking lot for items to be addressed at a later time.
4. Vectren does not authorize the use of cameras or video recording devices of any kind during this meeting.
5. Questions asked at this meeting will be answered here or later.
6. We will do our best to capture notes but request that you provide written feedback (concepts, inputs, methodology, etc.) at IRP@CenterPointEnergy.com following the meeting. Additional questions can also be sent to this e-mail address.

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FOLLOW-UP INFORMATION SINCE OUR LAST STAKEHOLDER MEETING

MATT RICE

VECTREN MANAGER OF RESOURCE PLANNING

GARY VICINUS

MANAGING DIRECTOR FOR UTILITIES, PACE GLOBAL

VECTREN COMMITMENTS FOR 2019/2020 IRP

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By the end of the second stakeholder meeting Vectren will have made significant progress towards the following commitments

- ✓ Utilizing an All-Source RFP to gather market pricing & availability data
- ✓ Including a balanced, less qualitative risk score card; draft was shared at the first public stakeholder meeting
- ✓ Performing an exhaustive look at existing resource options
- ✓ Using one model for consistency in optimization, simulated dispatch, and probabilistic functions
- ✓ Working with stakeholders on portfolio development

Vectren will continue to work towards the remaining commitments over the next several months

- Providing a data release schedule and provide modeling data ahead of filing for evaluation
- Striving to make every encounter meaningful for stakeholders and for us
- Ensuring the IRP process informs the selection of the preferred portfolio
- Modeling more resources simultaneously
- Testing a wide range of portfolios in scenario modeling and ultimately in the risk analysis
- Conducting a sensitivity analysis
- Including information presented for multiple audiences (technical and non-technical)

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PROPOSED 2019/2020 IRP PROCESS

- Conduct an All Source RFP
- Create Objectives, Risk Perspectives and Scorecard Development
- Create Base Case Assumptions and Scenario Development
- Portfolio Development Based on Various Strategies, Utilizing Optimization to Create a Wide Range of Portfolios and Refine with All Source RFP Data
- Portfolio Testing in Scenarios, Focused on Potential Regulatory Risks
- Portfolio Testing Using Probabilistic Modeling of 200 Potential Futures
- Utilize the Probabilistic Modeling to Conduct Sensitivity Analysis
- Populate the Risk Scorecard that was Developed Early in the Process and Evaluate Portfolios
- Select the Preferred Portfolio

REVIEW ROLE OF THE ALL SOURCE RFP

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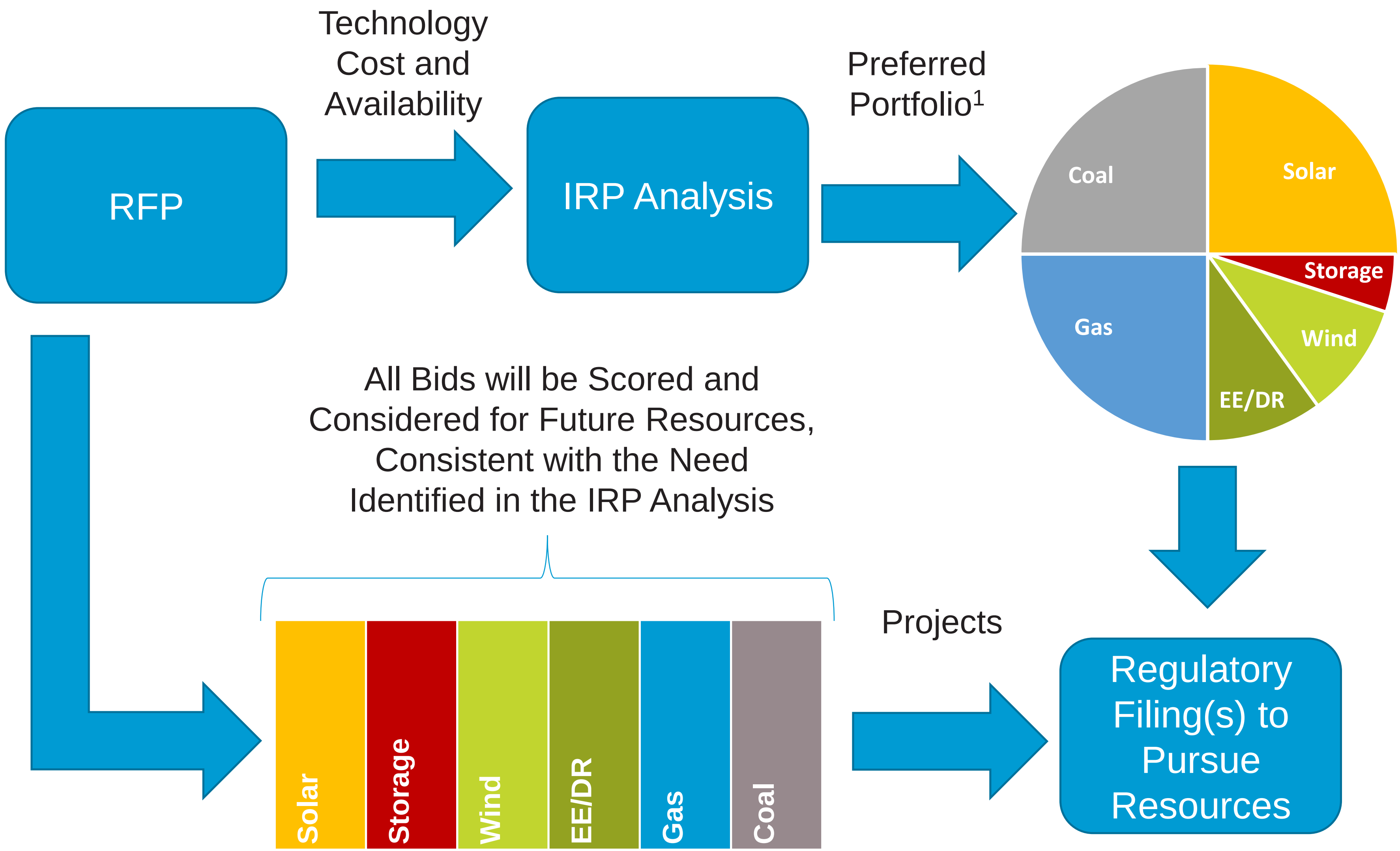

1 Illustrative example

STAKEHOLDER FEEDBACK

Request	Response
Scenario: Update the High Regulatory scenario to include a carbon dividend. Concern was expressed that the economic outlook would not necessarily grow worse under a high CO2 tax scenario.	Economic outlook is correlated with the load forecast. We have updated the High Regulatory scenario load forecast direction from lower than the base case forecast to equal with the base. The High Regulatory scenario includes other regulations, which we assume will net out any positive impact created from a carbon dividend.
Scenario: Update a scenario to have renewables costs lower than the base due to innovation and removal of waste from the value chain. The example provided was that the price of laptops declined as demand went up.	We have updated the 80% CO_2 Reduction and the High Regulatory scenarios to be lower cost than base.
Modeling: Options to view Aurora modeling files. Additionally, provide an understanding of “industry-supplied data” Include these modeling assumptions.	Read only copy of Aurora costs $5k and includes a help function and basic self learning slides. Additionally, we will provide Aurora release notes to those that request and sign an NDA.
Portfolio development: Fully explore the use of hydro resources, given Vectren’s proximity to the Ohio River.	Vectren reviewed available materials provided to better understand/compare to our technology assessment provided by Burns and McDonnell. While we did not receive a bid and costs are high, hydro could be included within portfolio development.

STAKEHOLDER FEEDBACK CONT.

Request	Response
Scorecard: Update Environmental Risk Minimization measure to report CO_2 equivalent and consider utilizing life cycle emissions by electric generation technology	Utilize NREL Life Cycle Greenhouse Gas Emissions (upstream and downstream) from Electricity Generation by resource analysis. NREL CO_2e rates per MWh will be applied to both retail sales covered by Vectren portfolios, as well as a CO_2e emissions estimate when relying on the market.
Scorecard: Consider sunk costs in Future Flexibility measure. Change basis from MWhs of impairment by asset to $ to better reflect uneconomic asset risk	Will update this measure to reflect dollars. Will measure when costs to run an asset do not cover energy and capacity revenues in three consecutive years. Methodology will be described later in this presentation.
Scorecard: Market Risk Minimization metric bounds of 15% rational needs to be described.	We reviewed the +/-15% deadband for energy and capacity market purchases for reasonableness and feel this is a reasonable assumption. We will discuss again today.
RFP/IRP costs: Concern was expressed that we could lose opportunities to include low cost resources within Integrated Resource Plan (IRP) modeling if we only include Request for Proposals bids with a delivered cost.	For modeling, we will include firm bids on our system and those with a delivered cost. Additionally, Burns and McDonnell will review other bids and assess potential congestion costs. Such evaluated resources (including congestion estimate) may also be included within IRP modeling.

STAKEHOLDER FEEDBACK CONT.

Request	Response
Scenarios: Include an RPS standard scenario.	There are several mandates that could be imposed in the future, from renewables interests to coal interests. The primary purpose of scenarios in this IRP will be to help determine how portfolios perform in various future states. We would like your feedback on portfolio development. We can develop various portfolios utilizing an RPS, coal portfolio mandate, etc. within the model. The performance of these portfolios will be assessed within the scenarios and probabilistic modeling.
Scorecard: Include a health benefits measure.	We reviewed a recent EPA report titled "Public Health Benefits per kWh of Energy Efficiency and Renewable Energy in the United States: A Technical Report[1]," which included a screening level estimate of Benefits-per-KWh value for EE, wind, and solar projects. The report noted that there are no comprehensive national studies available with data of this kind. Values from this report cannot be used for this analysis as estimates are explicitly only good through 2022.

1 Source: https://www.epa.gov/sites/production/files/2019-07/documents/bpk-report-final-508.pdf

AURORAxmp TOOL

- AURORAxmp (Aurora) is an industry standard model for electricity production costing and market simulations
- Aurora is licensed by approximately 100 clients in North America, ranging from consultants to full-scale utilities to traders to Indiana's State Utility Forecasting Group (SUFG)
- Aurora is accepted in many regulatory jurisdictions
- Vectren will use the Aurora model in the IRP to provide the following analysis:
  - Least cost optimization of different portfolios, including decisions to build, purchase, or retire plants
  - Simulation of the performance of different portfolios under a variety of market conditions
  - Production cost modeling to provide market prices for energy
  - Emissions tracking based on unit dispatch
  - A comparative analysis of various regulatory structures
- A primary output is portfolio cost performance in terms of Net Present Value

For more information: https://energyexemplar.com/solutions/aurora/

ACCESSING THE AURORA MODEL

- A one year, read-only End User License Agreement for AURORAxmp is available for $5k from Energy Exemplar; this purchase entitles access the library of modeling presentations via the web login
- The model's Help menu features material similar to a user manual
- IRP databases would include input and output tables used in the modeling and will require an NDA with Siemens
- The model database will be available for review but Siemens will not provide any review support beyond clearly-defined naming conventions (data key)

DRAFT SCENARIOS UPDATE

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Vectren has updated scenarios based on stakeholder feedback. Scenario modeling will evaluate various regulatory constructs. As a reminder, the Base Case serves as a benchmark. Alternative scenarios are shown as higher than, lower than, or the same as the Base Case

	CO_2	Gas Reg.	Water Reg.	Economy	Load	Gas Price	Coal Price	Renewables and Storage Cost	EE Cost
Base Case	ACE	none	ELG	Base	Base	Base	Base	Base	Base
Low Reg.	ACE Delay**	none	ELG Light*	Higher	Higher	Higher	Base	Base	Base
High Tech	Low CO2 Tax	none	ELG	Higher	Higher	Lower	Lower	Lower	Lower
80% CO_2 Reduction by 2050	Cap and Trade	Methane	ELG	Lower	Lower	Base	Lower	Lower	Higher
High Reg.	High CO_2 Tax w/ Dividend	Fracking Ban	ELG	Base	Base	Highest (+2 SD)	Lower	Lower	Higher

Increasing Environmental Regulation

*No bottom ash conversion required based on size of the unit and delay requirement for 2 years
**ACE Delayed for 3 years

Revised from last meeting

SCENARIO NARRATIVES

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80% CO_2 Reduction by 2050 (aka 2 degrees scenario)

- This scenario assumes a carbon regulation mandating 80% reduction of CO_2 from 2005 levels by 2050 is implemented. A glide path would be set using a cap and trade system similar to the CPP, gradually ratcheting down CO_2 emissions and driving CO_2 allowance costs up.
- Load decreases as the costs for energy and backup power increase and as the energy mix transitions.
- In this scenario, regulations on methane emissions initially drive up gas prices, but are partially offset by increased supply. The price of natural gas remains on par with the Base Case.
- There is less demand for coal, driving prices lower than the Base Case; however, some large and efficient coal plants remain as large fleets are able to comply with the regulation on a fleet wide basis.
- Renewables and battery storage technology are widely implemented to help meet the mandated CO_2 reductions. Despite this demand, costs are lower than the Base Case due to subsidies or similar public support to address climate change.
- Market based solutions are implemented to lower CO_2. Innovation occurs, but is offset by more codes and standards with no incentives, energy efficiency costs rise as a result.

Revised from last meeting

SCENARIO NARRATIVES

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High Regulatory (Revised)

- The social cost of carbon is implemented via a high CO_2 tax early in the scenario. Monthly rebate checks (dividend) redistribute revenues from the tax to American households based on number of people in the household.
- A fracking ban is imposed, driving up the cost of natural gas to +2 standard deviations in the long-term as supply dramatically shrinks.
- A strong decline in demand puts downward pressure on coal prices.
- The economic outlook remains at the Base Case level as any potential benefit of the CO2 dividend is offset by the drag on the economy imposed by additional regulations, including the fracking ban.
- Innovation occurs as renewables and battery storage are widely implemented to avoid paying high CO_2 prices, allowing costs to fall even as demand for these technologies increases.
- Utility-sponsored energy efficiency costs rise over time as the cost for regulatory compliance rises

Revised from last meeting

IRP OBJECTIVES & MEASURES UPDATE

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For each resource portfolio, the objectives are tracked and measured to evaluate portfolio performance in the Base Case, in four alternative scenarios, and across a wide range of possible future market conditions. All measures of portfolio performance are based on probabilistic modeling of 200 futures.

Objective	Measure	Unit
Affordability	20-Year NPVRR	$
Price Risk Minimization	95th percentile value of NPVRR	$
Environmental Risk Minimization	~~CO_2 Emissions~~ Life Cycle Greenhouse Gas Emissions	Tons CO_2e
Market Risk Minimization	Energy Market Purchases or Sales outside of a +/- 15% Band	%
	Capacity Market Purchases or Sales outside of a +/- 15% Band	%
Future Flexibility	~~MWh of impairment by asset~~ Uneconomic Asset Risk	~~MWh~~ $

Revised from last meeting

ENVIRONMENTAL RISK MINIMIZATION
LIFE CYCLE GREENHOUSE GAS EMISSIONS

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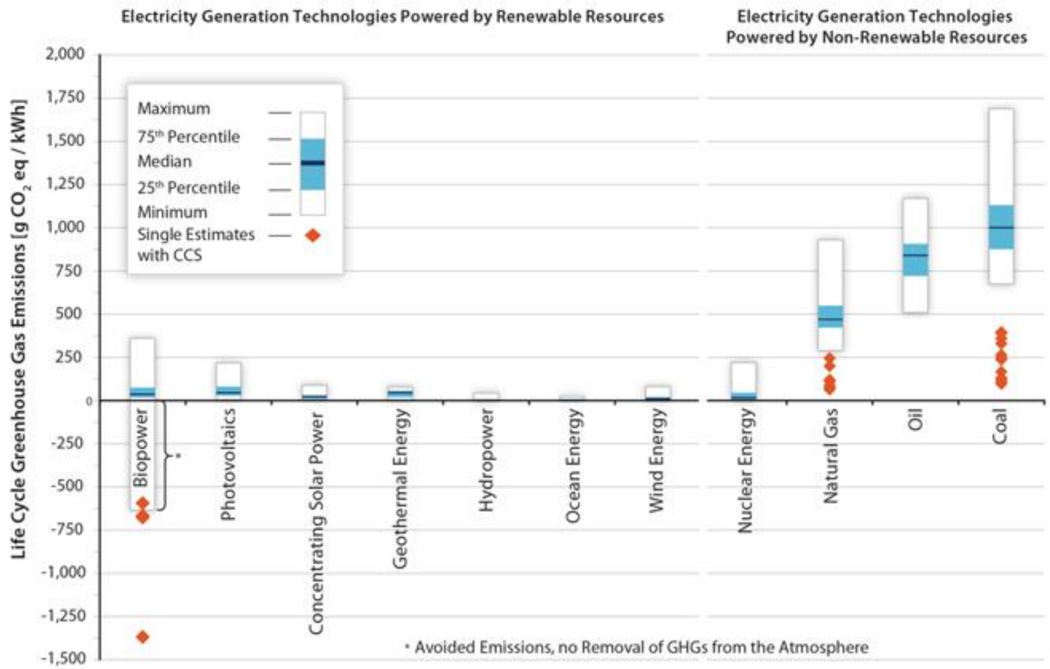
- Stakeholders requested a Life Cycle Analysis (LCA) and CO_2 equivalent on the scorecard
- LCA can help determine environmental burdens from “cradle to grave” and facilitate more consistent comparisons of energy technologies, including upstream, fuel cycle, operation, and downstream emissions
- NREL conducted a systematic review[1] of 2,100 life cycle greenhouse gas emissions studies for electricity generating technologies and screened down the list to about 300 credible references

Life Cycle GHG Emissions



	Biopower	Photovoltaics	Concentrating Solar Power	Geothermal Energy	Hydropower	Ocean Energy	Wind Energy	Nuclear Energy	Natural Gas	Oil	Coal
Count of Estimates	222(+4)	124	36	8	28	10	126	125	83(+7)	24	169(+12)
Count of References	52(+0)	26	10	6	11	5	49	32	36(+4)	10	50(+10)

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

ipcc
INTERGOVERNMENTAL PANEL ON climate change

1 Source: https://www.nrel.gov/analysis/life-cycle-assessment.html

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ENVIRONMENTAL RISK MINIMIZATION LIFE CYCLE GHG EMISSIONS CONTINUED…

- NREL utilizes median values[2] listed in the table to the right for life cycle analyses
- We plan to apply NREL rates (g CO_2e/kWh) to simulated portfolio generation emissions to serve retail load using specific technology rates
- In order to obtain a full picture of emissions, we must also estimate total emissions when customer load is being served by the market using the market rates and an average buildout of resources based on the MISO Transmission Expansion Plan (MTEP)
- Total CO_2 equivalent will be calculated for each portfolio based on emissions it generates and emissions generated from reliance on the market

Life Cycle GHG Emissions[1]

(grams of CO_2e per kWh)

	Specific Technology	Market
All Coal		1,002
Sub Critical	1,062	
Super Critical	863	
All Gas		474
Gas CT	599	
Gas CC[3]	481	
All Nuclear		16
Onshore Wind	12	12
All PV		54
Thin Film	35	
Crystalline	57	
All hydropower	7	7
Bio Power	43	43

1 Battery storage was not included in the NREL report. Evaluating options for this resource.
Source: https://www.nrel.gov/analysis/life-cycle-assessment.html
2 Values derived from graphs included for each resource type.
3 Assumes 70% shale gas, 30% conventional

+/-15% ENERGY AND CAPACITY PURCHASES AND SALES BAND JUSTIFICATION

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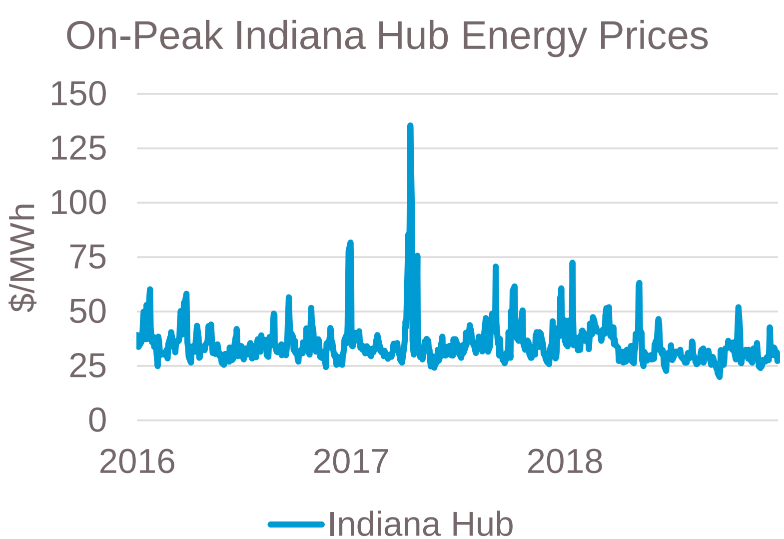
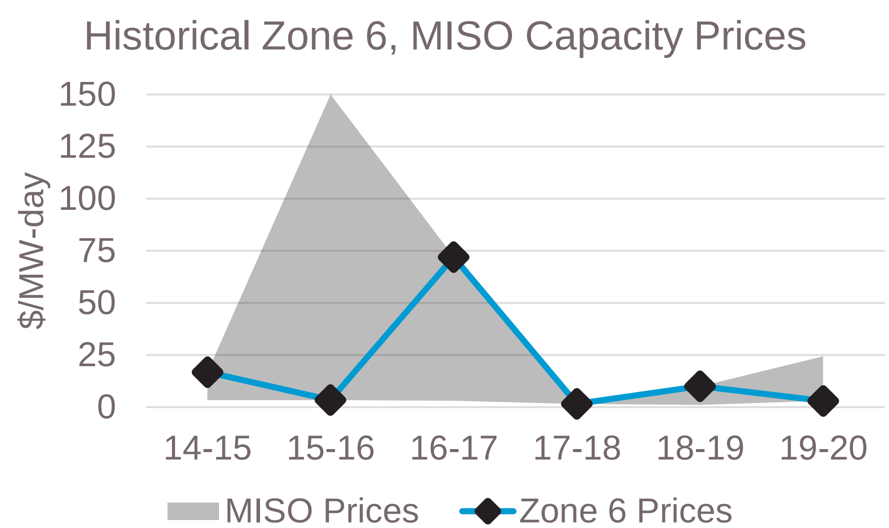
- Market transactions carry the risk for Vectren of buying when prices are high and selling when price are low.
- Vectren energy purchases are 1-2% of regional volumes* and 10-30% below regional prices for similar long-term transactions. On-peak power prices demonstrate ongoing volatility. To reduce exposure to this risk, we seek to minimize net energy sales and purchases to +/-15% of annual total sales.
- Capacity prices also fluctuate broadly in MISO and Zone 6 (Indiana). Exposure to price swings should be minimized to a range of +/-15% around forecasted demand.

Reliability First Corporation 2018 Energy Purchases by Contract Type (GWh)	
Short-Term	23,700
Intermediate-Term	14,500
Long-Term	53,100
of which Vectren	750
Other	298,000
Total	389,300





* 2016-2018; Reliability First Corporation NERC Subregion

UNECONOMIC ASSET RISK ANALYSIS

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- Following from stakeholder feedback, we changed the uneconomic asset risk objective measure from a MWh basis to a dollar cost basis
- Definition of an uneconomic asset: when going forward costs of the asset, which include annual variable costs (fuel + variable operations & maintenance or VOM + emissions) plus annual fixed operations & maintenance or FOM costs, are collectively greater than the total annual revenues (including both energy revenues and capacity revenues) in three successive years. By equation:

$$Going\ Forward\ Costs\ \left(\frac{\$}{kW-yr}\right) = \frac{[\,VOM+Fuel+Emissions+FOM\,]\left(\frac{\$}{yr}\right)}{Nameplate\ Capacity\ (kW)}$$

- We then identify in each stochastic model run:
  – Year when asset is deemed uneconomic
  – Undepreciated book value as of first uneconomic year
  – Revenues less going forward costs as of first uneconomic year for each year it is negative
- The resulting cost is weighted by frequency of occurrence across the iterations

FEEDBACK AND DISCUSSION

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MISO CONSIDERATIONS

JUSTIN JOINER

VECTREN DIRECTOR OF POWER SUPPLY SERVICES

MISO SUMMARY

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- Based on feedback from the last stakeholder meeting we felt it necessary to go over some of the MISO principles and considerations Vectren must take into account during the IRP process.
- This section is aimed at conveying four main points:
  - 1) MISO ensures low cost and reliable energy by enforcing market and planning rules that its members must adhere to; specifically:
    - Sufficient capacity to meet peak load
    - Adequate transmission to deliver the energy
  - 2) These rules focus on generator cost and ability to reach needed load; if the generation is not cost efficient or it can not be safely delivered on the MISO transmission system, MISO will not dispatch it
  - 3) MISO is undergoing a changing resource mix that has led to an increase in emergency events and a review of accrediting resources
  - 4) Because of these principles Vectren must fully evaluate the transmission components of a project and the expected output and accreditation it will receive in order to accurately evaluate the cost and efficiency of a project

WHAT IS MISO?

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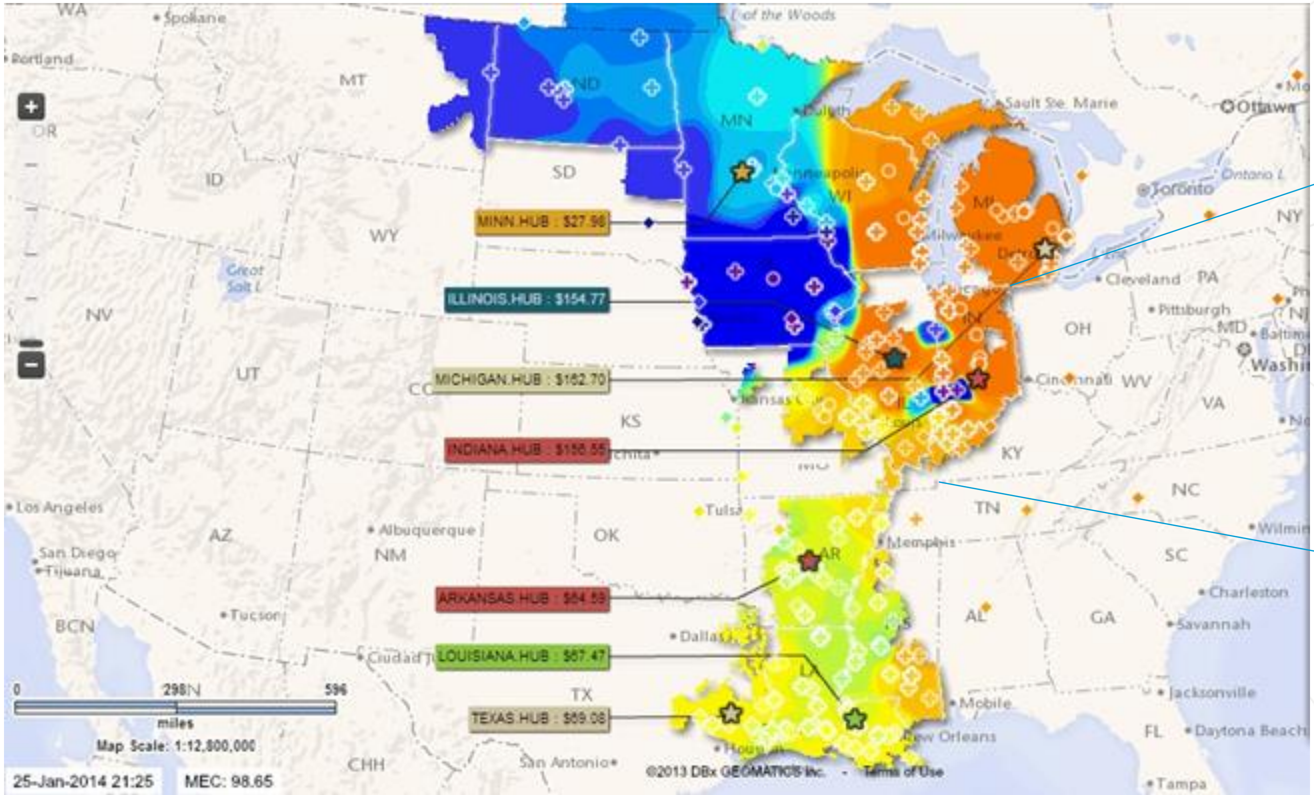
Midcontinent **I**ndependent Transmission **S**ystem **O**perator

- In 2001, MISO was approved as the first Regional Transmission Organization (RTO)
  - MISO has operational authority: the authority to control transmission facilities and coordinate security for its region to ensure reliability
  - MISO is responsible for dispatch of lowest cost generation units: MISO's energy market dispatches the most cost effective generation to meet load needs
- MISO is divided into 11 Local Resources Zones (LRZ), Indiana is part of Zone 6, which includes northwest Kentucky (Big Rivers Electric Cooperative)
- Each LRZ has its own planning requirements in regards to energy and capacity
- Each Zone's ability to rely on neighboring Zones depends largely on transmission infrastructure. Based on MISO's Local Clearing Requirement (LCR), approximately 70% of Vectren's generation must be physically located within MISO Zone 6

Source: MISO

CONGESTION

- Congestion on the MISO system during a period when energy in MN was $27.98 while at that same time energy in IN was $156.55; thereby, generators in MN received $128.57 less than load was paying in IN
  - Vectren experiences price separation for wind resource power purchase agreements within IN zone 6
  - Throughout the year there is a $5 price spread that magnifies over night during periods of low load
- Important consideration for long-term energy supplies as over time and depending on transmission build-out, generation retirements and additions and congestion could change the economics and reliability of a project



MISO INTERCONNECTION SNAPSHOT

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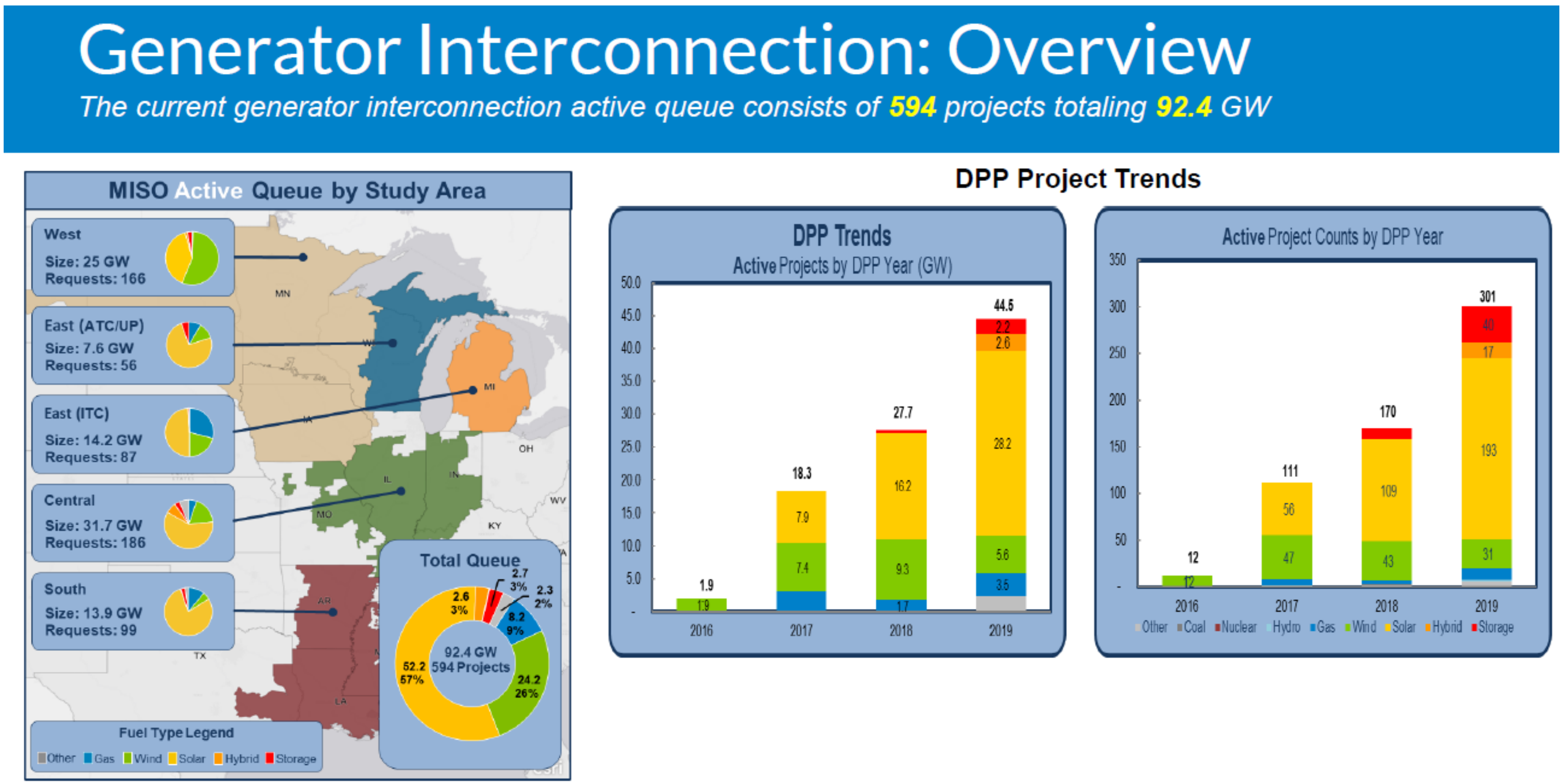
- Lengthy process that involves studies that are susceptible to many variables and cost allocation based on position in queue
- MISO Interconnection is predominantly composed of renewables (76%), followed by natural gas
- MISO's Renewable Integration Impact Assessment[1] is studying system impacts as renewables penetrate the grid and has determined that significant transmission upgrades will be necessary to reach 30% to 40% renewable penetration levels; this could lead to additional and substantial transmission investment

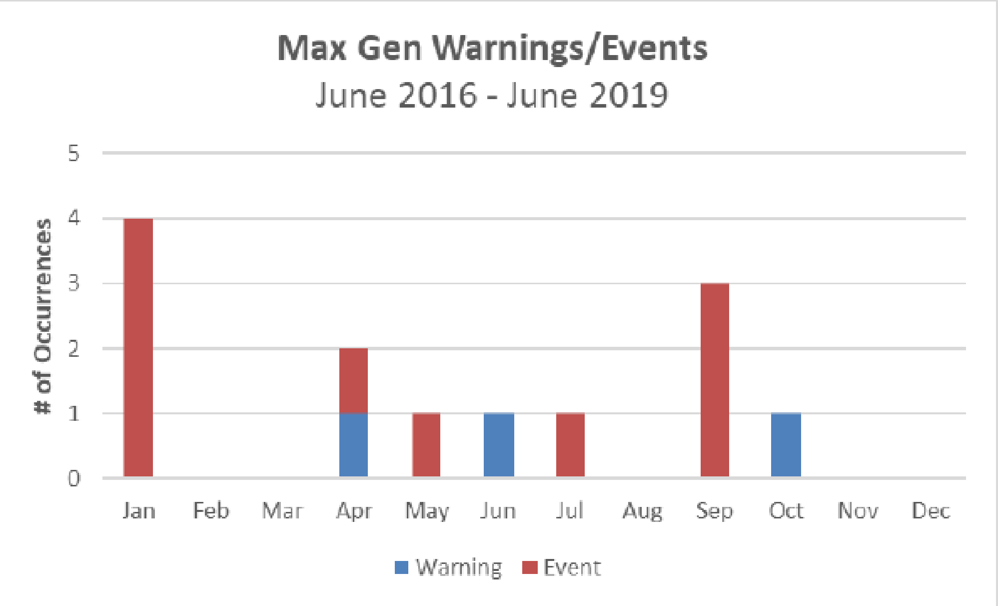


Updated: 9/1/2019 MISO

[1] https://www.misoenergy.org/planning/policy-studies/Renewable-integration-impact-assessment

MISO RESOURCE AVAILABILITY AND NEED (RAN) INITIATIVE

- Less capacity and lower generator availability have led to tighter operating conditions in all four seasons
- MISO has experienced 10 Max Generation Events in the last 4 years; a Max Gen Event used to occur once every couple years
- As such, the RAN Initiative is to ensure resource accreditation aligns with actual available generation throughout the year



Year	Warnings*	Events	Total
2009	0	0	0
2010	0	0	0
2011	0	1	1
2012	2	1	3
2013	0	0	0
2014	1	1	2
2015	0	0	0
2016	1	1	2
2017	1	3	4
2018	0	3	3
2019	1	3	4
Total	6	13	19

4

*Warnings occurring on the same day as an Event are not included

https://www.misoenergy.org/stakeholder-engagement/issue-tracking/resource-availability-and-need-ran/

ALL MISO CONSIDERATIONS NEED TO BE ACCOUNTED FOR DURING THE IRP

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- Due to MISO planning requirements being based on NERC reliability standards, generator location is an important consideration
- Location is also an important consideration from a financial perspective as congestion can add or reduce considerable costs to delivered energy costs
- Furthermore, a changing resource mix in MISO has led to an increase in emergency events and a review of accrediting resources
- The IRP must review and consider actual energy sources and not simply financial representations or obligations
  – Energy must be deliverable from a congestion standpoint and must be interconnected to the MISO transmission system
  – Energy credits from projects not connected to MISO will not provide needed low-cost energy to meet our customer needs during peak conditions
  – A seasonal construct will change the expected capacity credit for generating resources and the benefit Vectren customers can receive from a project
- Due to these multiple and complex considerations, we must carefully review all RFP responses and resource mixes in order to meet MISO requirements and appropriately value the costs and benefits of projects

FEEDBACK AND DISCUSSION

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SCENARIO MODELING INPUTS

GARY VICINUS

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SUMMARY

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- Pace Global utilized the qualitative draft scenarios discussed in the first stakeholder meeting to develop quantitative forecasts of key inputs
- Probabilistic modeling was utilized to develop higher and lower forecasts, relative to the base case for gas, CO_2, coal, load, and renewables/storage capital cost trajectories
- Coal and gas price forecasts have much wider ranges than the 2019 Energy Information Administration (EIA) Annual Energy Outlook (AEO)
- Note that capital cost forecasts will be adjusted to reflect RFP results. Final capital cost forecasts will be shared in the third public stakeholder meeting

SCENARIO MODELING

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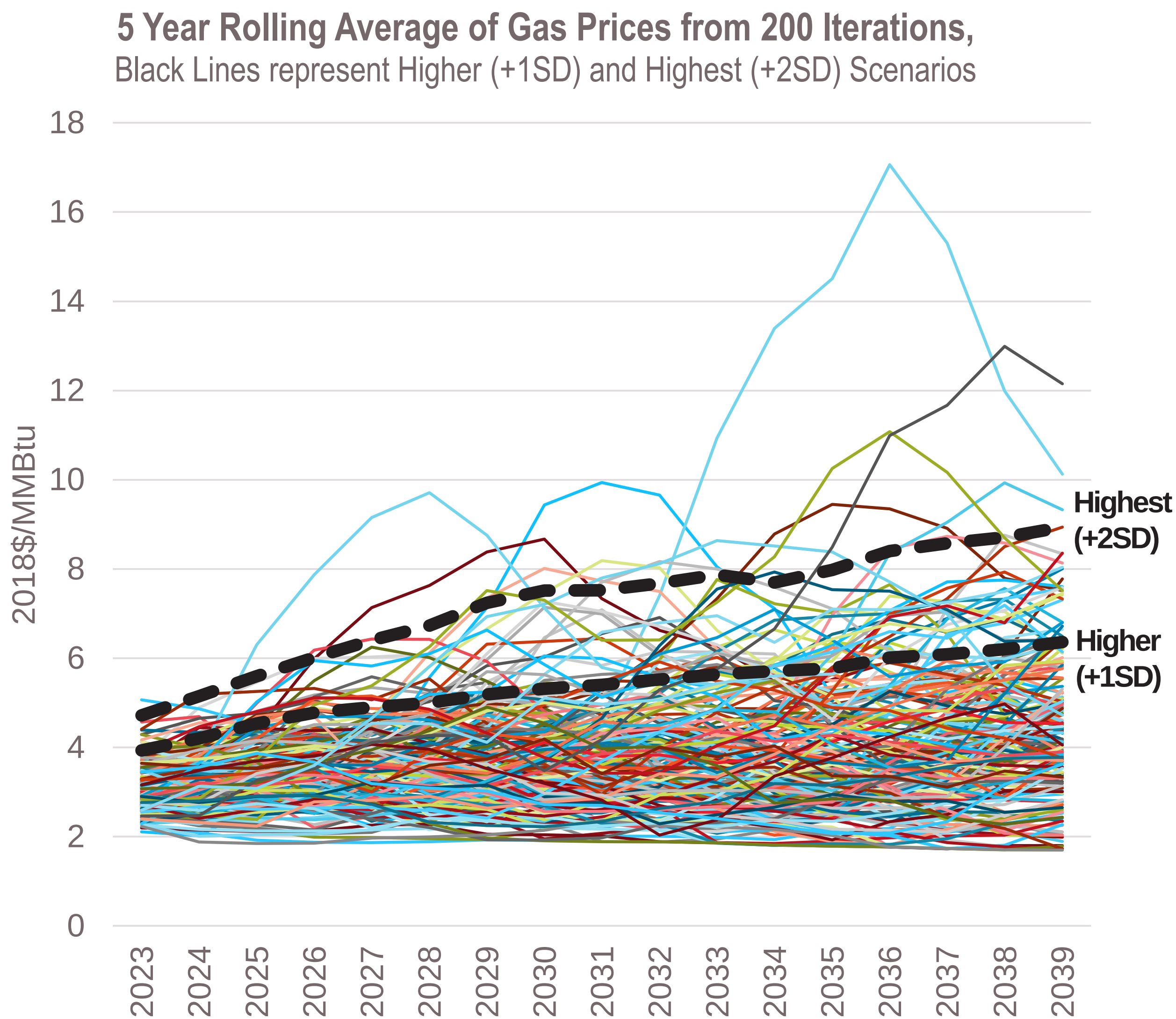
- In addition to the Base Case, four scenarios are being modeled. This will result in a least cost portfolio for each of the five cases. Additional portfolios will be developed beginning with today's stakeholder breakout session
- The Base Case inputs were shown in the first stakeholder presentation. To develop the scenario inputs, we begin with Base Case inputs and then shift into base, higher and lower ranges
- The higher and lower ranges are developed using a Monte Carlo (referred to as probabilistic or stochastic) simulation that creates 200 future paths for each variable
- A Base Case and Scenarios Assumptions Book in Excel format will be made available to intervenors
- Scenario data sheets included in the Appendix

PROBABILISTIC MODELING

- Probabilistic modeling helps to measure risk from two hundred potential future paths for each stochastic variable
- These iterations provide percentile bands that can be used to measure the probability that a variable will be above (or below) a given percentile in a given time period and relative to the Base Case
  - For +1 Standard Deviation (+1SD) in a normal distribution, it is 84.2%
  - For -1 Standard Deviation (-1SD) in a normal distribution, it is 15.8%
  - For +2 or -2 SD, it is 97.8% and 2.2%, respectively
- Scenarios are assumed to remain the same as the Base Case in the short-term (2019-2021). In the medium-term (2022-2028), they grow or decline to +/-1SD or (+/-2SD) by 2025 (midpoint of medium-term). After 2025, the variable stays at +/-1SD (or +/-2SD) into the long-term to 2039
- Because our price path remains at the one (or two) standard deviation(s) path for the entire planning horizon, these levels have a low probability and are very conservative

PROBABILISTIC MODELING CONT.

- This spaghetti diagram shows a 5-year rolling average of all 200 gas price iterations against the Higher and Highest gas price scenarios.
- In any given year, about 16% of prices are above the Higher line and about 2% are above the Highest line.
- Looking at the 20 year price average, about 7% of the 200 iterations were above the Higher line and none were above the Highest line.



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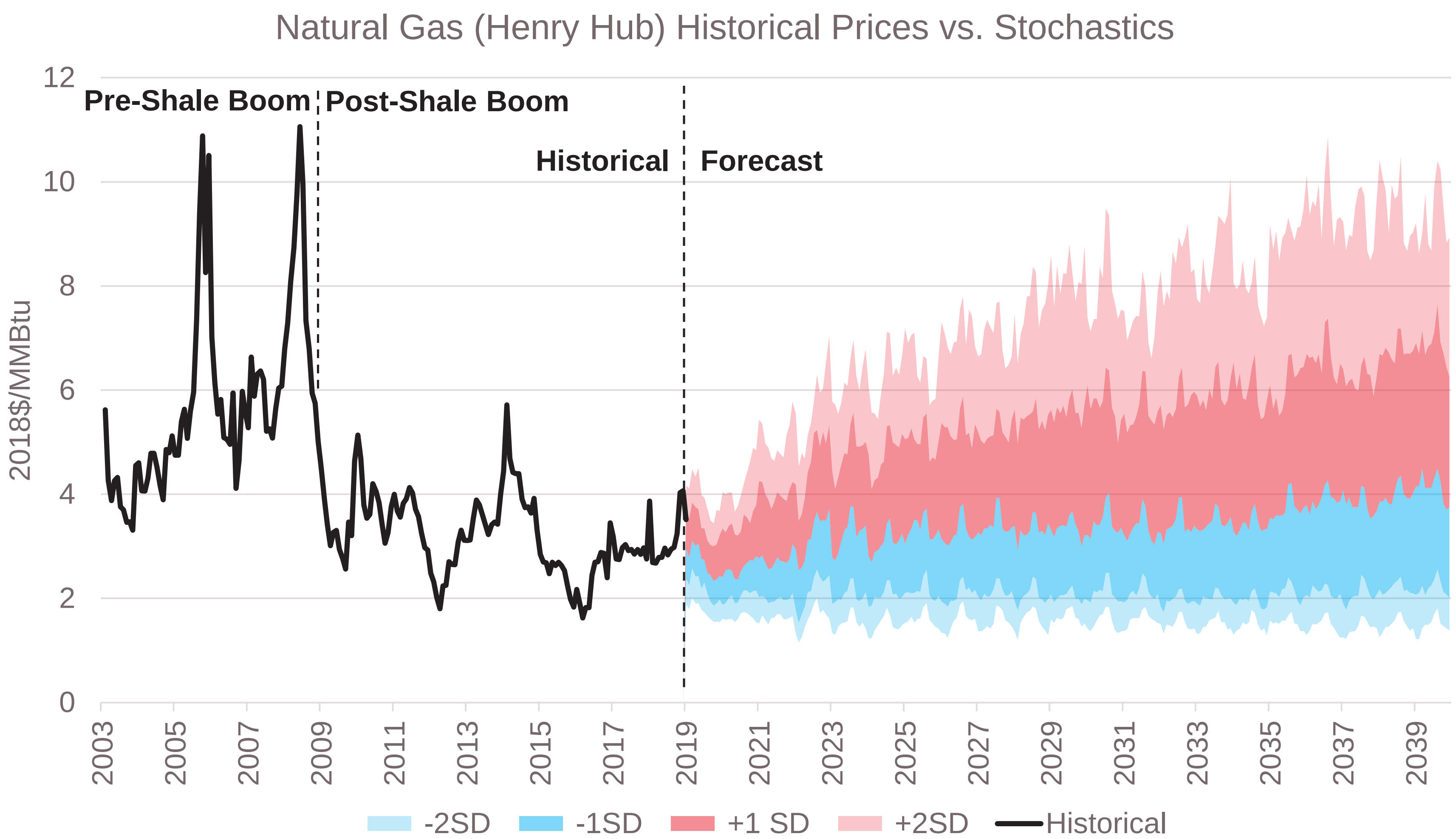
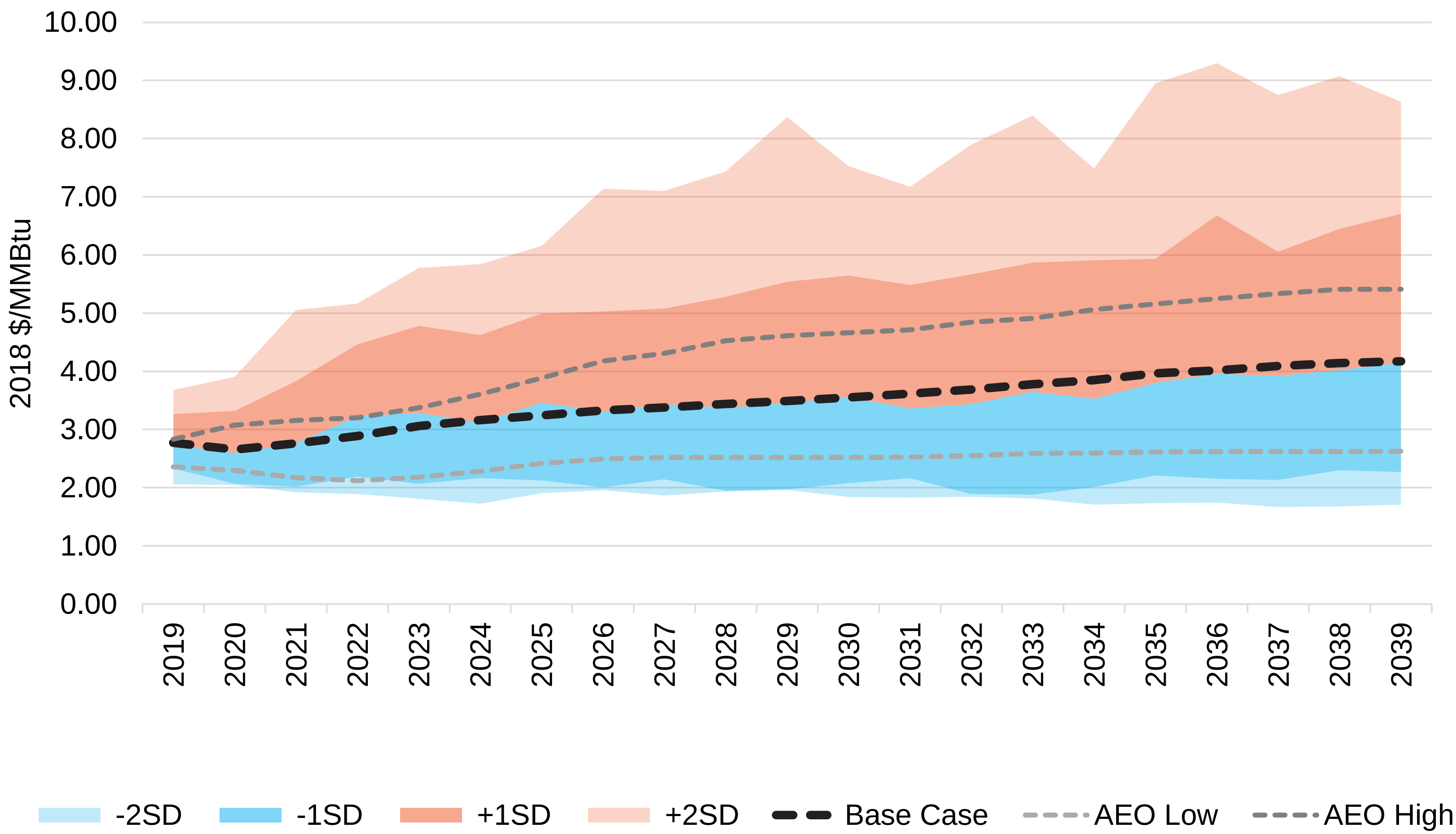
HISTORICAL PRICES VS. STOCHASTICS



HENRY HUB GAS PRICE DISTRIBUTIONS AND: COMPARISON TO EIA AEO[1] 2019



1Source:Energy Information Administration (EIA) Annual Energy Outlook (AEO) https://www.eia.gov/outlooks/aeo/
EIA Low = AEO 2019: High Oil & Gas Resource and Technology scenario
EIA High = AEO 2019: Low Oil & Gas Resource and Technology scenario

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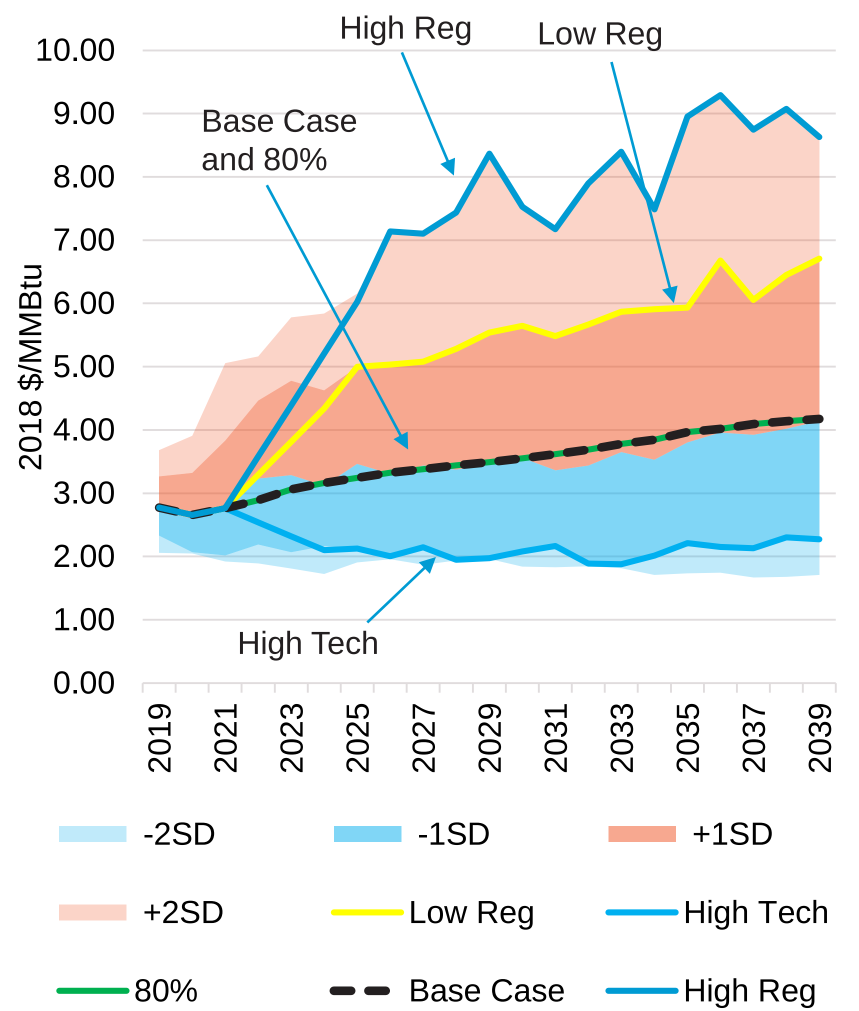
SCENARIO INPUTS: NATURAL GAS HENRY HUB (2018$/MMBTU)[1]

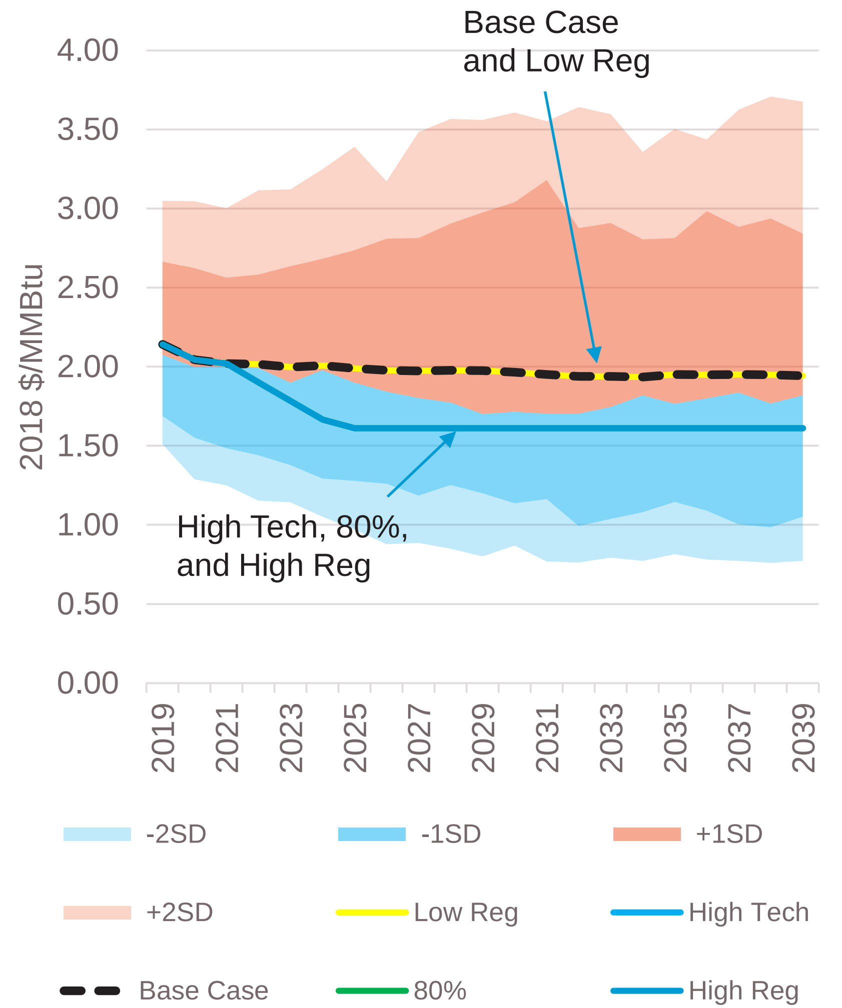
	Base Case	Low Reg	High Tech	80% Reduction	High Reg
2019	2.77	2.77	2.77	2.77	2.77
2020	2.66	2.66	2.66	2.66	2.66
2021	2.76	2.76	2.76	2.76	2.76
2022	2.89	3.46	3.01	2.89	3.58
2023	3.06	4.10	2.82	3.06	4.39
2024	3.16	4.75	2.64	3.16	5.21
2025	3.24	5.12	2.33	3.24	6.03
2026	3.33	5.27	2.08	3.33	7.14
2027	3.38	5.20	2.13	3.38	7.10
2028	3.44	5.45	2.06	3.44	7.43
2029	3.49	5.62	2.04	3.49	8.37
2030	3.55	5.77	2.12	3.55	7.53
2031	3.62	5.60	2.13	3.62	7.17
2032	3.69	5.76	1.97	3.69	7.89
2033	3.78	5.95	2.02	3.78	8.40
2034	3.85	6.02	1.95	3.85	7.49
2035	3.96	6.12	2.12	3.96	8.95
2036	4.02	6.64	2.12	4.02	9.29
2037	4.09	6.23	2.07	4.09	8.75
2038	4.14	6.77	2.19	4.14	9.07
2039	4.17	6.85	2.20	4.17	8.63



1 Modeling will include estimated inflation of 2.2% per year

SCENARIO INPUTS: ILLINOIS BASIN COAL DELIVERED TO BROWN (2018$/MMBTU) [1]

	Base Case	Low Reg	High Tech	80% Reduction	High Reg
2019	2.14	2.14	2.14	2.14	2.14
2020	2.04	2.04	2.04	2.04	2.04
2021	2.02	2.02	2.02	2.02	2.02
2022	2.02	2.02	1.90	1.90	1.90
2023	2.00	2.00	1.78	1.78	1.78
2024	2.01	2.01	1.67	1.67	1.67
2025	1.99	1.99	1.61	1.61	1.61
2026	1.98	1.98	1.61	1.61	1.61
2027	1.97	1.97	1.61	1.61	1.61
2028	1.98	1.98	1.61	1.61	1.61
2029	1.97	1.97	1.61	1.61	1.61
2030	1.97	1.97	1.61	1.61	1.61
2031	1.95	1.95	1.61	1.61	1.61
2032	1.94	1.94	1.61	1.61	1.61
2033	1.94	1.94	1.61	1.61	1.61
2034	1.93	1.93	1.61	1.61	1.61
2035	1.95	1.95	1.61	1.61	1.61
2036	1.95	1.95	1.61	1.61	1.61
2037	1.95	1.95	1.61	1.61	1.61
2038	1.95	1.95	1.61	1.61	1.61
2039	1.94	1.94	1.61	1.61	1.61

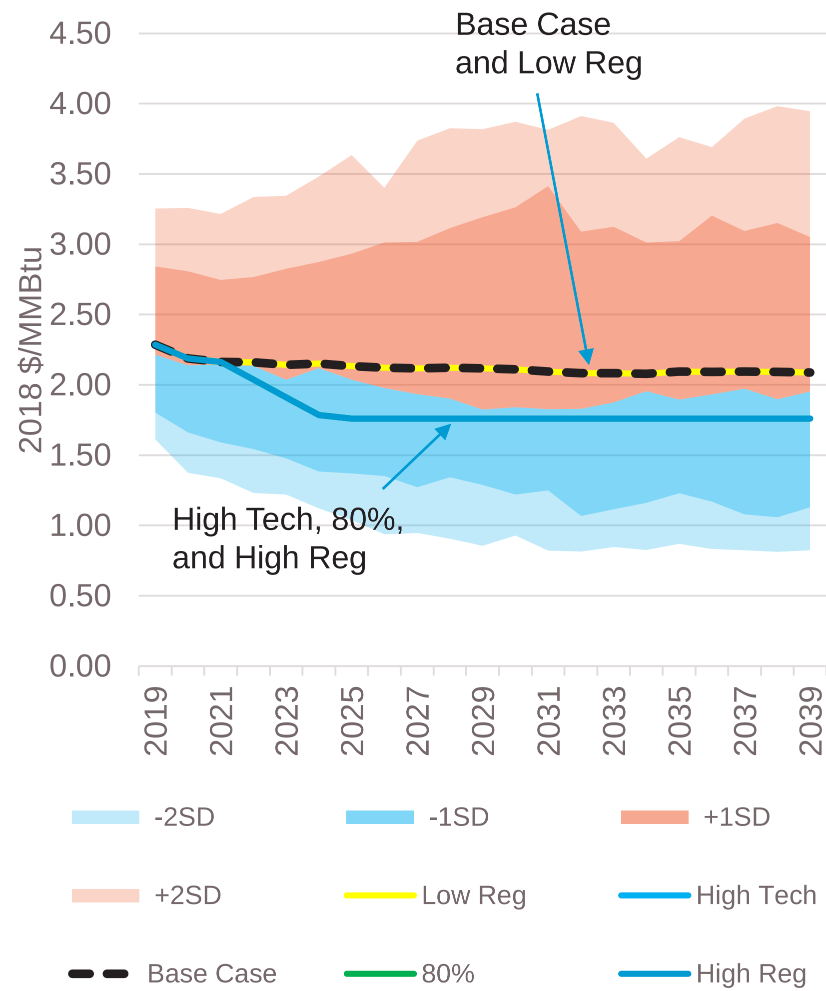


A price floor is set at $1.61/MMBtu

1 Modeling will include estimated inflation of 2.2% per year

SCENARIO INPUTS: ILLINOIS BASIN COAL DELIVERED TO CULLEY (2018$/MMBTU) [1]

	Base Case	Low Reg	High Tech	80% Reduction	High Reg
2019	2.29	2.29	2.29	2.29	2.29
2020	2.19	2.19	2.19	2.19	2.19
2021	2.16	2.16	2.16	2.16	2.16
2022	2.16	2.16	2.04	2.04	2.04
2023	2.14	2.14	1.91	1.91	1.91
2024	2.15	2.15	1.78	1.78	1.78
2025	2.13	2.13	1.76	1.76	1.76
2026	2.12	2.12	1.76	1.76	1.76
2027	2.12	2.12	1.76	1.76	1.76
2028	2.12	2.12	1.76	1.76	1.76
2029	2.12	2.12	1.76	1.76	1.76
2030	2.11	2.11	1.76	1.76	1.76
2031	2.09	2.09	1.76	1.76	1.76
2032	2.08	2.08	1.76	1.76	1.76
2033	2.08	2.08	1.76	1.76	1.76
2034	2.08	2.08	1.76	1.76	1.76
2035	2.09	2.09	1.76	1.76	1.76
2036	2.09	2.09	1.76	1.76	1.76
2037	2.10	2.10	1.76	1.76	1.76
2038	2.09	2.09	1.76	1.76	1.76
2039	2.09	2.09	1.76	1.76	1.76



A price floor is set at $1.76/MMBtu

1 Modeling will include estimated inflation of 2.2% per year

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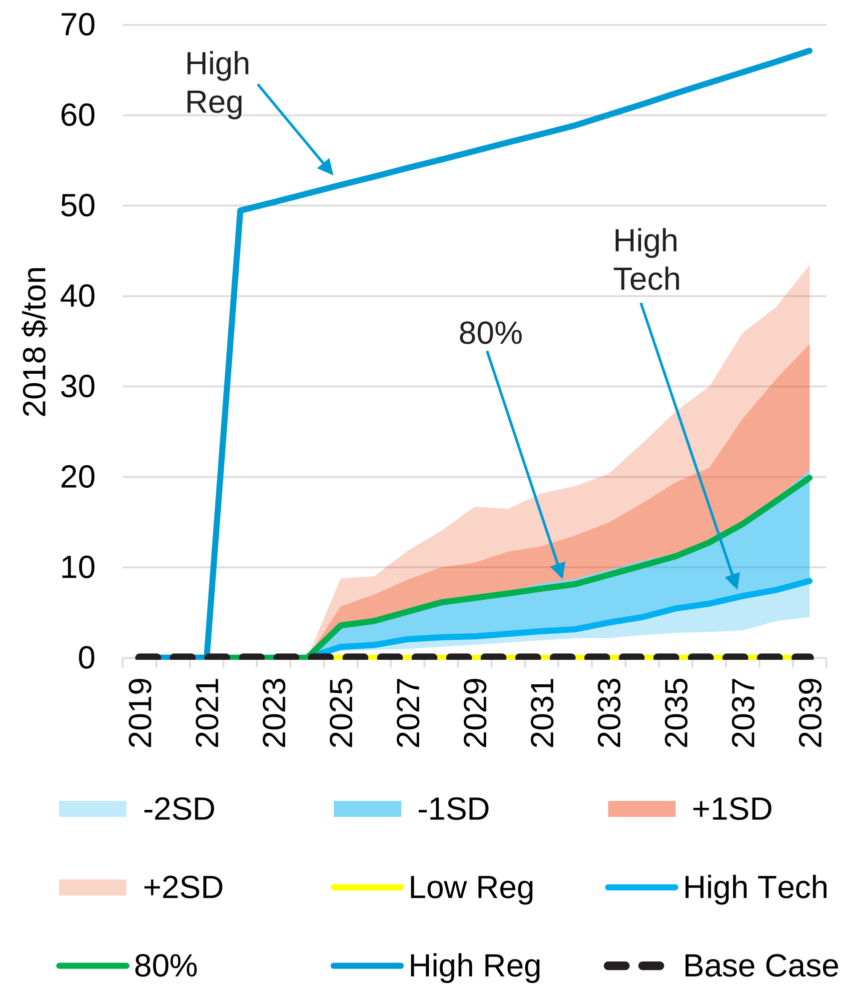
SCENARIO INPUTS: CO2 PRICE (2018$/TON) [1]

	Base Case	Low Reg	High Tech	80% Reduction	High Reg
2019	0	0	0	0	0
2020	0	0	0	0	0
2021	0	0	0	0	0
2022	0	0	0	0	49.46
2023	0	0	0	0	50.40
2024	0	0	0	0	51.34
2025	0	0	1.20	3.57	52.28
2026	0	0	1.44	4.08	53.23
2027	0	0	2.06	5.10	54.17
2028	0	0	2.28	6.12	55.11
2029	0	0	2.38	6.63	56.05
2030	0	0	2.68	7.14	56.99
2031	0	0	2.94	7.65	57.94
2032	0	0	3.17	8.16	58.88
2033	0	0	3.89	9.18	60.06
2034	0	0	4.49	10.20	61.23
2035	0	0	5.46	11.22	62.41
2036	0	0	6.01	12.75	63.59
2037	0	0	6.85	14.79	64.77
2038	0	0	7.52	17.34	65.94
2039	0	0	8.50	19.89	67.12



1 Modeling will include estimated inflation of 2.2% per year

SCENARIO INPUTS: VECTREN PEAK LOAD (MW)

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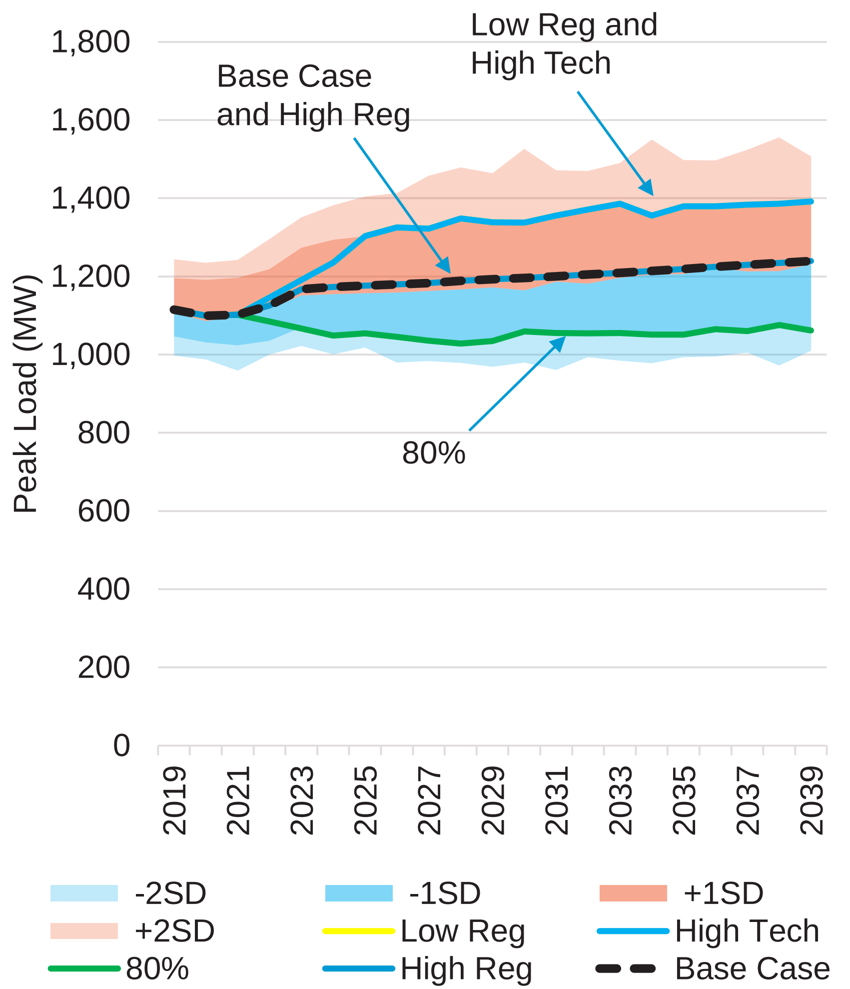
	Base Case	Low Reg	High Tech	80% Reduction	High Reg
2019	1,115	1,115	1,115	1,115	1,115
2020	1,100	1,100	1,100	1,100	1,100
2021	1,102	1,102	1,102	1,102	1,102
2022	1,126	1,146	1,146	1,084	1,126
2023	1,168	1,191	1,191	1,066	1,168
2024	1,173	1,235	1,235	1,049	1,173
2025	1,176	1,303	1,303	1,055	1,176
2026	1,179	1,325	1,325	1,045	1,179
2027	1,183	1,322	1,322	1,036	1,183
2028	1,189	1,348	1,348	1,028	1,189
2029	1,192	1,338	1,338	1,035	1,192
2030	1,196	1,337	1,337	1,059	1,196
2031	1,200	1,356	1,356	1,055	1,200
2032	1,205	1,371	1,371	1,055	1,205
2033	1,209	1,386	1,386	1,056	1,209
2034	1,214	1,356	1,356	1,051	1,214
2035	1,219	1,379	1,379	1,051	1,219
2036	1,225	1,379	1,379	1,065	1,225
2037	1,229	1,383	1,383	1,060	1,229
2038	1,234	1,386	1,386	1,076	1,234
2039	1,239	1,391	1,391	1,062	1,239



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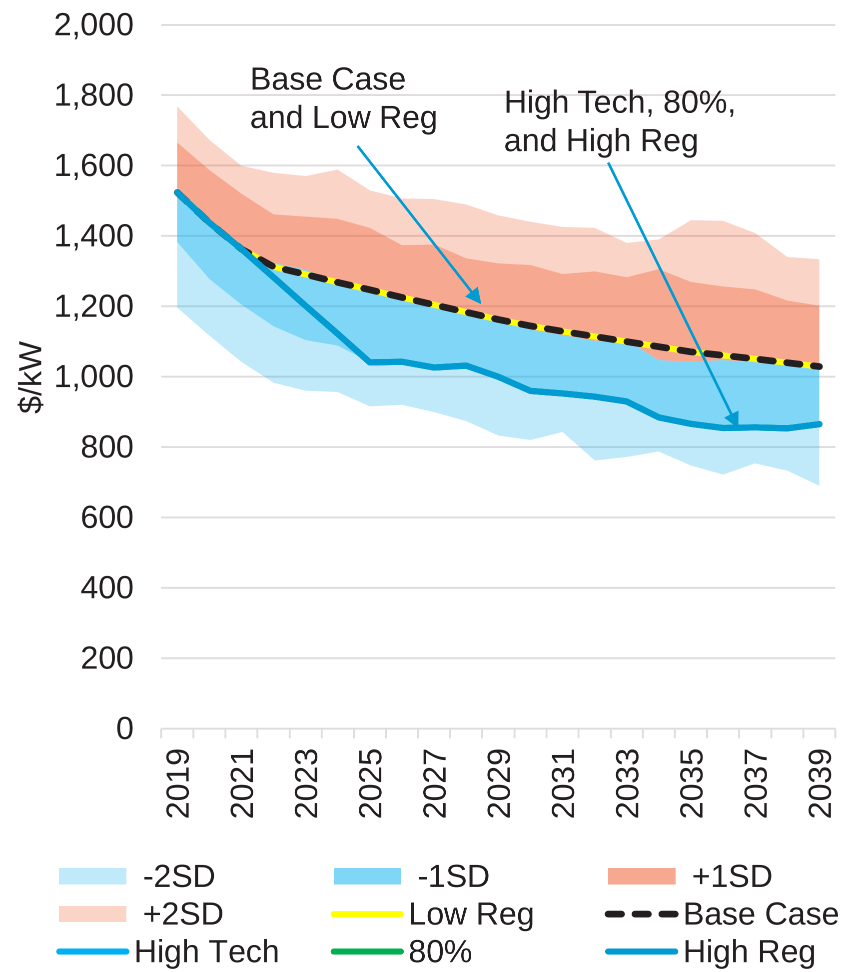
SCENARIO INPUTS: CAPITAL COST SOLAR (100 MW) (2018$/KW) [1]

	Base Case	Low Reg	High Tech	80% Reduction	High Reg
2019	1,524	1,524	1,524	1,524	1,524
2020	1,438	1,438	1,438	1,438	1,438
2021	1,362	1,362	1,362	1,362	1,362
2022	1,313	1,313	1,282	1,282	1,282
2023	1,290	1,290	1,202	1,202	1,202
2024	1,268	1,268	1,121	1,121	1,121
2025	1,247	1,247	1,041	1,041	1,041
2026	1,225	1,225	1,042	1,042	1,042
2027	1,204	1,204	1,026	1,026	1,026
2028	1,183	1,183	1,031	1,031	1,031
2029	1,162	1,162	999	999	999
2030	1,144	1,144	960	960	960
2031	1,129	1,129	952	952	952
2032	1,114	1,114	944	944	944
2033	1,100	1,100	929	929	929
2034	1,085	1,085	884	884	884
2035	1,070	1,070	866	866	866
2036	1,061	1,061	854	854	854
2037	1,050	1,050	856	856	856
2038	1,040	1,040	853	853	853
2039	1,029	1,029	865	865	865



1 Modeling will include estimated inflation of 2.2% per year

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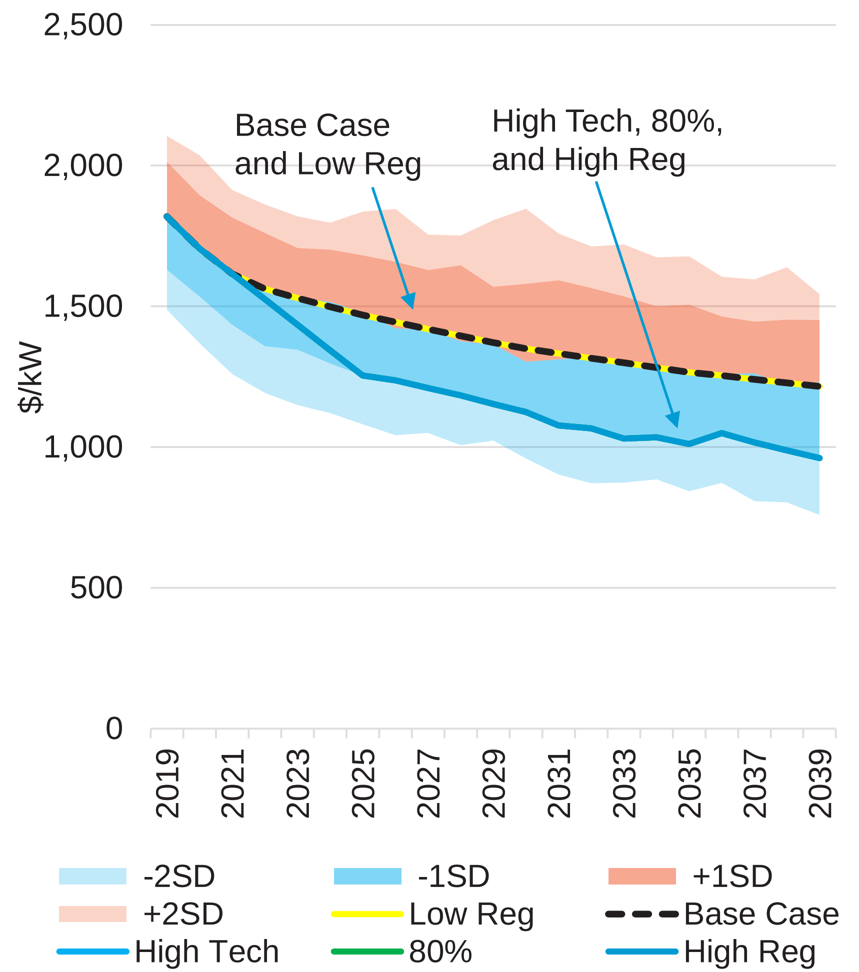
SCENARIO INPUTS: CAPITAL COST
SOLAR+STORAGE (50 MW PV + 10 MW/ 40 MWH STORAGE) [1]

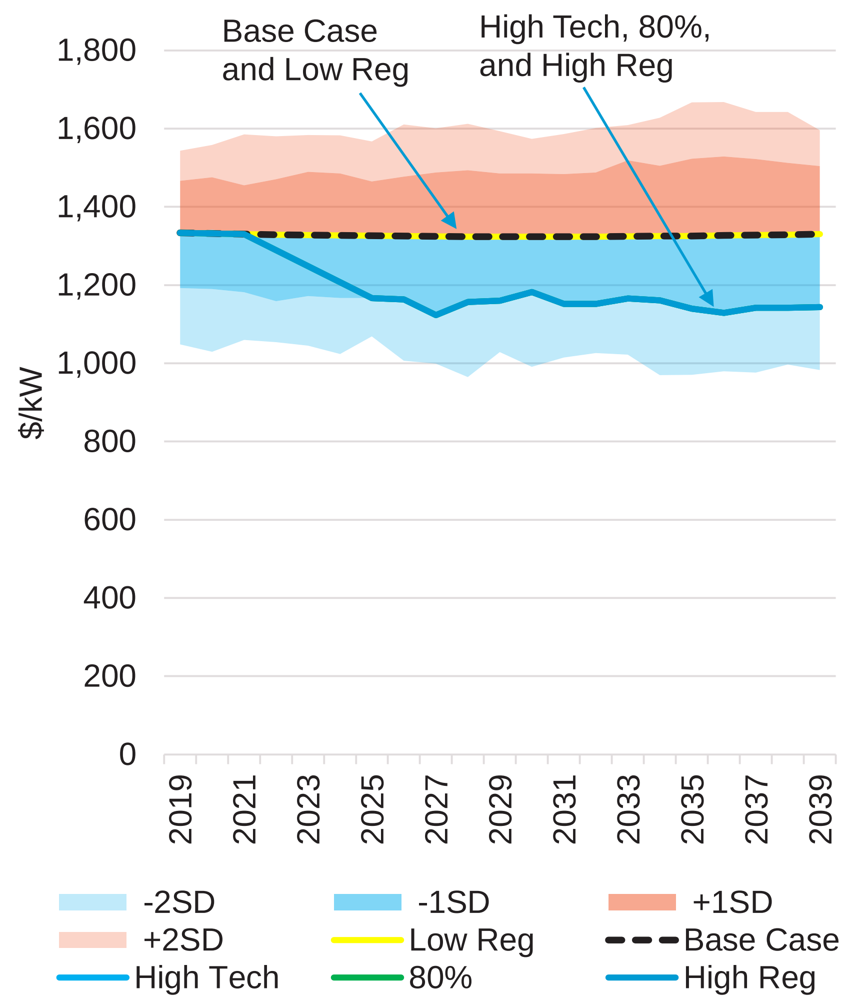
	Base Case	Low Reg	High Tech	80% Reduction	High Reg
2019	1,820	1,820	1,820	1,820	1,820
2020	1,705	1,705	1,705	1,705	1,705
2021	1,616	1,616	1,616	1,616	1,616
2022	1,562	1,562	1,526	1,526	1,526
2023	1,529	1,529	1,435	1,435	1,435
2024	1,499	1,499	1,344	1,344	1,344
2025	1,469	1,469	1,254	1,254	1,254
2026	1,443	1,443	1,237	1,237	1,237
2027	1,419	1,419	1,210	1,210	1,210
2028	1,395	1,395	1,183	1,183	1,183
2029	1,371	1,371	1,153	1,153	1,153
2030	1,349	1,349	1,124	1,124	1,124
2031	1,332	1,332	1,077	1,077	1,077
2032	1,316	1,316	1,066	1,066	1,066
2033	1,299	1,299	1,031	1,031	1,031
2034	1,282	1,282	1,034	1,034	1,034
2035	1,266	1,266	1,011	1,011	1,011
2036	1,254	1,254	1,049	1,049	1,049
2037	1,241	1,241	1,016	1,016	1,016
2038	1,228	1,228	988	988	988
2039	1,215	1,215	961	961	961



1 Modeling will include estimated inflation of 2.2% per year

SCENARIO INPUTS: CAPITAL COST WIND (200 MW) (2018$/KW) [1]

	Base Case	Low Reg	High Tech	80% Reduction	High Reg
2019	1,334	1,334	1,334	1,334	1,334
2020	1,332	1,332	1,332	1,332	1,332
2021	1,330	1,330	1,330	1,330	1,330
2022	1,329	1,329	1,289	1,289	1,289
2023	1,328	1,328	1,249	1,249	1,249
2024	1,327	1,327	1,208	1,208	1,208
2025	1,326	1,326	1,167	1,167	1,167
2026	1,325	1,325	1,163	1,163	1,163
2027	1,324	1,324	1,123	1,123	1,123
2028	1,324	1,324	1,157	1,157	1,157
2029	1,324	1,324	1,160	1,160	1,160
2030	1,324	1,324	1,182	1,182	1,182
2031	1,324	1,324	1,152	1,152	1,152
2032	1,324	1,324	1,152	1,152	1,152
2033	1,324	1,324	1,166	1,166	1,166
2034	1,325	1,325	1,161	1,161	1,161
2035	1,326	1,326	1,139	1,139	1,139
2036	1,327	1,327	1,129	1,129	1,129
2037	1,328	1,328	1,142	1,142	1,142
2038	1,329	1,329	1,142	1,142	1,142
2039	1,330	1,330	1,143	1,143	1,143



1 Modeling will include estimated inflation of 2.2% per year

FEEDBACK AND DISCUSSION

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LONG-TERM BASE ENERGY AND DEMAND FORECAST

Michael Russo, Sr. Forecast Consultant

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FORECAST SUMMARY

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- Moderate energy growth
  - Annual energy and demand growth of 0.6%[1]
  - Slow long-term population growth (0.2% annual growth) & moderate output growth (1.7% annual growth)
  - Strong end-use efficiency gains reflecting new and existing Federal codes and standards
    - Air conditioning, heating, lighting, refrigeration, cooking, etc. are becoming more efficient over time
  - Market-driven solar adoption
  - Electric vehicle projections based on EIA 2019 Annual Energy Outlook

[1] Future energy efficiency programs are not included in the sales and demand forecast and will be considered a resource option

BOTTOM-UP FORECAST APPROACH

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Energy, Customers, & Price

Population and Economic Drivers

Appliance Saturation and Efficiency

Historical utility DSM savings

Customer Energy Forecast
- Residential
- Commercial
- Industrial
- Street Lighting

Long-term, 20-Year Average Weather

System Hourly Load

System Energy and Peak Forecast

20-Year Avg. Peak-Day Weather

Customer-Owned Generation Forecast

Electric Vehicle Forecast

ECONOMIC DRIVERS

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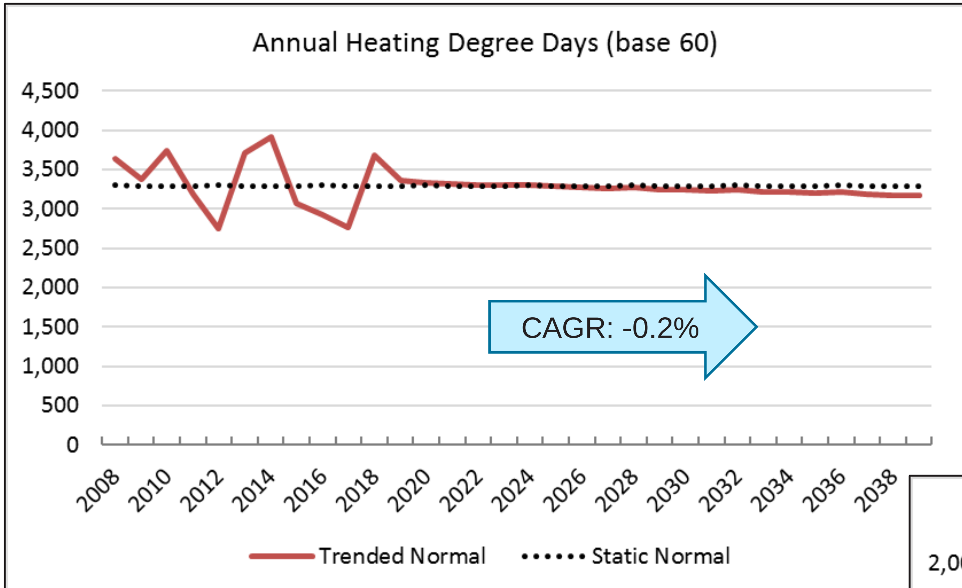
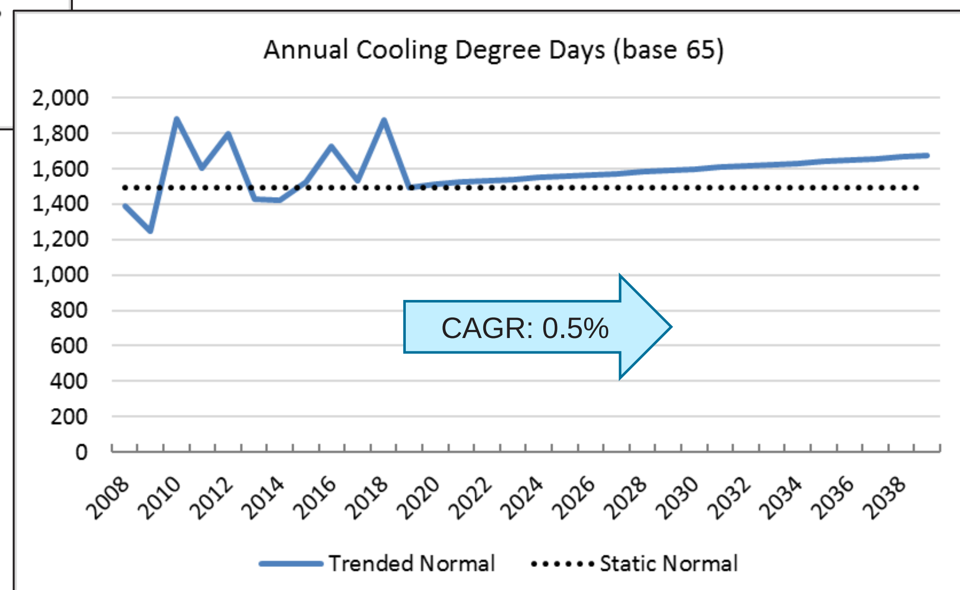
Moody's Analytic forecast for the Evansville MSA

- Residential Sector
  - Households: 0.4% CAGR
  - Real Household Income: 1.6% CAGR
  - Household Size -0.3% CAGR
- Commercial Sector
  - Non-Manufacturing Output: 1.7% CAGR
  - Non-Manufacturing Employment : 0.6% CAGR
  - Population 0.2% CAGR
- Industrial Sector
  - Manufacturing Output: 1.8% CAGR
  - Manufacturing Employment: -0.5% CAGR

TRENDED NORMAL WEATHER

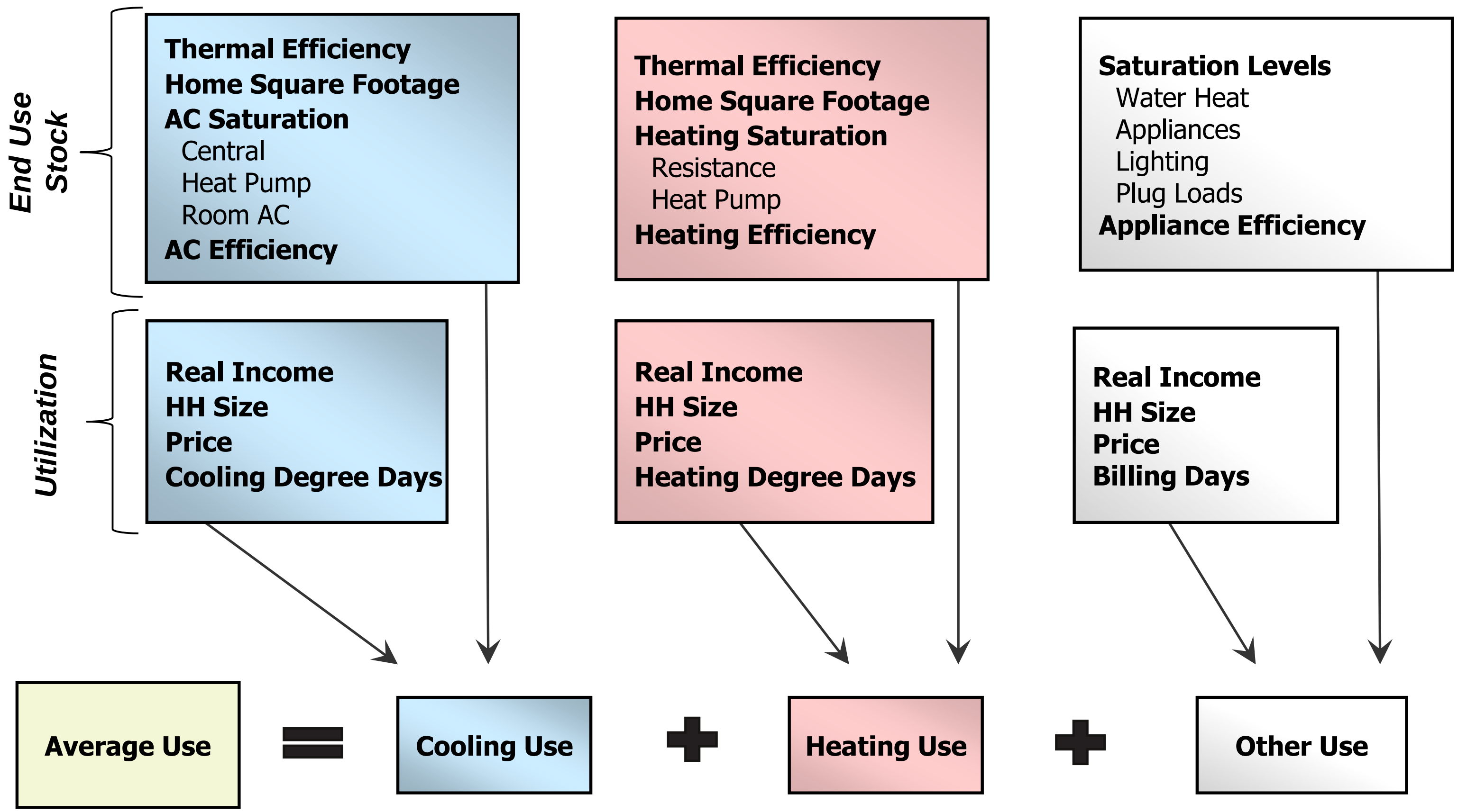


- Average temperature is increasing
  - Decline in HDD (warmer winters)
  - Increase in CDD (hotter summers)

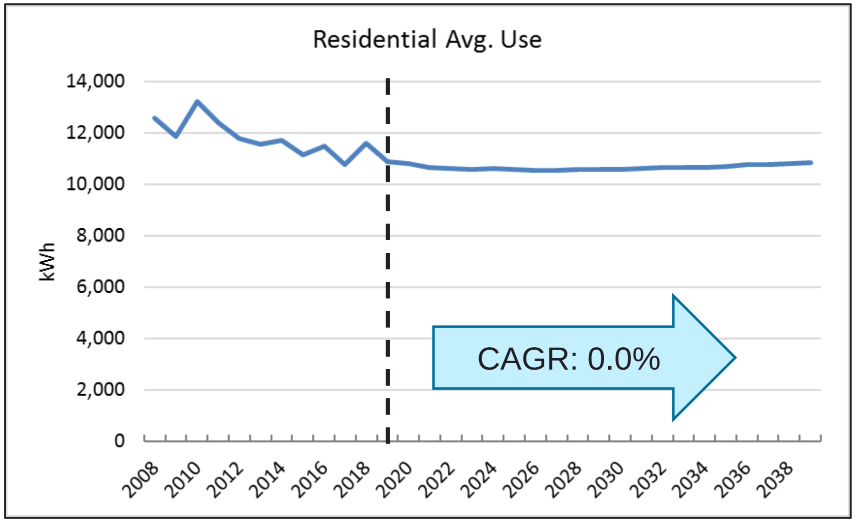


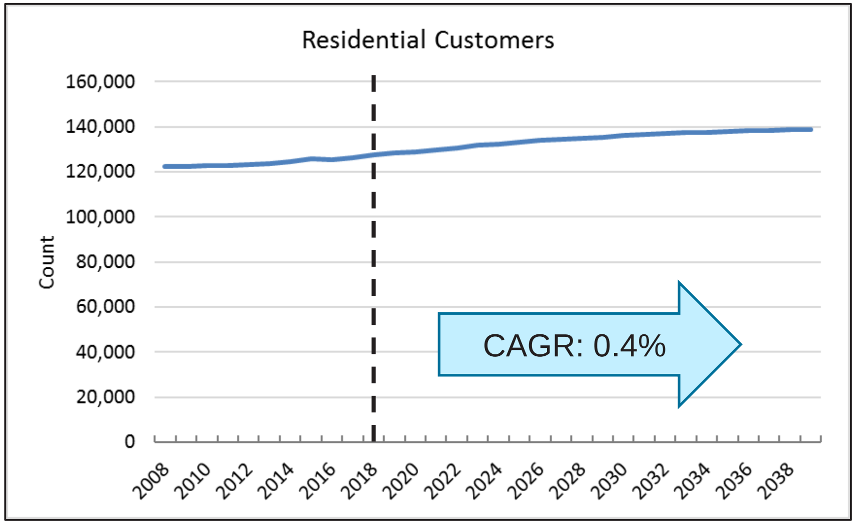
- Temperature trend based on statistical analysis of historical temperature data (1988 to 2018)

RESIDENTIAL AVERAGE USE MODEL

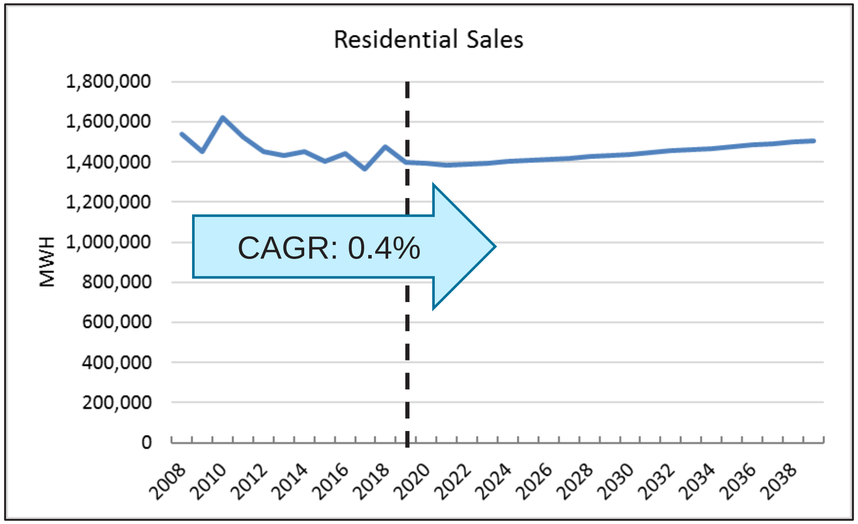


RESIDENTIAL FORECAST

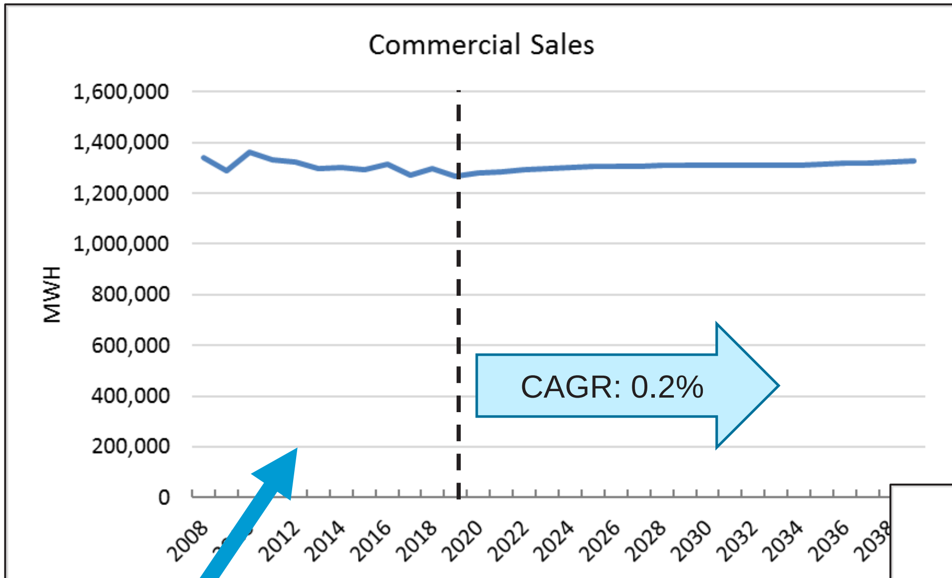


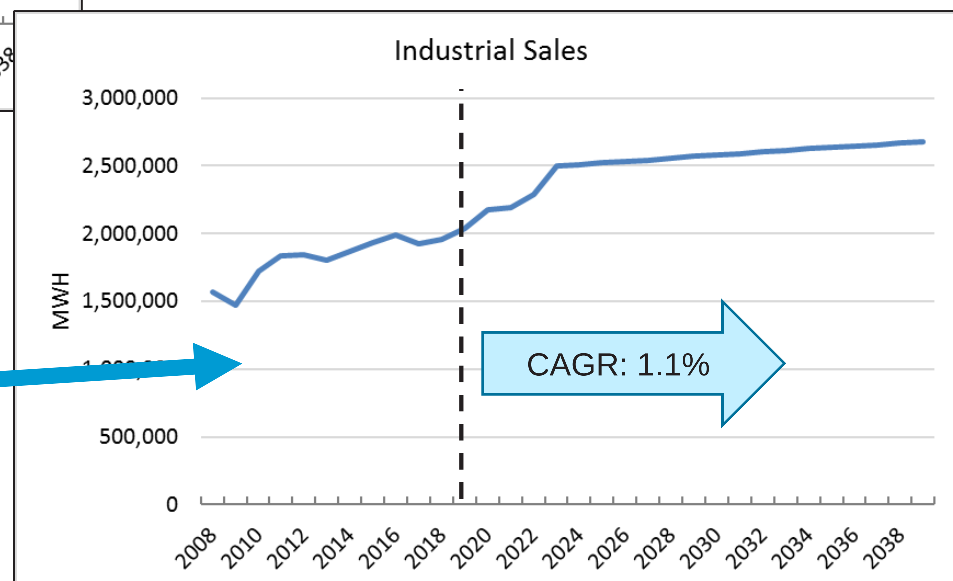


- Flat average use forecast, does not include the impact of future DSM program activity



C&I SALES FORECAST





- Increase in commercial business activity countered by end-use efficiency gains
- Strong industrial sales growth related to near-term expected industrial expansion

* Excludes future energy efficiency program impacts and customer-owned DG

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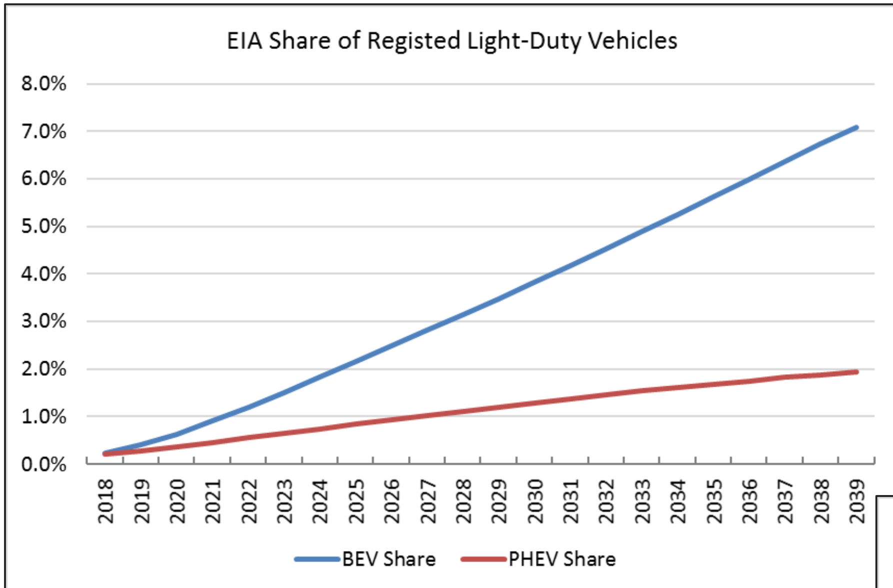
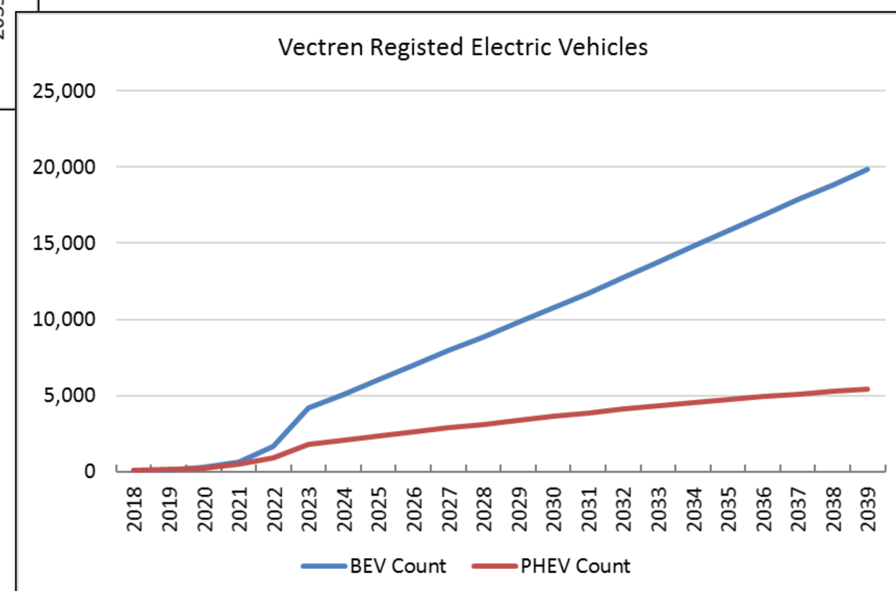
ELECTRIC VEHICLES



- Energy Information Administration (EIA) forecast based on share of total registered vehicles; differentiating between all electric (BEV) and plug-in hybrid electric (PHEV)



- Average annual kWh per vehicle based on weighted average of current registered BEV/PHEV
  – 3,752 kWh per BEV
  – 2,180 kWh per PHEV

CUSTOMER OWNED PV

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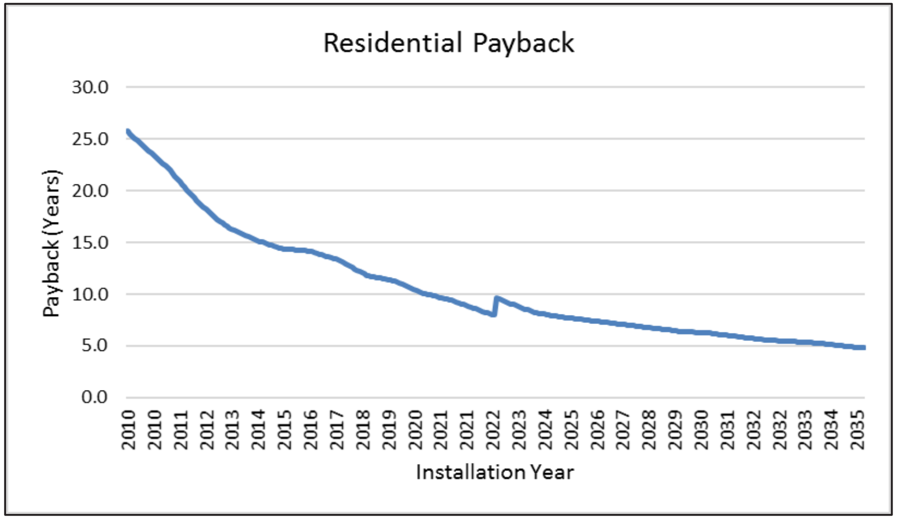
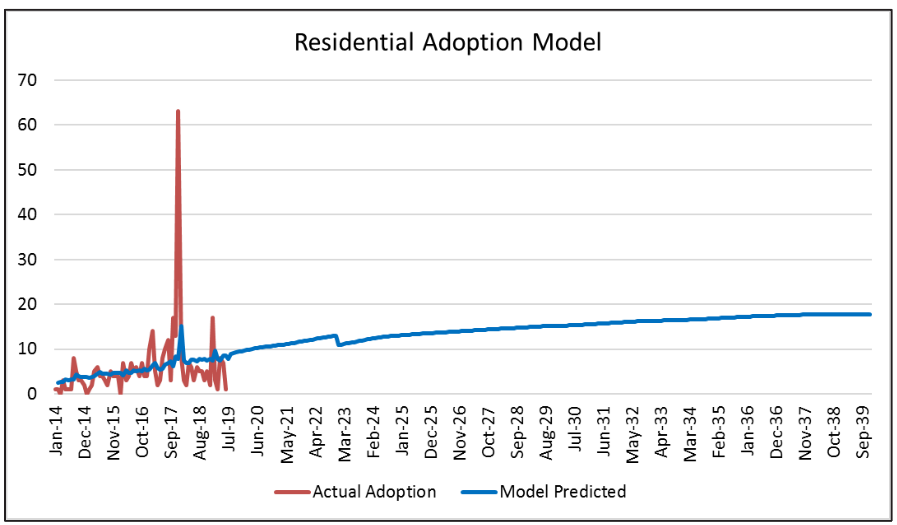


- Customer economics defined using simple payback
  - – incorporates declining solar system costs, electric price projections, changes in net metering laws, and federal incentives



- Monthly adoption based on simple payback

ENERGY & DEMAND FORECAST

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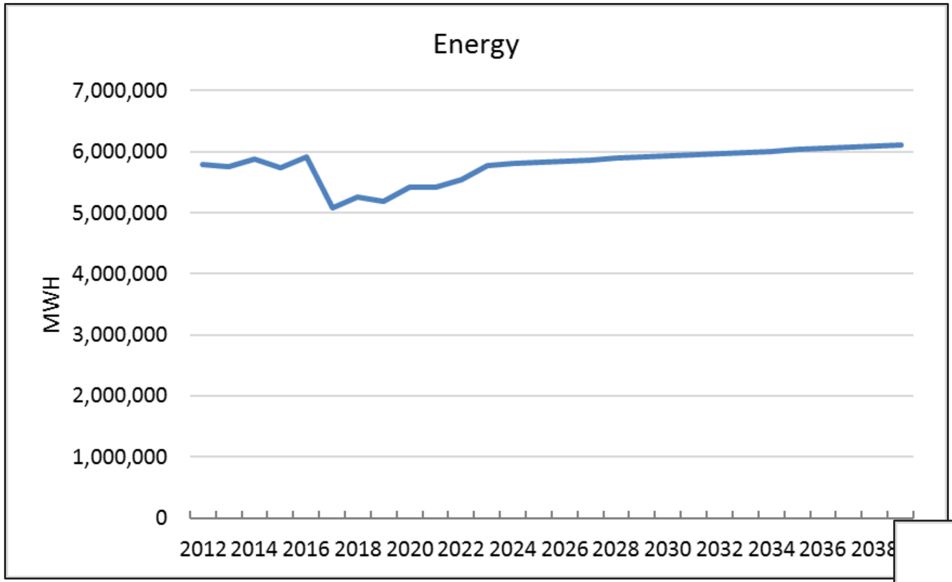

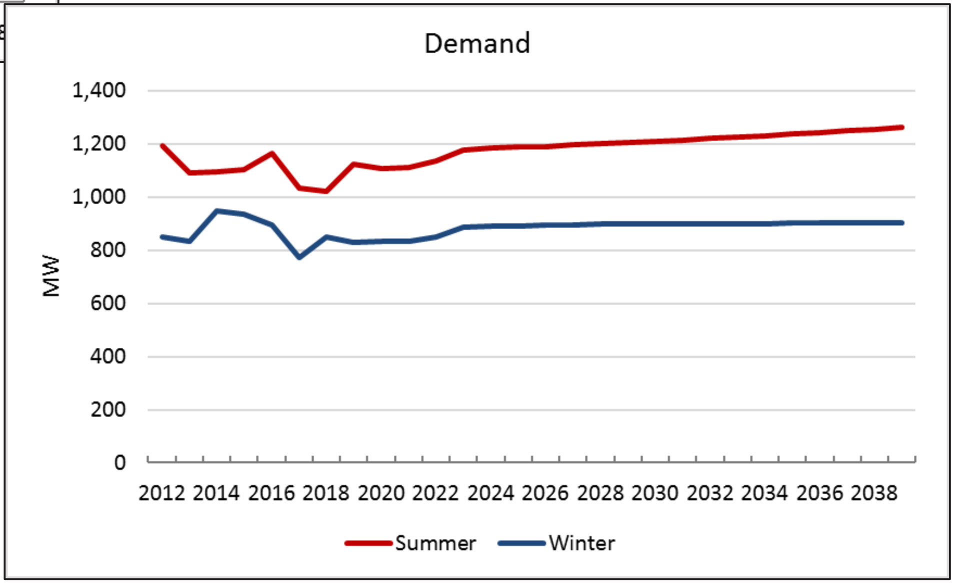

- Combining economic growth, end-use efficiency, and adoption of new technologies, and trended weather results in 0.6% long-term energy and summer demand CAGR (2020-2039)*

* Excludes future energy efficiency programs. Includes a forecast of customer owned solar generation and forecast for electric vehicle penetration. Excludes company owned generation on the distribution system

FEEDBACK AND DISCUSSION

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EXISTING RESOURCE OVERVIEW

WAYNE GAMES

VECTREN VICE PRESIDENT POWER GENERATION OPERATIONS

EXISTING RESOURCE SUMMARY

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- Vectren is doing an exhaustive look at options for existing coal resources, including continued operation, retirement and coal to gas conversion of units
- Vectren must comply with EPA regulations; as such we are performing several studies to determine compliance options
- There is risk for Vectren in continued joint operation or sole ownership options as it pertains to Warrick 4

DEFINITIONS

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- ACE – Affordable Clean Energy Rule; Carbon rule that establishes emission guidelines for states to use when developing plans to limit CO_2 (improve heat rate) at their coal fired power plants
  - Heat rate improvements can be achieved through equipment upgrades or operation & maintenance practices
  - State of Indiana expected to issue requirement to comply in 2021
- Capacity Factor – The amount of energy a resource produces in a given period of time divided by the maximum amount of energy the resource is capable of producing during the same period of time
- CCR – Coal Combustion Residuals
- $EFOR_d$ – Equivalent Forced Outage Rate Demand; reliability measure used by MISO in the calculation of capacity accreditation for thermal resources
- Heat Rate – Measure of efficiency of a thermal generating resource; lower values represent better efficiency
- ICAP – Installed capacity of a resource
- MW – Megawatt
- PPA – Purchase Power Agreement
- UCAP – Unforced capacity; capacity credit a market participant receives from MISO for their resources
  - Thermal resources are based on tested unit output and 3 year historical $EFOR_d$ (Takes into account forced outages and forced derates)
  - Intermittent resources are based on historical output during peak summer hours
    - Solar resources without operating data default to a credit of 50% of installed capacity
    - Wind resources without operating default to the MISO system wide wind capacity credit from the effective load carrying capability (ELCC) study
      - Received 8% and 9.2% capacity credit for current wind PPA’s in 2019-2020 planning year
- FGD – Flue gas desulfurization

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SUMMARY OF CURRENT RESOURCE UCAP ACCREDITATION FOR SUMMER PEAK

Resource	Fuel \ Technology	Installed Net Capacity (MW)	2019-2020 MISO Planning Year UCAP[2] (MW)	2020-2021 MISO Planning Year UCAP[2] Projection (MW)	ICAP Conversion to UCAP (%) – 2020-2021 Planning Year Projection
A.B. Brown 1	Coal (24x7 Power)	245	209	232	Coal Fleet 92%
A.B. Brown 2	Coal (24x7 Power)	245	225	234	
F.B. Culley 2	Coal (24x7 Power)	90	86	86	
F.B. Culley 3	Coal (24x7 Power)	270	251	247	
Warrick 4	Coal (24x7 Power)	150[1]	127	118	
OVEC	Coal (24x7 Power)	32	30	30	
A.B. Brown 3	Natural Gas (Peaking)	85	71	73	Natural Gas (Peaking) 85%
A.B. Brown 4	Natural Gas (Peaking)	85	71	72	
Demand Response	N/A	62	62	62	Demand Response 100%
Benton County	Wind (Intermittent)	30	2	2	Wind 9%
Fowler Ridge	Wind (Intermittent)	50	5	5	
50 MW Solar	Solar (Intermittent)	50	0	0[3]	N/A
Total		**1,344**	**1,139**	**1,161**	

1 – Vectren Share
2 – Unforced capacity
3 – 25MW of UCAP projected for 2021-2022 MISO planning year

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IRP OPTIONS FOR EXISTING COAL RESOURCES

- Continued operation of existing solely owned coal units –
  - Brown 1 & 2 and Culley 2
    - Cost to comply with CCR/ELG environmental requirements
    - Cost to comply with ACE requirements
    - AB Brown FGD replacement (Study performed to estimate cost for different technologies to identify best path forward)
  - Culley 3
    - IURC approval to install technologies to comply with CCR/ELG
    - Cost to comply with ACE requirement
- Retirement of Brown 1 & Brown 2 in 2029
    - Cost to comply with CCR/ELG environmental requirements
    - Cost to comply with ACE requirements[1]
    - Continue existing FGD operation
- Natural gas conversion for Brown 1, Brown 2, and Culley 2
- Retirement of Brown 1, Brown 2, and Culley 2 in 2023
- Extend or exit Warrick Unit 4 partnership; (agreement currently set to expire at the end of 2023)

1 - Costs are estimates pending the final IDEM implementation plan for Indiana.

RENEWABLES

- Solar (54 MW installed capacity)
  - Two 2 MW solar fields (behind the meter generation)
    - Both fields went in service late in 2018
    - 1 MW/4 MWH energy storage system connected at Volkman Road site
  - 50 MW solar field
    - Finalizing engineering & design and preparing to order materials
    - Currently scheduled for commercial operation in late 2020 to early 2021
- Wind PPA contracts (80 MW installed capacity)
  - Benton County
    - Contract for 30 MW of installed capacity expires in 2028
  - Fowler Ridge
    - Contract for 50 MW of installed capacity expires in 2030
- Blackfoot Landfill Gas (behind the meter generation)
  - Units are capable of producing 3 MW combined

COMBUSTION TURBINES (NATURAL GAS PEAKING UNITS)

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- Broadway Avenue Generating Station 1; 53 MW installed capacity
  - Retired in 2018
- Northeast units 1 and 2 (10 MW installed capacity each)
  - Retired in early 2019
- Broadway Avenue Generating Station 2; 65 MW installed capacity
  - Currently in process of retirement through MISO process
    - Typical life is 30-40 years; Unit has been in service for 38 years
    - Highest heat rate (least efficient) of current generating fleet
    - Recent five year capacity factor just over 1%
    - Several millions dollars needed for known repairs
    - High probability of additional expenses in the near future given current age and condition
- Brown 3; 85 MW installed capacity
  - Black start capabilities (able to burn fuel oil)
  - No upgrades required for continued operation
- Brown 4; 85 MW installed capacity
  - No upgrades required for continued operation

F.B. CULLEY OPTIONS

- Culley 2; 90 MW installed coal capacity
  - Business as usual (continue beyond 2023)
    - Requires CCR (Coal Combustion Residuals) and Effluent Limit Guidelines (ELG) compliance
    - Compliance with ACE (Affordable Clean Energy) rule; unit upgrades & improvements
  - Natural Gas Conversion
    - Preserve existing capacity
    - High cost energy
    - Anticipate low capacity factor with high reliance on market
  - Retirement in 2023 to avoid environmental investments

Business As Usual

Regulation	Upgrade	Estimated Cost	Potential Efficiency Improvement
CCR/ELG	Dry Bottom Ash Conversion	$6 million	N/A

Business As Usual

Regulation	Potential Upgrade/Projects	Estimated Cost	Potential Efficiency Improvement
ACE	• Turbine Upgrade • Air heater • Variable Frequency Drives • Boiler program • Condenser work • O&M Practices	$30 million[1]	~4-4.5%

Natural Gas Conversion

Item	Estimated Cost
Modifications to convert unit to natural gas firing	$46 million
Gas pipeline construction	$11 million
Total	**$57 million**

1 – Costs are estimates pending the final IDEM implementation plan for Indiana

F.B. CULLEY OPTIONS (CONT.)

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- Culley 3; 270 MW installed coal capacity
  - Moving forward with upgrades approved in cause 45052 to comply with CCR (Coal Combustion Residuals) and ELG (Effluent Limitations Guidelines)[1]
  - Compliance with ACE (Affordable Clean Energy) rule; requires unit upgrades to improve efficiency

Business As Usual

Regulation	Potential Upgrade/Projects	Estimated Cost	Potential Efficiency Improvement
ACE	• Turbine upgrades • Air heater Upgrade • Variable Frequency Drives • Boiler Program • Condenser Upgrade • O&M Practices	$35 million[1]	~3%

1 - Costs are estimates pending the final IDEM implementation plan for Indiana

WARRICK GENERATING STATION UNIT 4

- Warrick 4; 150 MW installed capacity (Vectren share of a 300 MW jointly owned coal fired unit)
  - Current operating agreement expires in 2023
  - Either party can exit earlier with sufficient notice
  - Alcoa currently evaluating future options. Committed to respond in 4th quarter
- Risks of continued joint operation
  - Lack of operational control
  - Environmental upgrades (cost and liability)
  - Alcoa can exit agreement after giving notice
    - Smelter future reliant on global aluminum market
- Ramifications of Alcoa exiting the operation agreement
  - Vectren takes ownership
    - 100% of environmental upgrade costs (lose benefit of industrial classification for water discharge and CCR)
    - 100% capital and O&M investment responsibility
    - Operational challenges of taking over facility
    - Future decommissioning costs
    - Increase percentage of coal capacity
  - Retire the unit
    - Procure replacement capacity

A.B. BROWN

- Brown 1 & 2; 245 MW installed coal capacity (each)
  - Natural Gas Conversion
    - Preserve existing capacity
    - High cost energy
    - Anticipate low capacity factor with high reliance on market

Item	Brown 1 Estimated Cost ($)	Brown 2 Estimated Cost ($)	Total
Modification to convert unit to gas	$89 million	$97 million	$186 million
Gas pipeline construction[1]	$50 million	$50 million	$100 million
Total	$139 million	$147 million	$286 million

1- Values shown assume both units are converted. Single unit conversion is approximately $77 million

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A.B. BROWN (CONT.)

- Brown 1 & 2; 245 MW (each)
  - Business as usual
    - Requires dry bottom ash conversion and dry flyash system upgrades for CCR (Coal Combustion Residuals) and ELG (Effluent Limitations Guidelines) compliance
    - A new landfill would be needed for disposal of FGD (Flue Gas Desulphurization) by-products and fly ash
    - FGD replacement is included in continued operation plan
    - Compliance with ACE (Affordable Clean Energy) rule; requires unit upgrades & improvements based on IDEM ruling

Business As Usual

Regulation	Upgrade Projects	Brown Unit 1 Estimated Cost	Brown Unit 2 Estimated Cost	Total Estimated Cost
CCR\ELG	• Dry bottom ash conversion • Dry Fly Ash Conversion • Water treatment	$53 million	$53 million	$106 million[2]

Regulation	Potential Upgrade/Projects	Brown Unit 1 Estimated Cost	Brown Unit 2 Estimated Cost	Total Estimated Cost	Potential Efficiency Improvement	Potential Efficiency Improvement
ACE	• Air heater • Variable Frequency Drives • Boiler program • Condenser work • O&M Practices	$13 million[1]	$13 million[1]	$26 million[1]	~2.2%	~2.6%

1 - ACE costs are estimates pending the final IDEM implementation plan for Indiana
2 – Does not include landfill cost for FGD by-products and ash. New landfill required to operate beyond 2023. Size and cost to be determined based on future FGD technology

NEW FGD OPTIONS

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Eight FGD technologies reviewed; four chosen for further analysis

- Market analysis being conducted for potential by-products sales
- Will perform Net Present Value (NPV) screening analysis in modeling to determine low cost option
- NPV results along with operating considerations will help determine the preferred FGD replacement technology

FGD Technology	Primary Reagent	Estimated Initial Capital Investment[1]	Estimated Landfill Capital and O&M	Estimated Variable O&M Cost/MWHr (2019$)	Marketable Fly Ash	Community Right-To-Know Emergency Action Plan	Marketable By-Product
Limestone Forced Oxidation (LSFO)	**Limestone**	**$596 million[2,4]**	**TBD Based on Gypsum and Ash Market**	**$4.44/MWHr**	**Yes**	**No**	**Gypsum**
Lime Inhibited Oxidation (LSIO)	**Lime Quicklime**	**$450 million[2,4]**	**$119 million**	**$9.39/MWHr**	**Yes (Limited)**	**No**	**No**
Ammonia Based (JET)	**Anhydrous Ammonia**	**$411 million[2,3,4,5]**	**TBD Based on Ammonium Sulfate Market**	**$11.67/MWHr**	**Yes**	**Yes**	**Ammonium Sulfate Fertilizer[6]**
Circulating Dry Scrubber (CDS)	**Lime**	**$387 million[2,3,5]**	**$125 million**	**$14.92/MWHr**	**Yes**	**No**	**No**

1 – Values represent estimated total cost for both A.B. Brown units
2 – Includes new wastewater treatment system
3 - Includes new mercury mitigation system
4 – Includes new SO_3 mitigation system
5 – Includes new particulate matter collection system
6 – Also produces unmarketable by-product (brominated powder activated carbon and mercury)

A.B. BROWN FGD OPTIONS (CONT.)

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- Replacement of existing FGD's (cont.)
  - Spray Dryer FGD and Flash Dryer FGD
    - Neither option can meet emission criteria based on 1 hour SO2 limit for Posey County and Illinois Basin Coal supply
- Conversion of existing FGD's to limestone based technologies
  - Lime Inhibited Oxidation (LSIO) or Limestone Forced Oxidation (LSFO)
    - Neither option can meet emissions criteria based on 1 hour SO2 limit for Posey County
- Continued operation of current Brown dual alkali FGD's through 2029

FGD Technology	Estimated 10 Year Capital	Estimated 10 Year O&M	Estimated Landfill Capital and O&M	Estimated Variable O&M Cost/MWHr (2019$)	Marketable Fly Ash	Community Right-To-Know Emergency Action Plan	Marketable By-Product
Dual Alkali	**$137 million**	**$58 million**	**$49 million**	**5.72**	**Yes**	**No**	**No**

FEEDBACK AND DISCUSSION

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POTENTIAL NEW RESOURCES AND MISO ACCREDITATION

MATT LIND,

RESOURCE PLANNING & MARKET ASSESSMENTS BUSINESS LEAD, BURNS & MCDONNELL

NEW RESOURCE AND MISO ACCREDITATION SUMMARY

- Vectren initially plans to model new potential resources with draft technology assessment information as RFP modeling inputs are being completed
- Technology costs will be updated with bid information, where applicable; final modeling inputs will be shared in December
- Intermittent resources lack dispatch flexibility, as penetration increases, MISO projects lower capacity accreditation
- MISO is planning for seasonal capacity accreditation (summer/winter), some resources will receive varying levels of capacity credit depending on differences in seasonal availability

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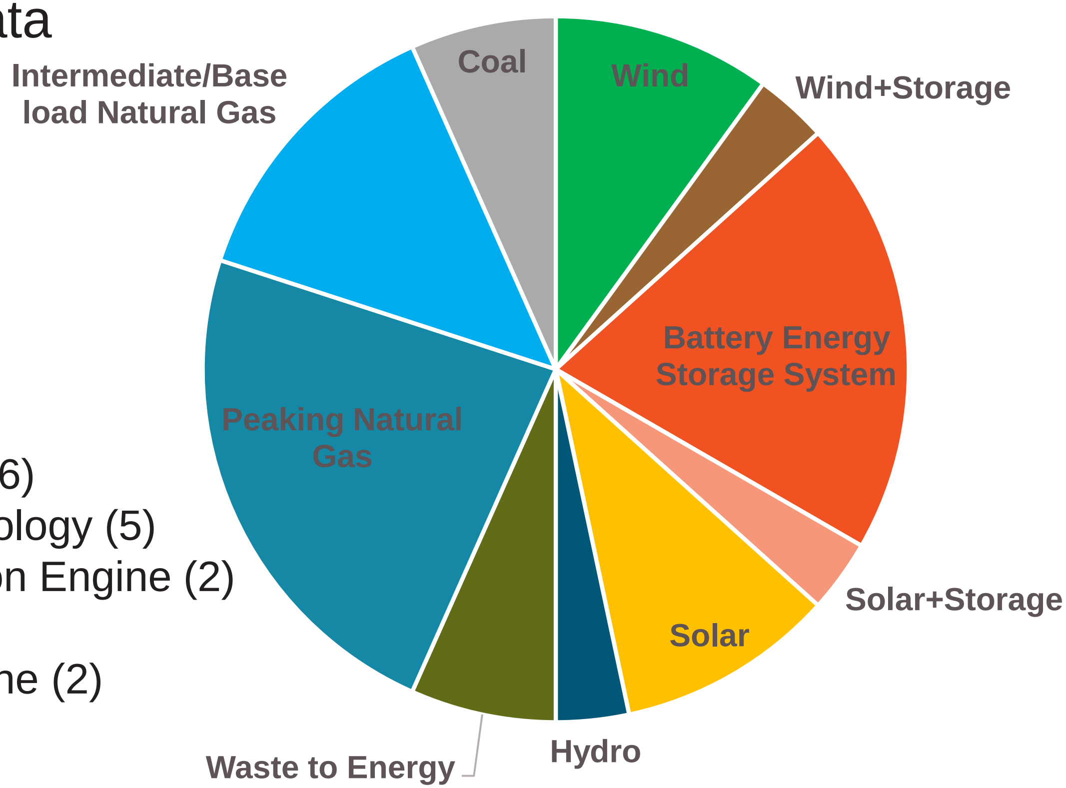
BACKGROUND

- Base Case Inputs for new power supply options
- Consensus estimates from Burns & McDonnell, Pace Global, and NREL for solar and storage resources
- Supplemental to RFP Bid data
- Resource Options (30):
  - Wind (3)
  - Wind + Storage (1)
  - Solar Photovoltaic (3)
  - Solar + Storage (1)
  - Hydro (1)
  - Landfill Gas (2)
  - Battery Energy Storage System (6)
  - Simple Cycle Gas Turbine Technology (5)
  - Reciprocating Internal Combustion Engine (2)
  - Combined Cycle Gas Turbine (2)
  - Combined Heat and Power Turbine (2)
  - Coal (2)



TECHNOLOGY DETAILS

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Examples of candidates for natural gas peaking generation:

Gas Simple Cycle (Peaking Units)	Example 1	Example 2	Example 3	Example 4
Combustion Turbine Type	LM6000	LMS100	E-Class	F-Class
Size (MW)	41.6 MW	97.2 MW	84.7 MW	236.6 MW
Fixed O&M (2019 $/kW-yr)	$36	$16	$21	$8
Total Project Costs (2019 $/kW)	~$2,400	~$1,700	~$1,500	~$800

Examples of candidates for natural gas combined cycle generation:

Gas Combined Cycle (Base / Intermediate Load Units)	Example 1	Example 2
Combustion Turbine Type	1x1 F-Class[1]	1x1 G/H-Class[1]
Size (MW)	357.2 MW	410.6 MW
Fixed O&M (2019 $/kW-yr)	$13	$12
Total Project Costs (2019 $/kW)	~$1,400	~$1,300

[1] 1x1 Combined Cycle Plant is one combustion turbine with heat recovery steam generator and one steam turbine utilizing the unused exhaust heat from the combustion turbine.

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TECHNOLOGY DETAILS

Examples of candidate combined heat and power gas generation:

Gas Combined Heat and Power[1]	2 x 10 MW Recip Engines	20 MW Combustion Turbine
Net Plant Electrical Output (MW)	17.9 MW	21.7 MW
Fixed O&M (2019 $/kW-yr)	$42	$35
Total Project Costs (2019 $/kW)	~$2,800	~$4,600

[1] Utility owned and sited at a customer facility

Examples of candidates for renewable energy and energy storage:

Renewable Generation & Storage Technologies	Solar Photovoltaic	Solar + Storage	Indiana Wind Energy	Lithium Ion Battery Storage
Base Load Net Output (kW)	100 MW (Scalable Option)	50 MW + 10MW/40 MWh	200 MW	10 MW/40 MWh (Scalable Option)
Fixed O&M (2019 $/kW-yr)	$20	$27	$44	$19
Total Project Costs (2019 $/kW)[1]	~$1,600	~$1,900	~$1,700	~$2,000

[1]Total Project Costs (2019 $/kW) may change based on economies of scale. The Technology Assessment contains unique costs for the different scales of the projects.

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TECHNOLOGY DETAILS

Example of candidates for hydroelectric generation:

	Low Head Hydroelectric Generation
Base Load Net Output (kW)	50 MW
Fixed O&M (2019 $/kW-yr)	$92
Total Project Costs (2019 $/kW)	~$5,900

Potential local resources:

Dam	2012 DOE[1] Estimated Potential Capacity (MW)	2013 U.S. Army Corps of Engineers Estimated Feasible Potential Capacity (MW)	2013 U.S. Army Corps of Engineers Estimated Optimal Potential Capacity (MW)
John T. Myers (Uniontown)	395	24-115	36
Newburgh	319	15-97	22

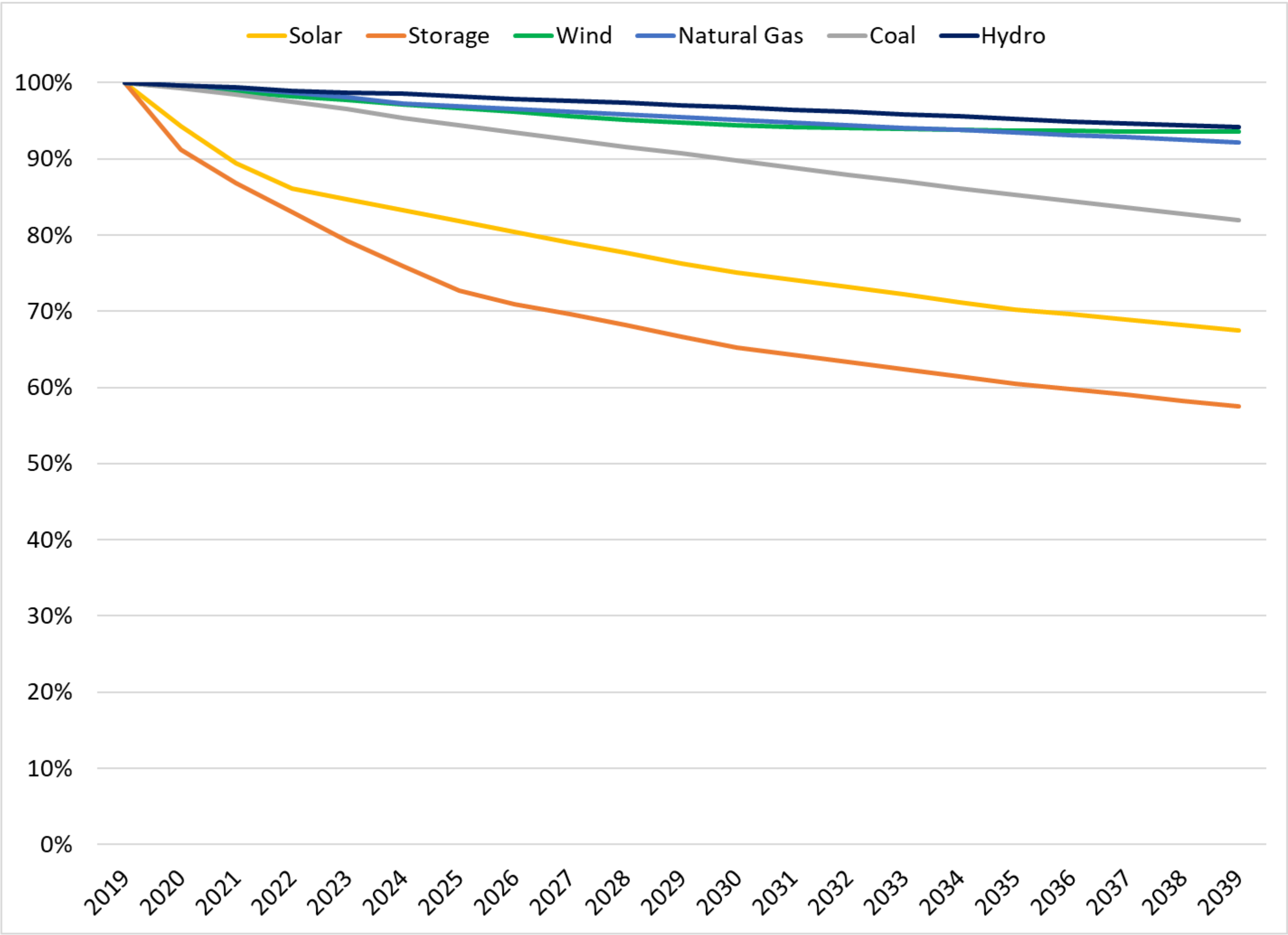
Notes:
In 2019 dollars, the Cannelton hydro project (~84 MW) total cost was approximately $5,500/kW (US Army Corps of Engineers press release)
Transmission upgrades required for the Uniontown dam are estimated at $14 million
Transmission upgrades required for the Newburgh dam are estimated at $10 million

TECHNOLOGY DETAILS

Examples of candidates for coal generation:

Coal Fired	Example 1	Example 2
Combustion Turbine Type	Supercritical Pulverized Coal with Carbon Capture	Ultra-Supercritical Pulverized Coal with Carbon Capture
Size (MW)	506 MW	747 MW
Fixed O&M (2019 $/kW-yr)	$29	$29
Total Project Costs (2019 $/kW)	~$6,100	~$5,500

FORWARD COST ESTIMATES



Technology Maturity

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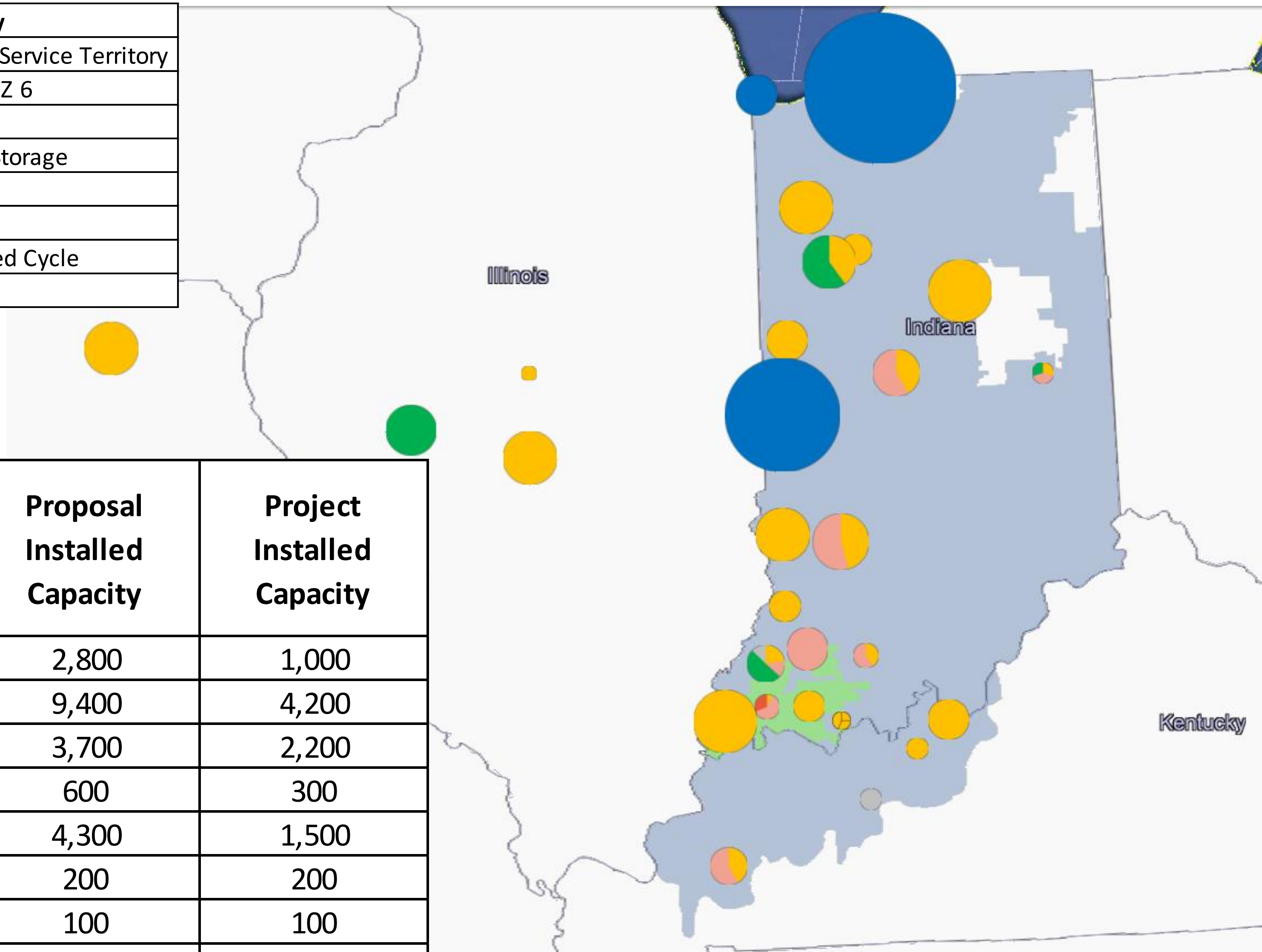
PROPOSAL LOCATION REVIEW

Key	
	Vectren Service Territory
	MISO LRZ 6
	Solar
	Solar + Storage
	Storage
	Wind
	Combined Cycle
	Coal



2019 RFP Responses (MW)	Proposal Installed Capacity	Project Installed Capacity
Wind	2,800	1,000
Solar	9,400	4,200
Solar + Storage	3,700	2,200
Storage	600	300
Combined Cycle	4,300	1,500
Coal	200	200
LMR/DR	100	100
System Energy	300	100
Total	**21,400**	**9,600**

PARTICIPATING COMPANIES

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bp
ST. JOSEPH energy center
Origis Energy POWERING THE SOLAR REVOLUTION
S·POWER An AES and AIMCo Company
EmberClear
RANGER POWER
Constellation. An Exelon Company
APEX CLEAN ENERGY
NEXTera ENERGY RESOURCES
Clēnera
edp renewables
e·on
CALPINE
lightsource bp
DUKE ENERGY.
enel x
ORION RENEWABLE ENERGY GROUP LLC
ENGIE
Big Rivers ELECTRIC CORPORATION
res
Invenergy
Capital Dynamics TRULY INVESTED.
TENASKA

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PROPOSAL GROUPING

Potential Grouping		RFP Count	Tier 1 Proposals	Tier 2 Proposals
1	Coal PPA	2	0	2
2	LMR/DR PPA	1	1	0
3	CCGT PPA	2	0	2
4	CCGT Purchase	5	0	5
5	Wind Purchase	2	0	2
6	12-15 Year Wind PPA	9	4	5
7	20 Year Wind PPA	2	1	1
8	Storage Purchase	4	4	0
9	Storage PPA	4	4	0
10	Solar + Storage PPA	6	5	1
11	Solar + Storage Purchase	9	5	4
12	Solar + Storage Purchase/PPA	4	1	3
13	Solar Purchase/PPA	6	1	5
14	12-15 Year Solar PPA	8	3	5
15	20 Year Solar PPA	16	7	9
16	25-30 Year Solar PPA	9	3	6
17	Solar Purchase	18	4	14
N/A	Energy Only	3	0	3
	Total	**110**	**43**	**67**

- Total installed capacity of RFP bids in Tier 1 ~5X greater than Vectren's peak load
- Resource options from the technology assessment will supplement these options as needed

110 Proposals

Tier 1
- Binding Pricing
- Delivered to SIGE.SIGW OR On System

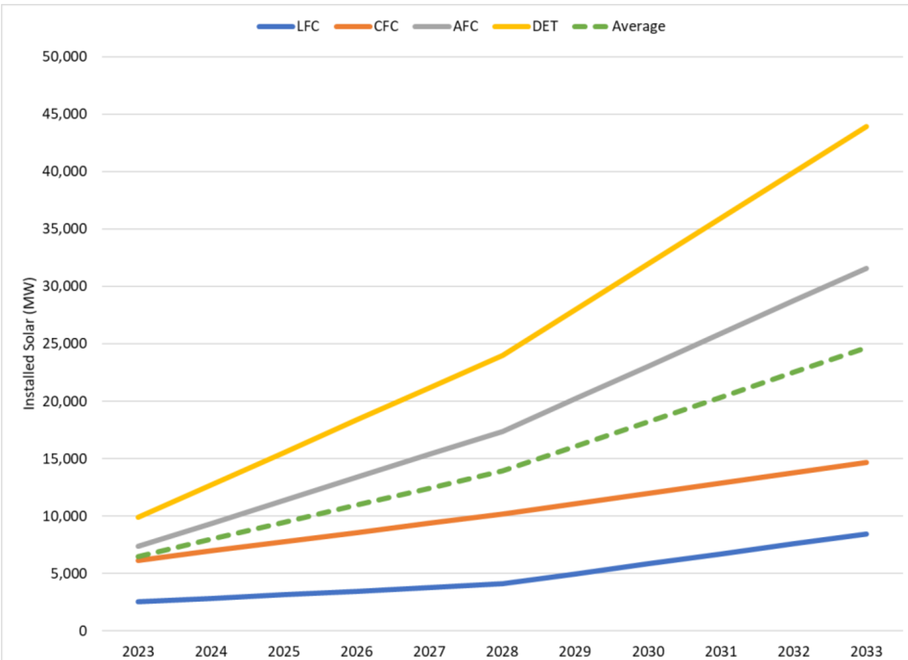
→ IRP Inputs

Tier 2
- Non-Binding Pricing
- Congestion / delivery risk

→ Potential IRP Inputs Based on Evaluation

MISO RENEWABLE PENETRATION TRENDS

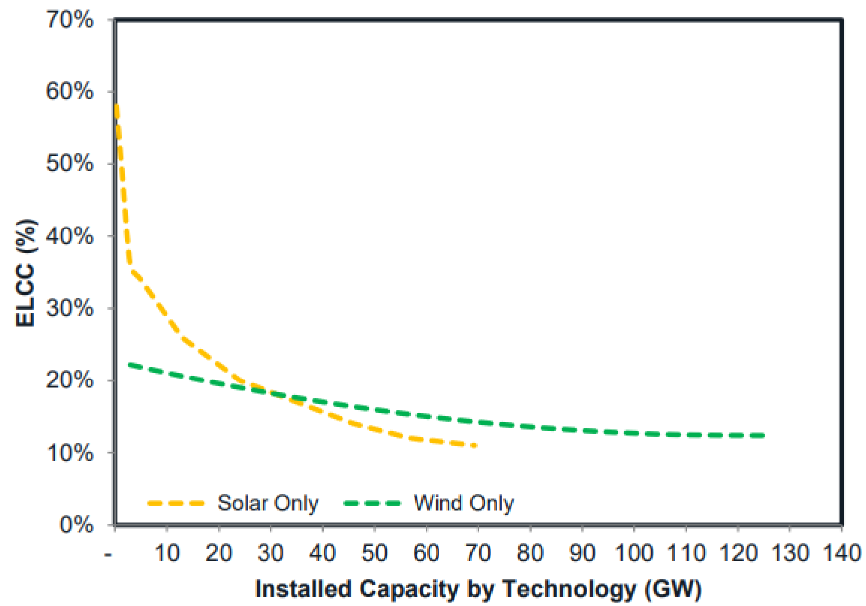
MTEP19 future solar capacity projections



https://cdn.misoenergy.org/MTEP19%20Futures%20Summary291183.pdf

MISO Transmission Expansion Plan (MTEP) study years 2023, 2028, and 2033. Data between study years is linearly interpolated.

Effects of increasing installations



https://cdn.misoenergy.org/RIIA%20Assumptions%20Doc_v7429759.pdf

As installed capacity (ICAP) goes ⬆… Accreditable capacity (UCAP) goes ⬇

ELCC – Effective Load Carrying Capability

SOLAR SEASONAL DIFFERENCES

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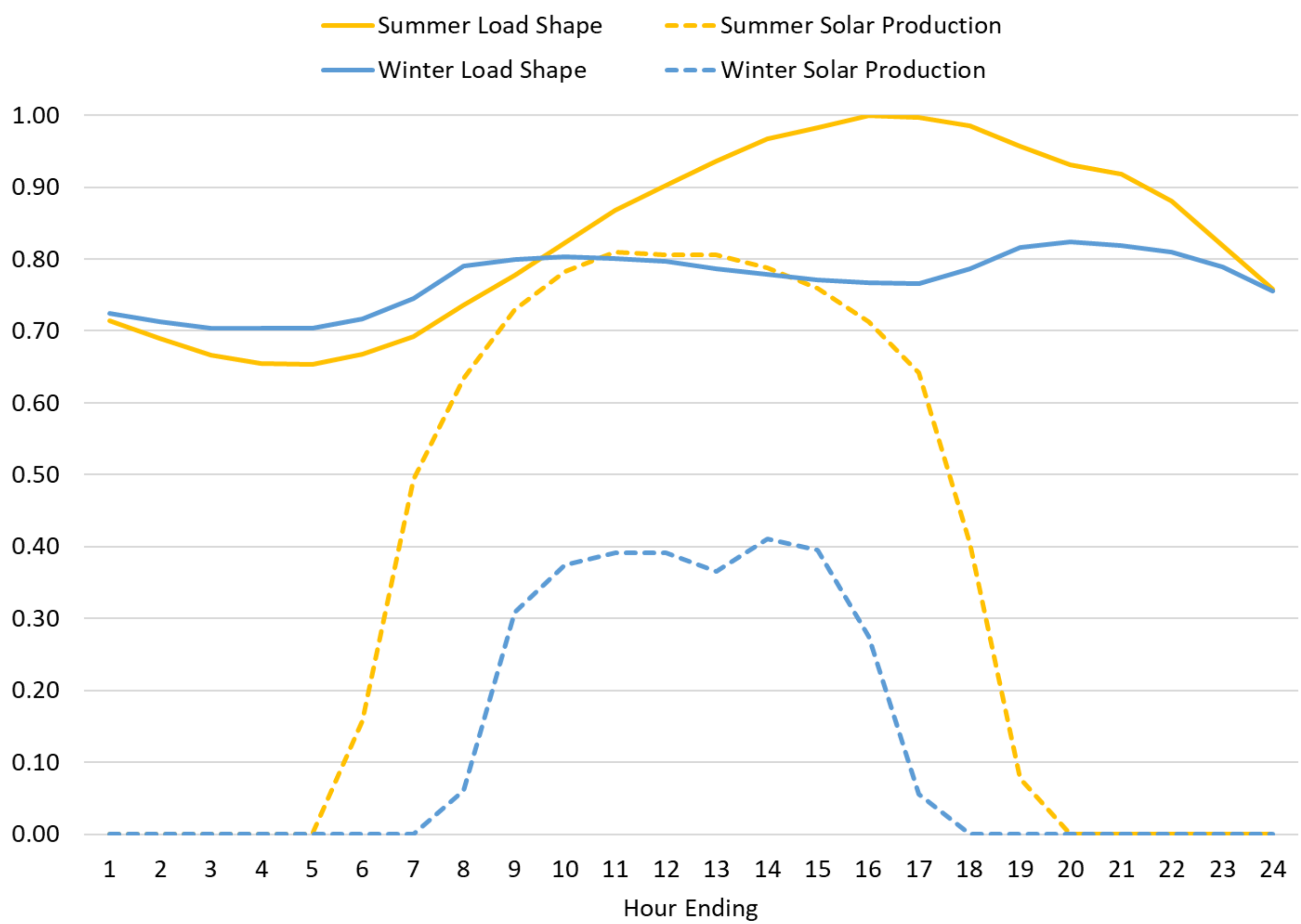
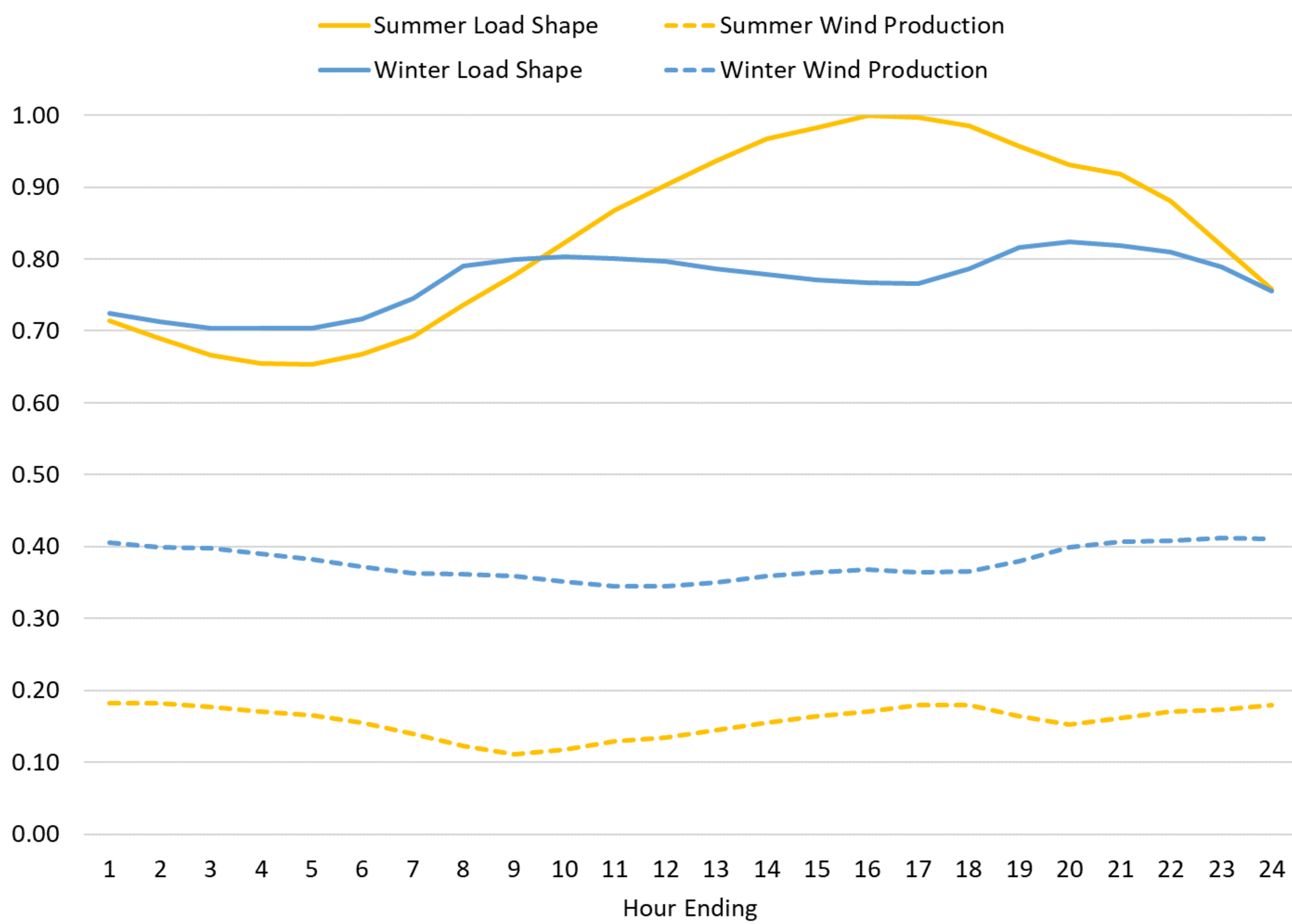
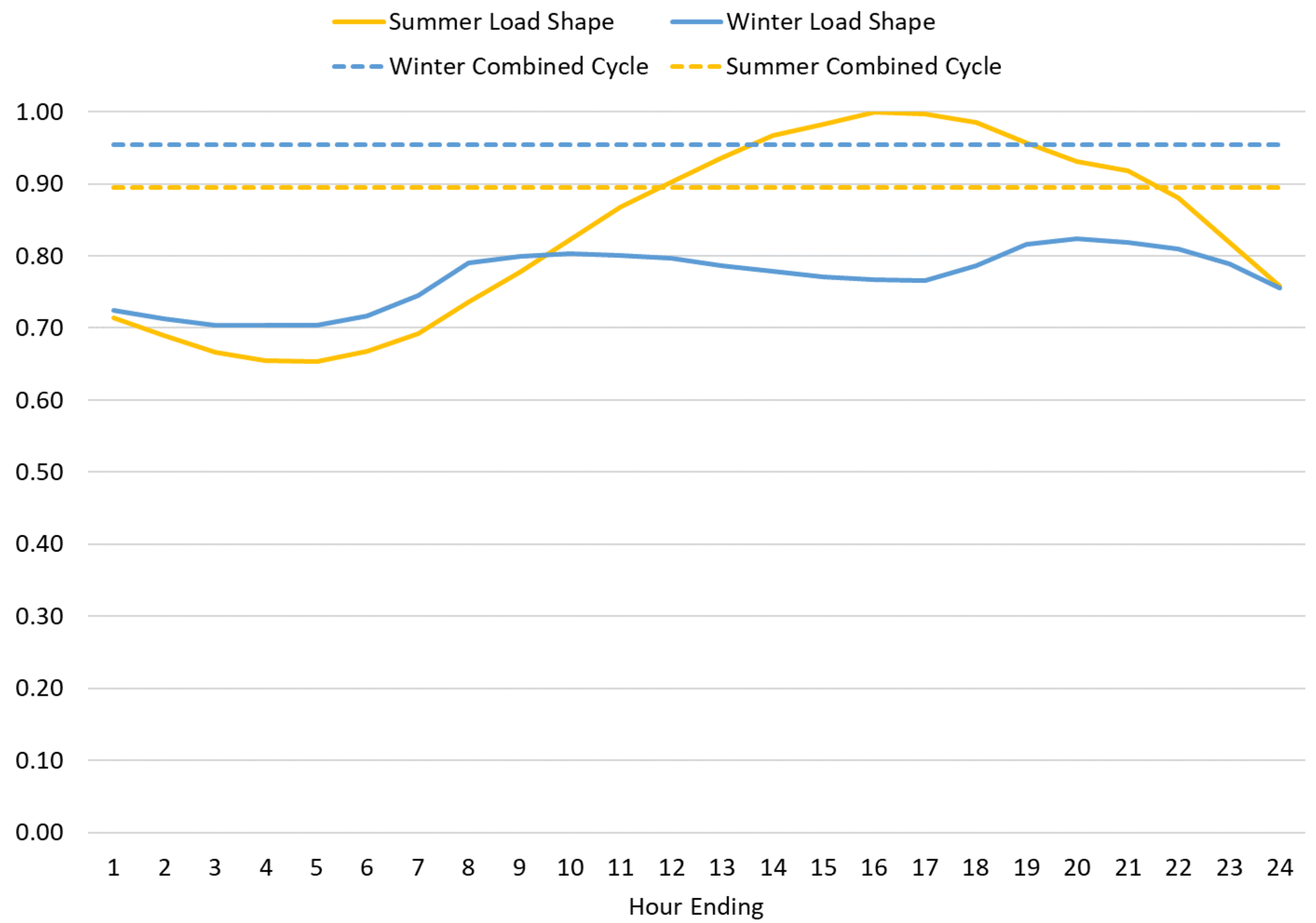


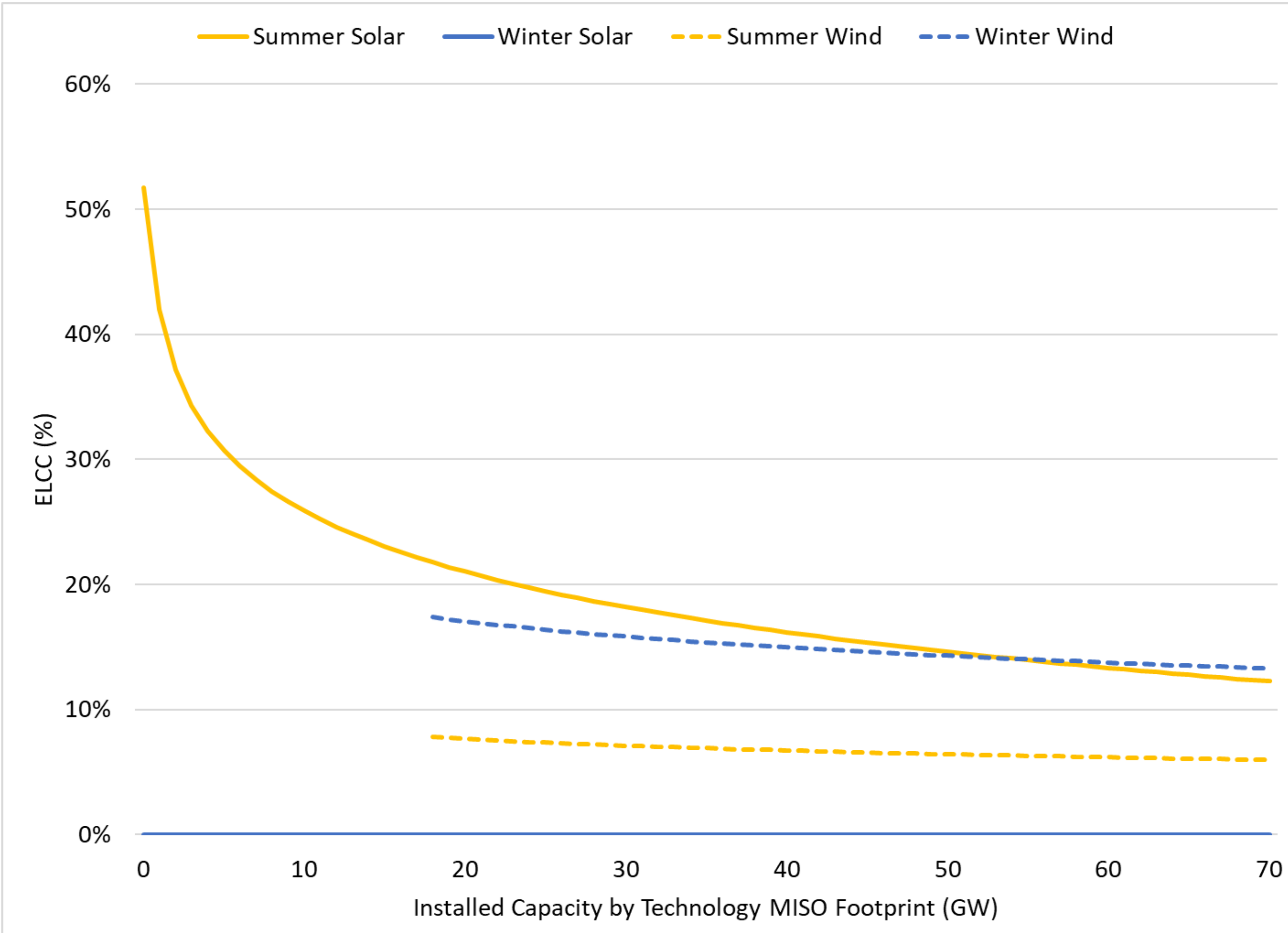
WIND SEASONAL DIFFERENCES



COMBINED CYCLE SEASONAL DIFFERENCES

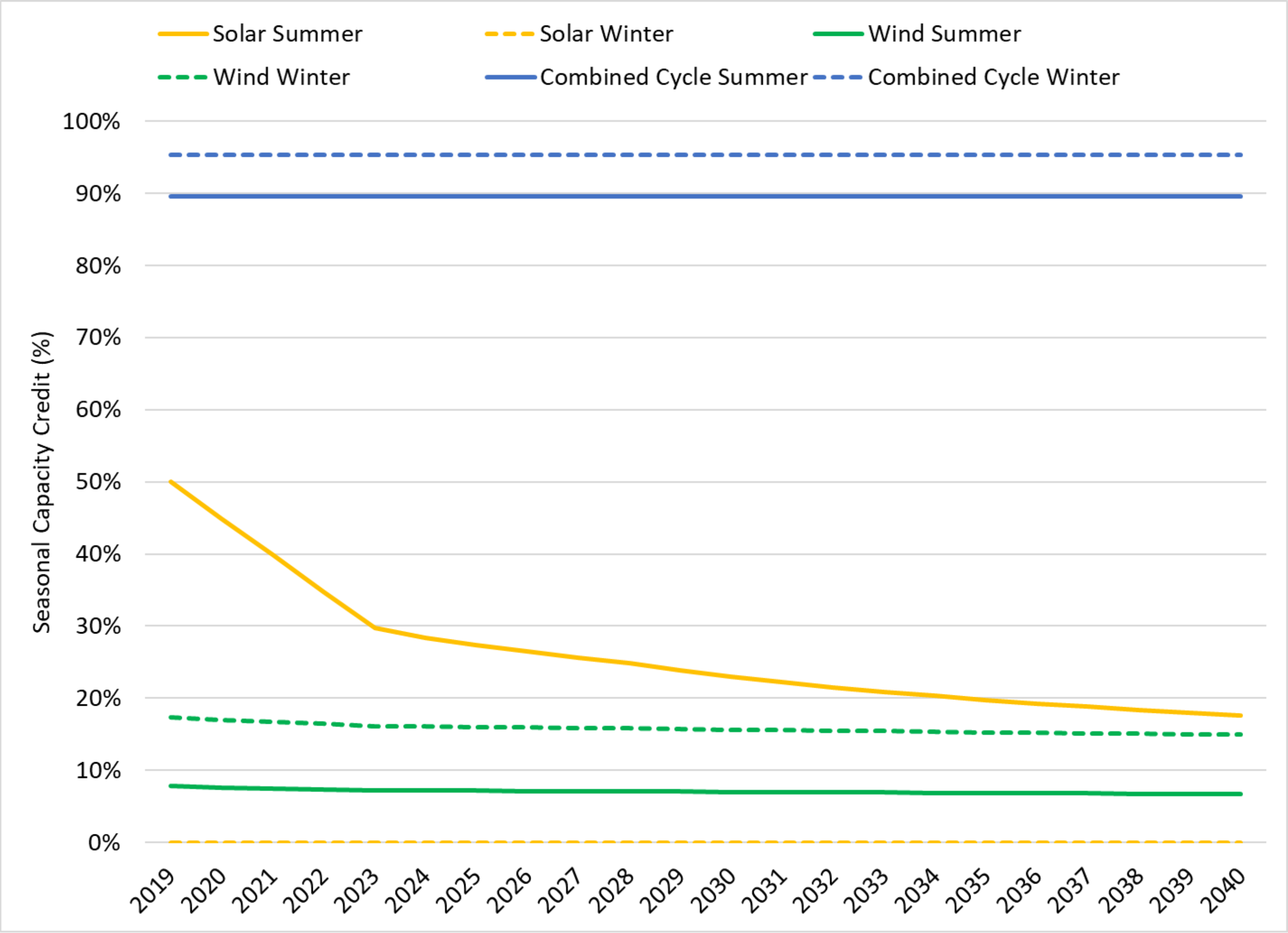


ZONE 6 SEASONAL ACCREDITATION



Winter accreditation based on similar methodology to summer

SEASONAL CAPACITY CREDIT FORECAST



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DSM MODELING IN THE IRP

JEFFREY HUBER

MANAGING DIRECTOR, GDS ASSOCIATES

Demand Side Management Process (DSM) and the Integrated Resources Plan (IRP)

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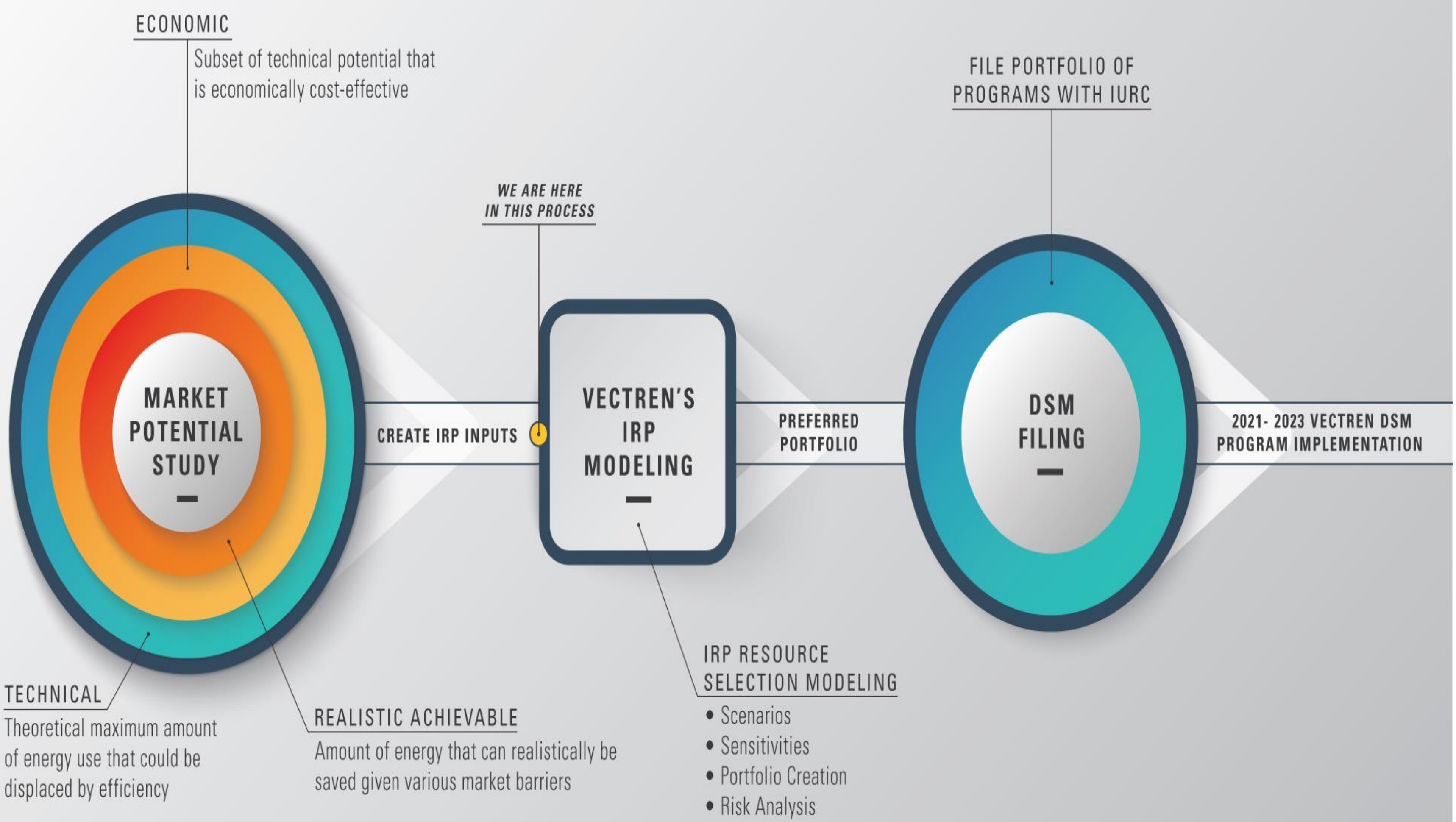

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ENERGY EFFICIENCY MODELING ASSUMPTIONS

No minimum level of EE has been embedded into our sales and demand forecast

EE savings for 2018-2020 will be based on EE plan approved in Cause 44927

Total of 10 bundles, of which 8 can be selected including DR.

7 EE bundles are available at 0.25% of eligible sales

The model may select up to 1.75% of eligible sales annually. Aligns with realistic achievable potential in MPS

EE bundles represent bundle of low cost to high cost programs

For optimization runs, EE bundle selection will run for a 3 year period for the 1st 6 years

IMPROVEMENTS SUMMARY

- 2019 modeled savings and costs will tie directly to latest Market Potential Study (completed 2019)
  - MPS analysis reliant on empirical/historical data derived from DSM effects by Vectren customers
- Initial years savings disconnected from later years
- Utilize bundle specific load shapes
- Include demand response bundles
- Conduct sensitivities

DSM BUNDLES IN IRP MODELING APPROACH OVERVIEW

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BASE CASE

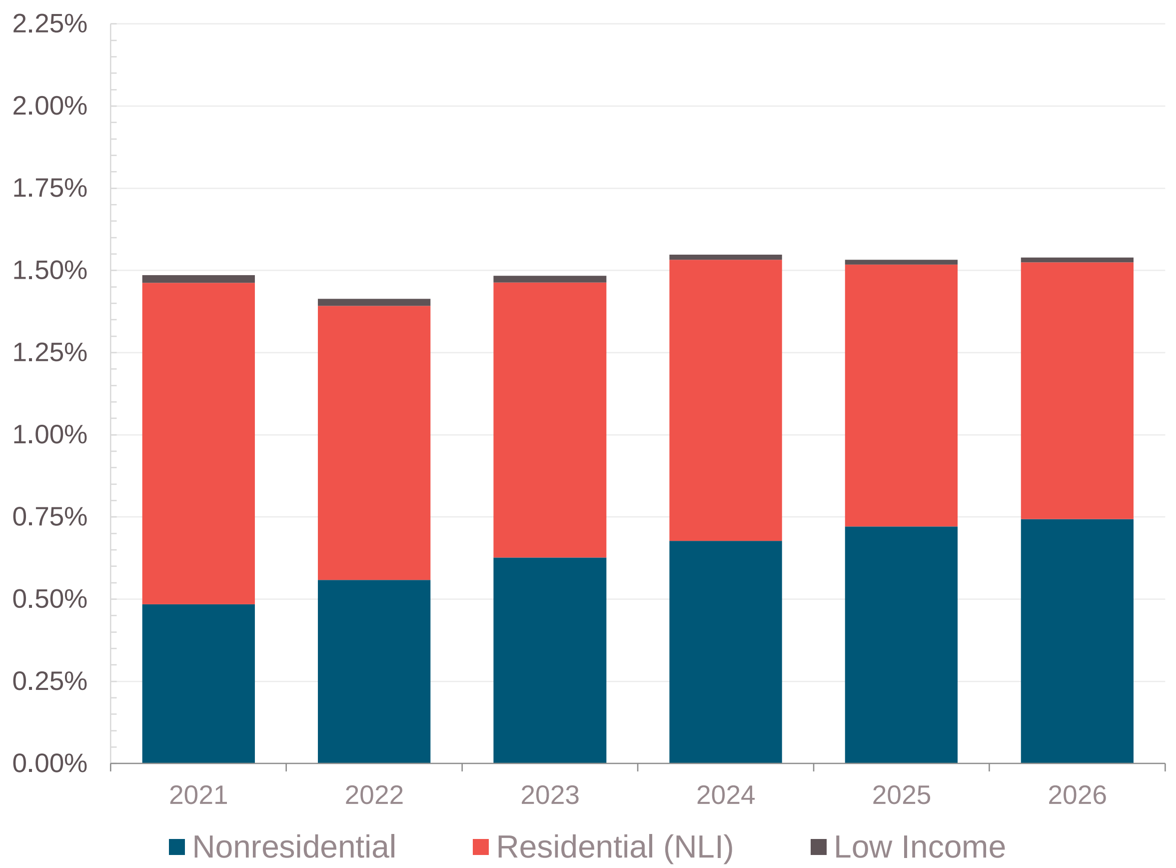
- DSM Bundles are 0.25% of annual load excluding opt-out sales
- Bundles are developed using the results from the 2018 Market Potential Study's (MPS) Realistic Achievable Potential
- Each bundle can have a mixture of residential and non-residential electric energy efficiency measures
- Each bundle has an associated loadshape and cost/MWh that serves as inputs into the IRP model
- Up to 10 bundles will be included as a selectable resource in the IRP model
    - 7 Energy Efficiency
    - 1 Low income
    - 2 Demand Response

DSM BUNDLES IN IRP MODELING INCREMENTAL SAVINGS FROM MPS

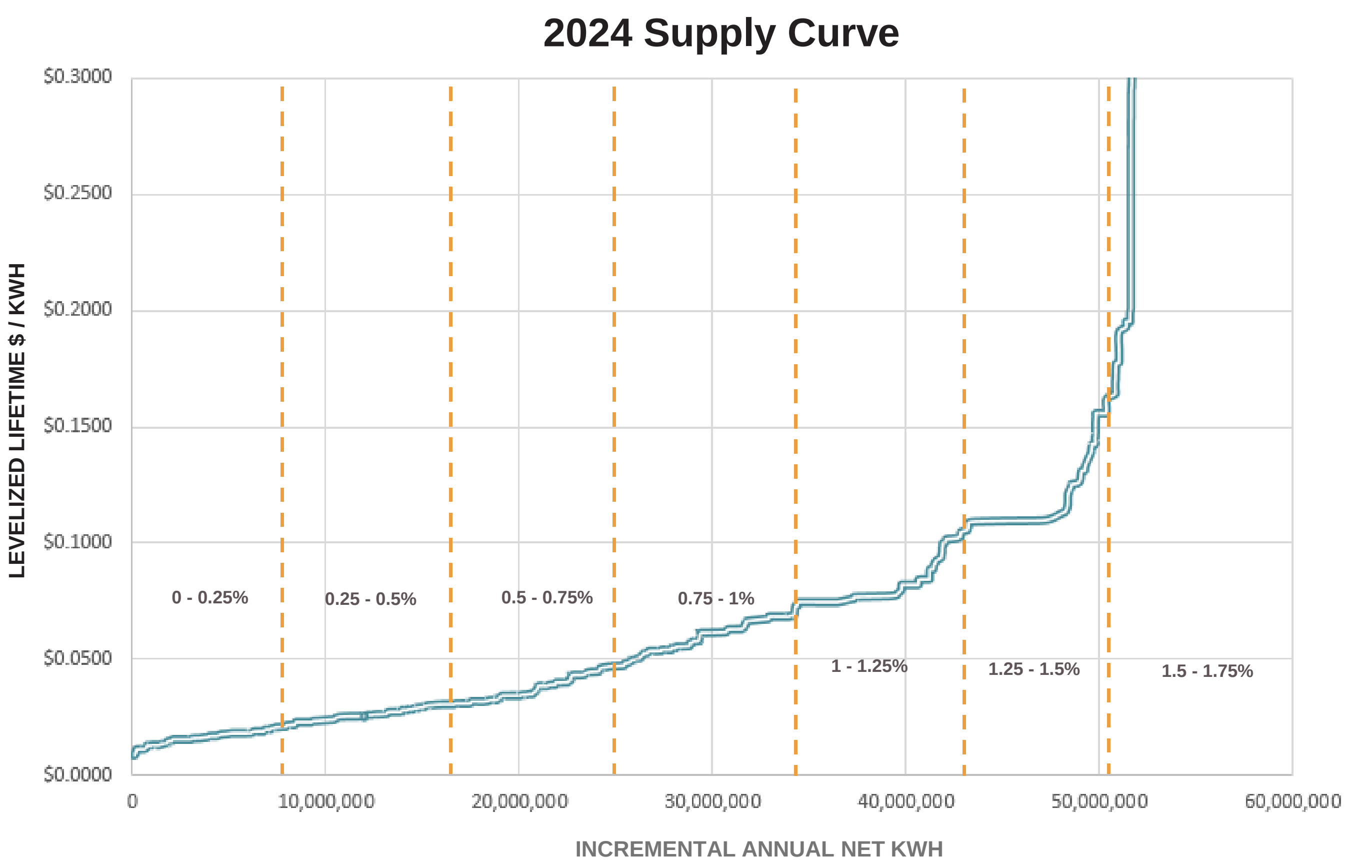
***Step 1:** Initial RAP Potential Estimates from MPS*

***Step 2:** Apply NTG Ratios (used latest evaluated NTG ratios)*

***Step 3:** Align Low Income Savings based on Historcal Spend*



DSM BUNDLES IN IRP MODELING
SUPPLY CURVE BUNDLE DEVELOPMENT



- Residential and Non-residential electric energy efficiency measures were ranked from cheapest to most expensive
- Measures were then bundled into groups of roughly 0.25% ***net*** energy savings, with each progressive bundle more expensive then the prior bundle
- Total amount of savings (and # of bundles) is dependent on the realistic achievable potential identified each year
- In 2024 example, the RAP allows for 6 complete bundles, and a partial 7th bundle

DSM BUNDLES IN IRP MODELING
BASE CASE LEVELIZED COST PER KWH

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	1	2	3	4	5	6	7	LI
	Gross Projected Cost per KWh; Cumulative by Bundle							
2021	$0.0144	$0.0189	$0.0209	$0.0240	$0.0279	$0.0328		$0.1517
2022	$0.0144	$0.0189	$0.0226	$0.0266	$0.0300	$0.0347		$0.1670
2023	$0.0147	$0.0190	$0.0226	$0.0271	$0.0314	$0.0359		$0.1839
2024	$0.0151	$0.0188	$0.0228	$0.0279	$0.0326	$0.0348	$0.0374	$0.2115
2025	$0.0156	$0.0204	$0.0244	$0.0298	$0.0346	$0.0381	$0.0390	$0.2265
2026	$0.0160	$0.0212	$0.0258	$0.0312	$0.0360	$0.0396	$0.0406	$0.2398
2027	$0.0166	$0.0223	$0.0269	$0.0329	$0.0376	$0.0411	$0.0421	$0.2583
2028	$0.0172	$0.0235	$0.0288	$0.0342	$0.0393	$0.0429	$0.0442	$0.2630
2029	$0.0181	$0.0245	$0.0306	$0.0367	$0.0410	$0.0454		$0.2648
2030	$0.0190	$0.0268	$0.0318	$0.0371	$0.0424	$0.0474		$0.2608
2031	$0.0198	$0.0277	$0.0325	$0.0390	$0.0436	$0.0482		$0.2686
2032	$0.0208	$0.0286	$0.0353	$0.0409	$0.0455	$0.0506		$0.2459
2033	$0.0220	$0.0297	$0.0373	$0.0439	$0.0470	$0.0520		$0.2494
2034	$0.0228	$0.0307	$0.0394	$0.0455	$0.0487	$0.0539		$0.2164
2035	$0.0188	$0.0243	$0.0294	$0.0366	$0.0420	$0.0441	$0.0491	$0.2411
2036	$0.0190	$0.0241	$0.0291	$0.0363	$0.0413	$0.0441	$0.0491	$0.2538
2037	$0.0190	$0.0242	$0.0291	$0.0357	$0.0412	$0.0442	$0.0490	$0.2064
2038	$0.0198	$0.0233	$0.0294	$0.0353	$0.0406	$0.0452	$0.0499	$0.2118
2039	$0.0206	$0.0238	$0.0302	$0.0354	$0.0415	$0.0459	$0.0505	$0.2175

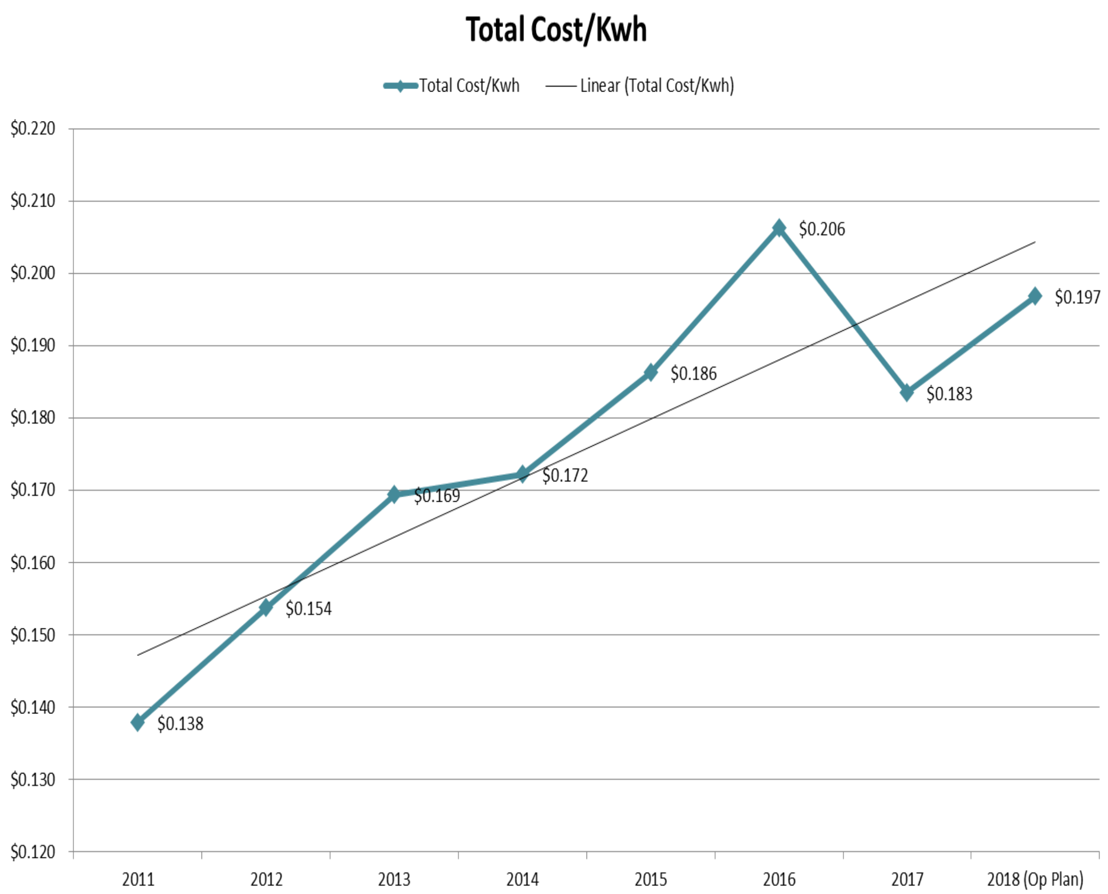
- LI Costs reflect paying 100% incentives for measures.
- Aligned to historical levels to produce an annual budget of $1.15 million per year
- Annual savings range from 457 MWh to 889 MWh

- Cost per bundle and annual costs are based on 2018 MPS costs, with two exceptions:
- IRP bundles reduced non-residential incentive costs in early years to more closely align with historical and 2019 planned Vectren data
- Non-incentive program costs were escalated at an annual estimated rate of inflation of 2.2% (in lieu of 1.6%) to be consistent with other IRP planning assumptions

DSM BUNDLES IN IRP MODELING
DSM BUNDLE SENSITIVITIES

HIGH/LOW CASE

- Sensitivity to reflect alternative DSM Costs
- Used 2011-2018 actual portfolio costs Calculated one standard deviation from the mean ($0.02097)
- Results in 11.9% increase/reduction in levelized cost
- No sensitivity performed on low-income potential



DSM BUNDLES IN IRP MODELING
DEMAND RESPONSE BUNDLES

- Two Demand Response bundles
- First bundle includes AC DLC as well as Smart Thermostat DR (from Smart Cycle Program) (fixed)
  - Slow phase out of DLC Switch and replacement with Thermostat-controlled DR through 2039
  - Projected Summer Peak impacts range from 17.5 MW (2020) to 36.9 MW (2039)
- Second bundle include BYOT Thermostat DR (selectable)

FEEDBACK AND DISCUSSION

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STAKEHOLDER BREAKOUT SESSION: STRATEGY DEVELOPMENT

GARY VICINUS

MANAGING DIRECTOR FOR UTILITIES, PACE GLOBAL

STAKEHOLDER BREAKOUT SESSION

- The purpose of this breakout session is to allow stakeholders to discuss and develop several different strategies to meet load obligations over the next 20 years
- Specifically, stakeholders are asked to collaborate to develop alternative or additional strategies to the ones already being modeled, i.e. 80% reduction in CO_2 by 2050
- We will run a least-cost portfolio run for various strategies
- Breakout Process:
  1. Separate into groups
  2. Discuss potential strategies to meet load obligations over the next 20 years, i.e. least cost, minimizing CO_2, diversification, etc.
  3. Designate a spokes person for each table (those on the phone are welcome to send in suggestions at irp@centerpointenergy.com)
  4. In the next meeting, strategies will be defined as model structures
  5. Structures will be consolidated into several portfolios for further evaluation. We will take your into consideration and ultimately develop 10-15 portfolios for modeling. Final portfolios will be discussed in the third stakeholder meeting

PORTFOLIO STRATEGY WORKSHEET

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Create a set of strategies for a portfolio and the timeframe for implementation:

Strategy	Timeframe

Short-term=2019-2021; Medium-term=2022-2028; Long-term=2029-2039

FEEDBACK AND DISCUSSION

APPENDIX

ADDITIONAL STAKEHOLDER FEEDBACK

Request	Response
Scenarios: Include the social cost of carbon.	Included in the High Regulatory scenario.
Portfolio development: Provide a list of potential portfolio strategies within the Q&A document to help groups prepare for the portfolio development workshop.	Included within meeting minutes Q&A posted to vectren.com/irp
Portfolio development: Flag portfolios that meet Intergovernmental Panel on Climate Change (IPCC) criteria.	IPCC criteria can be raised during the portfolio development discussion to ensure that we build portfolios that meet the criteria.
Listen to a local talk on Indiana Climate Change (Purdue).	Vectren attended the local meeting.
Please provide historic delivered coal prices, compared to projections	Please see the appendix for this slide.
Identify impacts on different customer groups (e.g. disadvantaged)	Price impacts are a big consideration within portfolio evaluation, captured in the scorecard. However, impacts of eventual rate making proceedings are not within scope of an IRP.
Post meeting minutes in Q&A format	Meeting minutes Q&A posted to vectren.com/irp

FOLLOW-UP QUESTION
DELIVERED COAL COST

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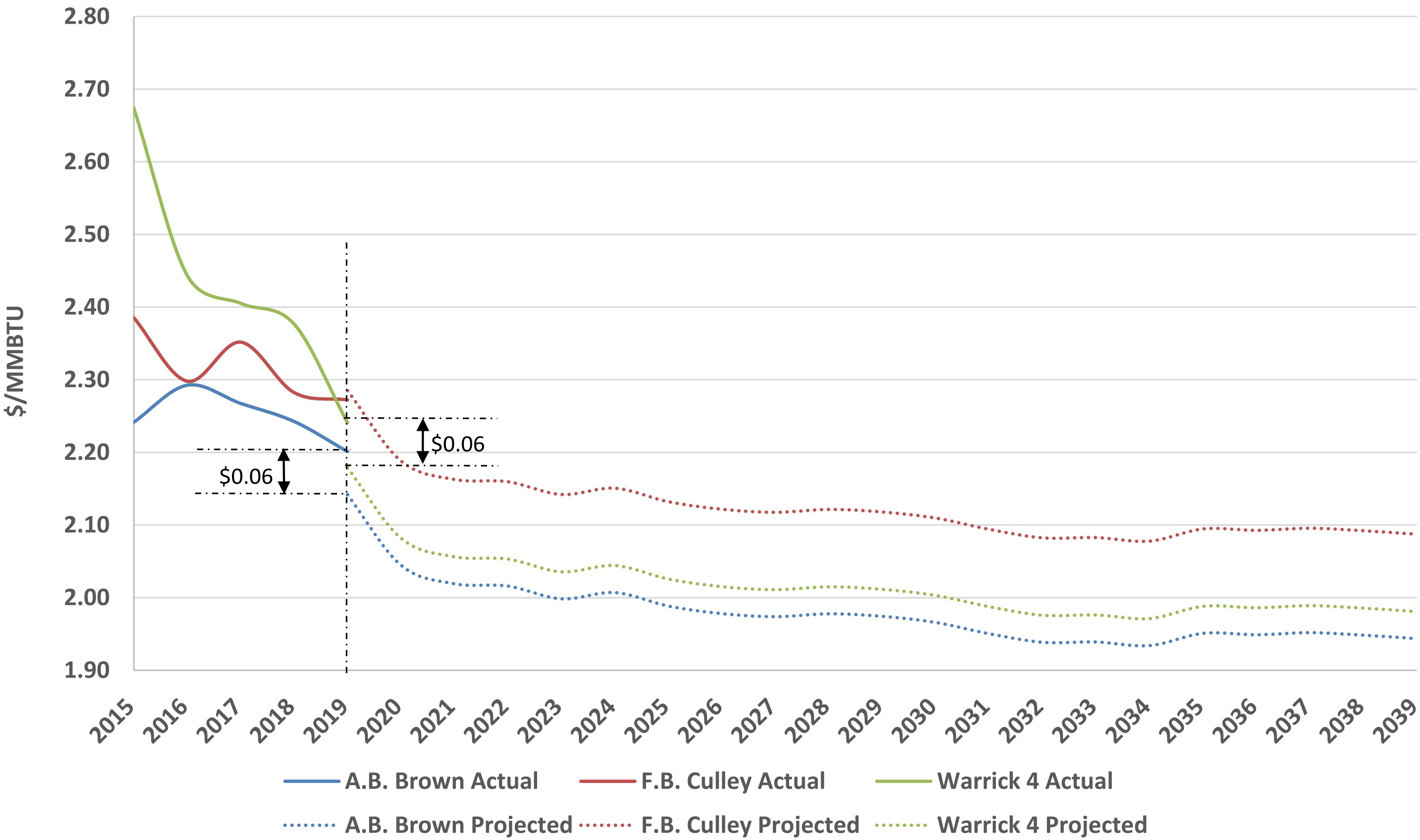

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DRAFT BASE CASE INPUTS

Input	Unit	2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039
Coal (ILB mine)	2018$/MMBtu	1.78	1.66	1.64	1.63	1.61	1.61	1.59	1.58	1.59	1.59	1.58
CO2	2018$/ton	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gas (Henry Hub)	2018$/MMBtu	2.77	2.76	3.06	3.24	3.38	3.49	3.62	3.78	3.96	4.09	4.17
Vectren Peak Load	MW	1,115	1,102	1,168	1,176	1,183	1,192	1,200	1,209	1,219	1,229	1,239
Wind (200 MW)	2018$/kW	1,334	1,330	1,328	1,326	1,324	1,324	1,324	1,324	1,326	1,328	1,330
Solar (100 MW)	2018$/kW	1,524	1,362	1,290	1,247	1,204	1,162	1,129	1,100	1,070	1,050	1,029
Li-Ion Battery (50 MW, 4 hr)	2018$/kW	2,088	1,811	1,654	1,518	1,452	1,391	1,342	1,301	1,263	1,232	1,201
Flow Battery (50 MW, 6 hr)	2018$/kW	2,968	2,665	2,450	2,242	2,116	1,996	1,892	1,803	1,719	1,651	1,586
Gas CC (442 MW + DF)	2018$/kW	1,122	1,114	1,100	1,088	1,079	1,072	1,063	1,056	1,049	1,042	1,034
Gas CT (237 MW)	2018$/kW	548	544	536	529	525	521	517	513	510	506	502
USC Coal w/ CCS	2018$/kW	5,421	5,339	5,231	5,121	5,016	4,916	4,814	4,717	4,624	4,531	4,445

DRAFT LOW REGULATORY CASE INPUTS

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Input	Unit	2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039
Coal (ILB mine)	2018$/MMBtu	1.78	1.66	1.64	1.63	1.61	1.61	1.59	1.58	1.59	1.59	1.58
CO2	2018$/ton	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gas (Henry Hub)	2018$/MMBtu	2.77	2.76	4.10	5.12	5.20	5.62	5.60	5.95	6.12	6.23	6.85
Vectren Peak Load	MW	1,115	1,102	1,217	1,311	1,314	1,352	1,357	1,390	1,381	1,386	1,423
Wind (200 MW)	2018$/kW	1,334	1,330	1,328	1,326	1,324	1,324	1,324	1,324	1,326	1,328	1,330
Solar (100 MW)	2018$/kW	1,524	1,362	1,290	1,247	1,204	1,162	1,129	1,100	1,070	1,050	1,029
Li-Ion Battery (50 MW, 4 hr)	2018$/kW	2,088	1,811	1,654	1,518	1,452	1,391	1,342	1,301	1,263	1,232	1,201
Flow Battery (50 MW, 6 hr)	2018$/kW	2,968	2,665	2,450	2,242	2,116	1,996	1,892	1,803	1,719	1,651	1,586
Gas CC (442 MW + DF)	2018$/kW	1,122	1,114	1,100	1,088	1,079	1,072	1,063	1,056	1,049	1,042	1,034
Gas CT (237 MW)	2018$/kW	548	544	536	529	525	521	517	513	510	506	502
USC Coal w/ CCS	2018$/kW	5,421	5,339	5,231	5,121	5,016	4,916	4,814	4,717	4,624	4,531	4,445

DRAFT HIGH TECHNOLOGY CASE INPUTS

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Input	Unit	2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039
Coal (ILB mine)	2018$/MMBtu	1.78	1.66	1.49	1.27	1.25	1.25	1.25	1.25	1.25	1.25	1.25
CO2	2018$/ton	0.00	0.00	0.00	1.20	2.06	2.38	2.94	3.89	5.46	6.85	8.50
Gas (Henry Hub)	2018$/MMBtu	2.77	2.76	2.82	2.33	2.13	2.04	2.13	2.02	2.12	2.07	2.20
Vectren Peak Load	MW	1,115	1,102	1,217	1,311	1,314	1,352	1,357	1,390	1,381	1,386	1,423
Wind (200 MW)	2018$/kW	1,334	1,330	1,249	1,167	1,123	1,160	1,152	1,166	1,139	1,142	1,143
Solar (100 MW)	2018$/kW	1,524	1,362	1,202	1,041	1,026	999	952	929	866	856	865
Li-Ion Battery (50 MW, 4 hr)	2018$/kW	2,088	1,811	1,513	1,214	1,156	1,096	1,042	965	928	901	894
Flow Battery (50 MW, 6 hr)	2018$/kW	2,968	2,665	2,220	1,774	1,678	1,538	1,408	1,231	1,268	1,124	1,020
Gas CC (442 MW + DF)	2018$/kW	1,122	1,114	1,100	1,088	1,079	1,072	1,063	1,056	1,049	1,042	1,034
Gas CT (237 MW)	2018$/kW	548	544	536	529	525	521	517	513	510	506	502
USC Coal w/ CCS	2018$/kW	5,421	5,339	5,231	5,121	5,016	4,916	4,814	4,717	4,624	4,531	4,445

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80% REDUCTION CASE INPUTS

Input	Unit	2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039
Coal (ILB mine)	2018$/MMBtu	1.78	1.66	1.49	1.27	1.25	1.25	1.25	1.25	1.25	1.25	1.25
CO2	2018$/ton	0.00	0.00	0.00	3.57	5.10	6.63	7.65	9.18	11.22	14.79	19.89
Gas (Henry Hub)	2018$/MMBtu	2.77	2.76	3.06	3.24	3.38	3.49	3.62	3.78	3.96	4.09	4.17
Vectren Peak Load	MW	1,115	1,102	1,131	1,060	1,025	1,039	1,038	1,038	1,053	1,053	1,065
Wind (200 MW)	2018$/kW	1,334	1,330	1,249	1,167	1,123	1,160	1,152	1,166	1,139	1,142	1,143
Solar (100 MW)	2018$/kW	1,524	1,362	1,202	1,041	1,026	999	952	929	866	856	865
Li-Ion Battery (50 MW, 4 hr)	2018$/kW	2,088	1,811	1,513	1,214	1,156	1,096	1,042	965	928	901	894
Flow Battery (50 MW, 6 hr)	2018$/kW	2,968	2,665	2,220	1,774	1,678	1,538	1,408	1,231	1,268	1,124	1,020
Gas CC (442 MW + DF)	2018$/kW	1,122	1,114	1,100	1,088	1,079	1,072	1,063	1,056	1,049	1,042	1,034
Gas CT (237 MW)	2018$/kW	548	544	536	529	525	521	517	513	510	506	502
USC Coal w/ CCS	2018$/kW	5,421	5,339	5,231	5,121	5,016	4,916	4,814	4,717	4,624	4,531	4,445

DRAFT HIGH REGULATORY CASE INPUTS

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Input	Unit	2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039
Coal (ILB mine)	2018$/MMBtu	1.78	1.66	1.49	1.27	1.25	1.25	1.25	1.25	1.25	1.25	1.25
CO2	2018$/ton	0.00	0.00	50.40	52.28	54.17	56.05	57.94	60.06	62.41	64.77	67.12
Gas (Henry Hub)	2018$/MMBtu	2.77	2.76	4.39	6.03	7.10	8.37	7.17	8.40	8.95	8.75	8.63
Vectren Peak Load	MW	1,115	1,102	1,168	1,176	1,183	1,192	1,200	1,209	1,219	1,229	1,239
Wind (200 MW)	2018$/kW	1,334	1,330	1,249	1,167	1,123	1,160	1,152	1,166	1,139	1,142	1,143
Solar (100 MW)	2018$/kW	1,524	1,362	1,202	1,041	1,026	999	952	929	866	856	865
Li-Ion Battery (50 MW, 4 hr)	2018$/kW	2,088	1,811	1,513	1,214	1,156	1,096	1,042	965	928	901	894
Flow Battery (50 MW, 6 hr)	2018$/kW	2,968	2,665	2,220	1,774	1,678	1,538	1,408	1,231	1,268	1,124	1,020
Gas CC (442 MW + DF)	2018$/kW	1,122	1,114	1,100	1,088	1,079	1,072	1,063	1,056	1,049	1,042	1,034
Gas CT (237 MW)	2018$/kW	548	544	536	529	525	521	517	513	510	506	502
USC Coal w/ CCS	2018$/kW	5,421	5,339	5,231	5,121	5,016	4,916	4,814	4,717	4,624	4,531	4,445

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DSM BUNDLES IN IRP MODELING
DSM BUNDLE SENSITIVITIES

	1	2	3	4	5	6	7
	Gross Projected Cost per KWh; Cumulative by Bundle (LOW CASE)						
2021	$0.01270	$0.01668	$0.01840	$0.02112	$0.02461	$0.02891	
2022	$0.01265	$0.01660	$0.01992	$0.02346	$0.02643	$0.03053	
2023	$0.01298	$0.01676	$0.01994	$0.02385	$0.02764	$0.03165	
2024	$0.01332	$0.01654	$0.02009	$0.02460	$0.02868	$0.03064	$0.03291
2025	$0.01374	$0.01798	$0.02149	$0.02623	$0.03043	$0.03356	$0.03434
2026	$0.01408	$0.01872	$0.02274	$0.02744	$0.03172	$0.03487	$0.03578
2027	$0.01461	$0.01964	$0.02373	$0.02895	$0.03316	$0.03623	$0.03708
2028	$0.01515	$0.02067	$0.02537	$0.03010	$0.03460	$0.03783	$0.03895
2029	$0.01593	$0.02158	$0.02695	$0.03237	$0.03616	$0.03999	
2030	$0.01671	$0.02358	$0.02804	$0.03272	$0.03732	$0.04174	
2031	$0.01742	$0.02439	$0.02864	$0.03436	$0.03838	$0.04250	
2032	$0.01829	$0.02515	$0.03111	$0.03605	$0.04009	$0.04459	
2033	$0.01942	$0.02617	$0.03285	$0.03866	$0.04136	$0.04582	
2034	$0.02010	$0.02701	$0.03467	$0.04009	$0.04292	$0.04749	
2035	$0.01656	$0.02140	$0.02586	$0.03225	$0.03697	$0.03889	$0.04328
2036	$0.01674	$0.02122	$0.02561	$0.03197	$0.03641	$0.03886	$0.04329
2037	$0.01670	$0.02129	$0.02566	$0.03146	$0.03627	$0.03897	$0.04315
2038	$0.01742	$0.02048	$0.02591	$0.03110	$0.03577	$0.03984	$0.04399
2039	$0.01814	$0.02097	$0.02656	$0.03122	$0.03652	$0.04043	$0.04449

	1	2	3	4	5	6	7
	Gross Projected Cost per KWh; Cumulative by Bundle (HIGH CASE)						
2021	$0.01613	$0.02119	$0.02337	$0.02682	$0.03126	$0.03673	
2022	$0.01607	$0.02109	$0.02530	$0.02979	$0.03357	$0.03877	
2023	$0.01649	$0.02129	$0.02533	$0.03029	$0.03510	$0.04020	
2024	$0.01691	$0.02100	$0.02552	$0.03125	$0.03643	$0.03892	$0.04181
2025	$0.01745	$0.02283	$0.02730	$0.03332	$0.03866	$0.04262	$0.04362
2026	$0.01788	$0.02377	$0.02888	$0.03486	$0.04029	$0.04429	$0.04544
2027	$0.01856	$0.02495	$0.03014	$0.03677	$0.04212	$0.04601	$0.04710
2028	$0.01924	$0.02626	$0.03222	$0.03823	$0.04394	$0.04805	$0.04947
2029	$0.02023	$0.02742	$0.03423	$0.04111	$0.04593	$0.05080	
2030	$0.02122	$0.02995	$0.03561	$0.04156	$0.04740	$0.05302	
2031	$0.02212	$0.03098	$0.03638	$0.04364	$0.04875	$0.05398	
2032	$0.02323	$0.03195	$0.03951	$0.04579	$0.05092	$0.05663	
2033	$0.02466	$0.03324	$0.04173	$0.04911	$0.05253	$0.05820	
2034	$0.02553	$0.03431	$0.04404	$0.05092	$0.05452	$0.06032	
2035	$0.02103	$0.02718	$0.03284	$0.04096	$0.04696	$0.04939	$0.05498
2036	$0.02126	$0.02695	$0.03253	$0.04060	$0.04625	$0.04936	$0.05499
2037	$0.02121	$0.02704	$0.03259	$0.03996	$0.04607	$0.04949	$0.05480
2038	$0.02212	$0.02601	$0.03291	$0.03950	$0.04544	$0.05060	$0.05587
2039	$0.02304	$0.02663	$0.03374	$0.03965	$0.04638	$0.05135	$0.05650

VECTREN
A CenterPoint Energy Company

DSM BUNDLES IN IRP MODELING
BASE CASE LEVELIZED COST PER KWH

	1	2	3	4	5	6	7
	Gross Projected Cost per KWh; Cumulative by Bundle						
2021	$0.0144	$0.0189	$0.0209	$0.0240	$0.0279	$0.0328	
2022	$0.0144	$0.0189	$0.0226	$0.0266	$0.0300	$0.0347	
2023	$0.0147	$0.0190	$0.0226	$0.0271	$0.0314	$0.0359	
2024	$0.0151	$0.0188	$0.0228	$0.0279	$0.0326	$0.0348	$0.0374
2025	$0.0156	$0.0204	$0.0244	$0.0298	$0.0346	$0.0381	$0.0390
2026	$0.0160	$0.0212	$0.0258	$0.0312	$0.0360	$0.0396	$0.0406
2027	$0.0166	$0.0223	$0.0269	$0.0329	$0.0376	$0.0411	$0.0421
2028	$0.0172	$0.0235	$0.0288	$0.0342	$0.0393	$0.0429	$0.0442
2029	$0.0181	$0.0245	$0.0306	$0.0367	$0.0410	$0.0454	
2030	$0.0190	$0.0268	$0.0318	$0.0371	$0.0424	$0.0474	
2031	$0.0198	$0.0277	$0.0325	$0.0390	$0.0436	$0.0482	
2032	$0.0208	$0.0286	$0.0353	$0.0409	$0.0455	$0.0506	
2033	$0.0220	$0.0297	$0.0373	$0.0439	$0.0470	$0.0520	
2034	$0.0228	$0.0307	$0.0394	$0.0455	$0.0487	$0.0539	
2035	$0.0188	$0.0243	$0.0294	$0.0366	$0.0420	$0.0441	$0.0491
2036	$0.0190	$0.0241	$0.0291	$0.0363	$0.0413	$0.0441	$0.0491
2037	$0.0190	$0.0242	$0.0291	$0.0357	$0.0412	$0.0442	$0.0490
2038	$0.0198	$0.0233	$0.0294	$0.0353	$0.0406	$0.0452	$0.0499
2039	$0.0206	$0.0238	$0.0302	$0.0354	$0.0415	$0.0459	$0.0505

	1	2	3	4	5	6	7	8
	2016 Projected Cost per kWh (Cumulative)							
2017	$0.03462	$0.03480	$0.03498	$0.03516	$0.04402	$0.04998	$0.05429	$0.05756
2018	$0.03607	$0.03626	$0.03645	$0.03664	$0.04547	$0.05142	$0.05572	$0.05899
2019	$0.03759	$0.03779	$0.03798	$0.03818	$0.04698	$0.05291	$0.05720	$0.06046
2020	$0.03917	$0.03938	$0.03958	$0.03979	$0.04855	$0.05446	$0.05873	$0.06197
2021	$0.04082	$0.04103	$0.04124	$0.04146	$0.05018	$0.05606	$0.06030	$0.06354
2022	$0.04254	$0.04276	$0.04298	$0.04320	$0.05187	$0.05771	$0.06193	$0.06514
2023	$0.04433	$0.04456	$0.04479	$0.04502	$0.05362	$0.05942	$0.06361	$0.06680
2024	$0.04619	$0.04643	$0.04667	$0.04691	$0.05544	$0.06118	$0.06534	$0.06851
2025	$0.04813	$0.04837	$0.04862	$0.04888	$0.05732	$0.06301	$0.06713	$0.07027
2026	$0.05016	$0.05042	$0.05068	$0.05094	$0.05928	$0.06491	$0.06898	$0.07209
2027	$0.05227	$0.05254	$0.05281	$0.05309	$0.06132	$0.06687	$0.07090	$0.07397
2028	$0.05447	$0.05475	$0.05503	$0.05532	$0.06343	$0.06890	$0.07286	$0.07589
2029	$0.05676	$0.05705	$0.05735	$0.05765	$0.06562	$0.07101	$0.07491	$0.07789
2030	$0.05914	$0.05945	$0.05976	$0.06007	$0.06789	$0.07318	$0.07702	$0.07995
2031	$0.06163	$0.06195	$0.06227	$0.06260	$0.07026	$0.07544	$0.07920	$0.08207
2032	$0.06422	$0.06456	$0.06489	$0.06523	$0.07271	$0.07777	$0.08145	$0.08426
2033	$0.06693	$0.06728	$0.06758	$0.06795	$0.07524	$0.08017	$0.08376	$0.08651
2034	$0.06974	$0.07010	$0.07046	$0.07083	$0.07790	$0.08269	$0.08618	$0.08885
2035	$0.07268	$0.07306	$0.07343	$0.07382	$0.08066	$0.08529	$0.08867	$0.09127
2036	$0.07573	$0.07613	$0.07652	$0.07692	$0.08351	$0.08798	$0.09125	$0.09375

Vectren 2019 IRP
2nd Stakeholder Meeting Minutes Q&A
October 10, 2019, 9:00 a.m. – 3:00 p.m.

Lynnae Wilson (CenterPoint Energy Indiana Electric Chief Business Officer) – Welcome and Safety Message (distracted driving) and Vectren introductions

Subject Matter Experts in the room: Anna Nightingale, Justin Joiner, Ryan Wilhelmus, Matt Rice, Wayne Games, Tom Bailey, Steve Rawlinson, Rina Harris, Shane Bradford, Heather Watts, Angie Bell, Natalie Hedde, Angie Casbon-Scheller, Bob Heidorn, Cas Swiz.

Gary Vicinus (Moderator, Managing Director for Utilities, Pace Global) discussed the agenda and provided a summary of stakeholder process (last meeting and present meeting). Approximately 35 stakeholders attended in person. List of affiliations include the following:

CAC
Country Mark
Hallador Energy
IBEW Local 702
Inovateus Solar LLC
IURC
NIPSCO
Orion Renewable Energy Group LLC
OUCC
Sierra Club
Solarpack Development, Inc.
SUFG
Valley Watch

Approximately 35 registered to attend the webinar; several participated. Those registered included representatives from:

Advanced Energy Economy
AEP
Boardwalk Pipeline Partners
Development Partners Group
Ecoplexus
Energy and Policy Institute
Energy Futures Group
EQ Research
First Solar
Hoosier Energy
ICC
Indiana Distributed Energy Alliance
IPL
IURC

juwi Inc.

Lewis Kappes

MEEA

Morton Solar & Electric

NextEra

NextEra Energy Resources

OUCC

Sierra Club

Vote Solar

Matt Rice (Vectren Manager of Resource Planning) and **Gary Vicinus** (Pace Global, Managing Director for Utilities) – presented Follow-up Information Since Our Last Stakeholder Meeting - Slides 9-13

- Slide 13 Stakeholder Feedback Cont.:
  - Request for folks to introduce themselves in the room and on the phone
    - Response: We have a full agenda; maybe we can take 5 minutes if there is time.
- Slide 13 Stakeholder Feedback Cont.:
  - Question: Can we send you additional health benefits studies for your consideration?
    - Response: Yes
- Slides 17-18 Scenario Narratives:
  - Clarifying question: Can we focus more on these two slides, as I'm interested in discussing the changes?
    - Response: Yes, we can discuss at the end of this session.
- Slide 24: Feedback and Discussion:
  - Question: With regards to the uneconomic asset risk analysis, you mentioned that you would be running 200 iterations. Will you be considering an earthquake in one of those iterations when assessing a portfolio?
    - Response: We will be assessing changing market conditions; I would not say earthquakes. We will be assessing the costs of various portfolios to determine if a portfolio becomes uneconomic under various market conditions, including fuel, load, technology costs, etc.
  - Question: Last meeting, you said you would consider a carbon fee and dividend scenario. But what you've included doesn't look like what we proposed. It's apples and oranges. I'm suggesting a carbon dividend is national and would affect gas, coal, etc. right here in Indiana. By definition, a carbon dividend is Low Regulatory but it is lumped in here with High Regulatory. HR 763 is a pending bill at national level with 60+ co-sponsors that may very well become law [link: https://www.congress.gov/bill/116th-congress/house-bill/763]. This was recently highlighted in a January Wall Street Journal article [WSJ article link: https://www.wsj.com/articles/economists-statement-on-carbon-dividends-11547682910] with a letter signed by 3,500 prominent economists advocating for a carbon dividend that will happen within 20 year timeframe of IRP. You've put it in High Reg but it looks more like the 80% case. No one is talking about cap & trade anymore. Rather than generic terms, why not put in this pending legislation and why not put it in the Low Reg scenario? Use what the bill proposed: $15/ton in first year, escalates by $10/ton each year thereafter?
    - Response: We'll consider that feedback. We need to consider a range of carbon prices, and maybe what you've suggested will align better with another scenario.
  - Question: Why not use actual pending legislation based on Paris Accord?
    - Response: We are going to capture a very wide range of carbon prices in the analysis. We do consider the Paris Accord in our analysis; you will see the CO_2 graph that demonstrates this. You'll see very high carbon prices in one scenario,

a 2% solution, ACE, and we're also considering adding a carbon price to the Base Case.

- Question: You mentioned using global warming potential of methane. Does CO_2 -e capture this?
    - Response: CO_2 -e will be captured in the stochastic runs (risk analysis and included in the scorecard). But within the scenario analysis, it is CO_2 .
- Question: On Slide 21, Life Cycle Green House Gas (GHG) Emissions, what it really boils down to is methane. Credible reports show 2.3% methane leakage. Math is simple. Gas isn't any better than coal in terms of GHG emissions.
    - Response: This is based on an NREL study that considers upstream and downstream emissions, which includes methane leaks.
- Statement: It's not complicated, 2.3% leakage and 87x more global warming potential. You can do it on a scratch pad.
    - Response: We are including methane leakage. We want to have quantitative measures in our scorecard. This rate includes what you're asking for.
- Question: Are there only five possible scenarios in your modeling software? Can you add more, e.g., Lani Ethridge's scenario [HR 763]?
    - Response: I would like to hold this question until we discuss the scenario inputs and show you the wide range of scenarios that we've created. Additionally, we will gather strategies to create other portfolios later today.
- Question: Please let folks on phone ask questions. Thank you for the tentative 10/24 Aurora call with Energy Exemplar. However, the $5k cost raises incredibly grave concerns for us, particularly as this process is supposed to lessen disputes before we enter litigation phase. This cost forecloses stakeholder participation and charging us for transparency is problematic. Also, according to Indiana Administrative Code 170 IAC 4-7-2.5, Vectren doesn't comply if we can't access the model at this cost. In Michigan, a utility was granted ~10 licenses within their subscription.
    - Response: We'll talk about that during the call on 10/24.
- Question: On Slide 21, happy to see Life Cycle GHG emissions; however, the NREL study is very dated, especially on solar. Can I provide updated studies?
    - Response: Yes, please send, though what we liked about the NREL study was that it considered many other studies and multiple perspectives, even if it is a little dated.
- Question: All the closures and retirements in the 2016 IRP, is that the base case in this IRP?
    - Response: This IRP is an update, and we are re-evaluating. Wayne Games will discuss how we will be evaluating existing resources.
- Question: So, it's possible that AB Brown could stay open?
    - Response: Yes.
- Question: Can we please try again for the phone?
    - Response: Please type questions. We do not see any typed questions at the moment.

<u>Justin Joiner</u> (Director of Power Supply Services) – MISO Considerations – slides 25-32:

- Slide 26 MISO Summary
    - Question: Why do you attribute changing resource mix to accreditation when weather, forced outages at fossil fuels plants, etc. can also be a driver?
        - Response: We'll address in detail shortly but changing resource mix is one of the main drivers. Outrages or load are other contributing factors.
    - Question: Wouldn't an increase in emergency events change accreditation?
        - Response: No, let's address shortly.
- Slide 28 Congestion
    - Question: Please explain price separation in zone 6.
        - Response: Overnight when there are low load periods and high wind output, MISO sends a negative price signal, which lowers the price that we are receiving

- there. The $5 price difference is a simple average over the last 12 months on an hourly basis.
  - Question: Do we need more transmission since we're talking about congestion?
    - Response: Yes, the next slide discusses MISO planning. MISO has two processes. (Slide 29) Interconnection queue (paid by new generators) and transmission planning process (paid for by all MISO participants, thus socialized across MISO footprint) helps to plan for new transmission needs to remedy congestion.
- Slide 31 All MISO Considerations Need to Be Accounted for During the IRP
  - Question: Which zones saw maximum generation events?
    - Response: Most recent maximum generation event was several zones (the North Central Region), including LRZ6 but up to Minnesota. The prior maximum generation events were more in MISO-South. We can follow-up on other events, if needed.
  - Question: How, within Aurora, does Vectren intend to try to account for seasonal accreditation?
    - Response – Pace can speak to this in more detail if needed, but you can set UCAP values in Aurora and the PRM requirement monthly.
  - Question: You mentioned one event was due to non-firm gas delivery. Wasn't the gas line to supply your formerly proposed gas plant with a non-firm contract?
    - Response: We were planning on serving that plant with firm delivery to ensure that we had high priority on delivery list.
  - Question: For transmission over 345 kW you mentioned costs would be distributed across MISO participants. Would that be true if a hydro unit was installed at the Meyers dam?
    - Response: I apologize, we're talking about 345 kV, so transmission delivery, not energy. We are talking about the rating of the line (line size).
  - Question: Were you involved with Duff Coleman transmission? I was involved as a property owner. Looking at current transmission corridors, and the effect of eminent domain on property owners. I think Vectren needs to consider corridors, competitor lines. How can you consider existing corridors?
    - Response: Planning is typically to use existing corridors. Vectren is not involved in the construction of the Duff Coleman transmission line (MISO opened it up to bids). MISO must consider all of this when planning transmission Right of Ways.
  - Comment: It is premature to modify reserve margin requirement based on max gen events. There are other options besides a seasonal resource adequacy construct. Could it help to address those issues with coordinated outage/maintenance schedules? It is perfectly fine to model as a base case sensitivity but not a base case assumption.
    - Response: MISO already implemented coordinated maintenance schedule reporting, which Vectren is already complying with. On seasonal construct, this is driven by MISO and we can't ignore or avoid; Vectren is only one stakeholder among many. Four season construct is already planned for implementation in 2021 by MISO. Vectren is looking at two seasons, not four, which is a conservative assumption that could potentially limit impact.
  - Question: Will recorded NPVs be based on deterministic modeling or stochastic modeling?
    - Response: Both. We'll look at portfolio performance on an expected (probabilistic) basis (from 200 iterations in the risk analysis) as well as deterministic NPV results (from the scenario analysis).
  - Question: Can you count on MISO to fill gaps for a year or two after coal is retired but before new resources are online? It seems like that would create some flexibility in how you move forward.
    - Response: We do have the ability to account for purchases to fill in gaps. That's part of the economic analysis.
  - Question: Does MISO plan to mitigate max gen events with solar+storage or even stand-alone storage?

        - Response: MISO requires four consecutive hours of output. So, if nameplate storage is 100 MW, then accreditation is 25 MW over four hours. To your question, MISO seasonal accreditation planning is meant to better align actual output with accreditation.
    - Question: When is MISO planning on incorporating new technology resources into their planning?
        - Response: They try to be as responsive but given all the stakeholders they can be a little slow at times for the latest technologies. They are responsive. To get changes done in the marketplace, that process usually takes 12-18 months to implement in new tariffs, etc. They also try to make market rules (with a year lag) based on annual transmission planning process, with respect to state planning processes.

Gary Vicinus (Pace Managing Director for Utilities) - Scenario Modeling Inputs – slides 33-48:
Slide 48 Feedback and Discussion:

- Question: You're showing these inputs, but what about distributed generation? If you lift policy caps on solar, your demand would drop a lot with solar as well as behind-the-meter storage. Don't the caps limit solar DG (in schools, etc.)? We could get there at a reasonable cost because the investment comes from individuals.
    - Response: We don't cap the amount of distributed solar considered, but payback calculation within the model is affected by net metering structure. We are going to analyze a wide range for peak loads; Itron did a sensitivity on rooftop solar that falls within this range.
- Comment: I'd like to see intentional changes in policy to promote distributed energy and how would that affect the rest of your modeling (and Behind The Meter, bi-directional batteries)? I would like to see incentives.
    - Response: I would suggest that this be one of the strategies for the group breakout session.
- Comment: Under Energy Innovation and Carbon Dividend Act being considered in congress right now, in 2022 CO_2 would be $15 but in 2039 it would be $185. That would change the outlook considerably.
- Question: Also, why is coal price lower if costs are higher?
    - Response: Lower coal prices follow from lower coal demand. With reduced demand, only the most efficient will survive.
- Question: The peaks and valleys on these graphs would indicate to me that the same distribution is not being assumed in any given year. For example, the distribution is not always normal. For the capital costs in particular, that strikes me as a level of precision that does not actually exist. For example, why would two standard deviations give you a wider range of distributions in 2033 vs. 2036 for solar? In general, I would reiterate the feedback that we have given previously. Stochastic simulation is not a good tool for capex (just for volatile variables like gas). Will these standard deviations be applied to the bids received from the RFP?
    - Response: Distributions do vary over time, as one would expect, as uncertainty increases over time. It's correct to say the distributions are not always normal (e.g., gas wouldn't fall below $2 because costs must be recovered). Market conditions drive the upper end. Many of our distribution are skewed to the upward side. To say that stochastic simulation is not a good test, I would say that is a point of view. We use stochastics in many jurisdictions and it is widely accepted. It is intended to reflect not only the volatility but also the uncertainty as we go forward.
- Question: Why do distributions widen, narrow, widen, etc., if uncertainty grows? And using stochastics for solar capital costs standard deviations doesn't reflect how actual capital costs move. Why not use sensitivities, which is what is typically seen in IRPs?
    - Response: A lot of these graph reflect monthly variations as opposed to annual. They tend to smooth out when you look at them on an annual basis. Ultimately, we will do some annual smoothing. I agree that the monthly variations are not easily explained, but they tend to level out on an annual basis.
    - Question: Will you apply distributions to bid prices?

        - Response: We will use for the various years where we have bid information as an input at base levels. After the bid years, the stochastic distributions will be reflected.
    - Question: If a bid resource would come online in 2022, you wouldn't apply distributions there?
        - Response: In your example, we will utilize the bid information for 2022 and use the distributions going forward (beyond 2022). We will set up a follow-up conversation.
- Question: How did you come up with 2.2% inflation assumption?
    - Response: It is a projection from Moodys.com.
- Question: When do the probability distributions come into effect (after bids)?
    - Response: Bids come in in different years, then we start uncertainty shortly thereafter.

Michael Russo (Sr. Forecast Consultant, Itron) – Long term Base Energy and Demand Forecast – slides 49-60:

- Slide 57 C&I Sales Forecast:
    - Question: Can you pull out Electric Vehicle (EV) owners who have solar Distributed Generation (DG)? EV owners aren't adding to load given that they have solar DG too.
        - Response: We start with 200 registered EV owners but Itron doesn't have info on who also has solar distributed generation. Theimpact won't be large given the small starting number.
- Slide 60 Feedback and Discussion:
    - Question: You did the forecasts for the 2016 IRP. How accurate were those forecasts?
        - Response: We did not specifically look at the last couple of years, but in general we do look at forecasting error. We do hold out the last year of the model and compare how well the model performs, now that we have the actuals. Our Mean Absolute Percentage Errors (MAPE) on the residential and commercial side is typically around 2%. They are higher on the industrial and peak models.
    - Question: On Slide 59, you show significant drops in both energy and demand that don't seem to be reflected in residential and C&I.
        - Response: That is a large industrial customer that is modeled separately (and not included on Slide 56 C&I Sales Forecast).
    - Question: The industrial growth is very significant. Can you say more?
        - Response: We can't comment on individual load additions publicly. What we can say is that there are two public projects in Southwest Indiana that received air permits in the past two years (in public domain). We have formulated expected MWs and MWhs from potential customers that have come to us. We have signed NDAs for projects (required for all economic development opportunities), but large industrials account for the majority of industrial uptick. We have an obligation to serve this load.
    - Question: How will these load forecasts be translated into high/low load forecasts, particularly given large industrial customers? I have similar concern to the CAC.
        - Response: The answer depends upon the component. Looking at higher/lower EV forecast, we take that input in developing upper/lower boundary scenarios. Pace starts with what Vectren/Itron provides us, then we look at uncertainties around this. Even when individual components such as EV or solar, we're still within the boundaries showed earlier. We haven't finalized load, so we'll look at individual components and adjust accordingly.
    - Question: Is the coal to diesel plant reflected in to the two permits that you discussed earlier?
        - We are not going to comment on those two specific permits.
    - Question: Is Southern Indiana petrochemical facility included in industrial outlook?
        - Response: Cannot comment on specific projects.
    - Comment: The coal-to-diesel plant won't happen, so if you're considering this in the forecast, you need a new forecast. If they're already permitted, why can't you discuss them?

    - Response: We have signed NDAs with perspective customers at their request. and so, we can't discuss their load for competitive reasons.
  - Comment: I've been having a moment at these meetings. It struck me when we looked the slide about trended normal weather. It feels to me like we're rearranging deck chairs on the Titanic. I think that the issue that we need to be basing our decisions on is around that exact fact. Climate crisis demands we act, not because we're forced to by any rule, but because we need to act for our children. I feel like what we're talking about is not what is important.
    - We're basing off historical weather trends, which is used by government and others.

Wayne Games (Vice President power Generation Operations) – Existing Resource Overview – slides 61-75:

- Slide 75 Feedback and Discussion:
  - Question: (Clarification on solar resources) Do you plan to build 54 MWs of solar or over 100 MWs (referring to slides 64 Summary of Current Resource UCAP Accreditation for Summer Peak and 66 Renewables)?
    - Response: We have two 2 MW projects and plan to build an additional 50 MWs.
  - Comment: These options for AB Brown, etc.…these plants are obsolete now. It seems awkward to invest more in dying technologies.
    - Response: I'm not saying we should or shouldn't. We're required to look at all options and some stakeholders have asked us to look at these options.
  - Comment: Even when you show 80% carbon reduction by Paris Treaty, that doesn't reflect what we face now. Right now, there is a lake in Siberia that is bubbling up methane because we under-projected. We need a Greta Thunberg portfolio, which means we put everything possible into cutting carbon emissions. We need a crisis scenario.
  - Comment: On carbon, Vectren should be looking into technology to sequester carbon. Where can Vectren use science, like Duke Energy, to get today's youth involved in STEM classes. You need to look at the bigger environmental picture.
  - Comment: There were a lot of numbers and analysis. We'd like to work with you to get access to your numbers, including Slide 74 A.B. Brown FGD Options, derived from outside engineering studies.
  - Question: Where will 50 MW solar plant be built?
    - Response: East side of Spencer County.
  - Question: I don't understand why you use historical weather when Purdue University. uses different projections? I don't understand why your projections don't look like their projections.
    - Response: What we use is consistent with what EIA uses. We did not use the Purdue data set.
  - Question: So, you're saying you should use historical approach because you expect nothing out of the usual?
    - Response: Our forecast is different than what we've done in the past to address the trended weather concern.
  - Comment: Have you looked at Purdue report?
    - Response: We attended the talk the other night and looked at the website. If you'd like to send me the report, we'll look. We will reach out to Purdue to understand their dataset.

Matt Lind (Resource Planning & Market Assessments Business Lead, Burns and McDonnell) Potential New Resources and MISO Accreditation – slides 76-92:

  - Question (Slide 81 Technology Details): Can you explain difference between estimated potential capacity and estimate feasible capacity and estimated optimal capacity?

        - Response: We would need to look more closely, but I believe that the Estimated Potential Capacity is the technical potential, not necessarily the most economic option.
    - Question: On slide 84 & 80, does solar+storage mean exclusively charged by solar or charged by grid?
        - Response: The former (exclusively supplied by the sun) is generally the case, depending on the bids.
    - Question: On slide 84 Proposal Location Review, what is the difference between proposal installed and project installed capacities?
        - Response: Proposal includes double- and triple-counting.
    - Question: On Slide 85 Participating Companies, is Duke Energy a participant?
        - Response: Yes
- Slide 87 MISO Renewable Penetration Trends
    - Question: Counterintuitive – Your credit to solar shouldn't go down as installed capacity goes up. It's counterintuitive to me.
        - Response: As more solar, a non-dispatchable resource, is added to the system accreditation goes down. As you add more solar, the risk of being deficient from a resource perspective shifts to the evening hours. ELCC is a calculation that MISO has been using for wind resources for several years.
    - Question: Is the ELCC based on fixed or tracking solar?
        - Response: Orientation, geography, etc. are all considered, but accreditation (the amount of credit MISO is projected to provide for resource) will still decline over time.
    - Question: Prices are higher than I've seen. Are these prices typical or representative of actual bids?
        - Response: This is technology assessment data, not bid data.
    - Question: Wouldn't MISO accreditation change with storage?
        - Response: Yes, though even standalone storage would be affected given the duration of storage. To be eligible for full accreditation for storage, you need more than 4 hours of storage. This reinforces the diversity of resources and the location of resources.
- Slide 89 Wind Seasonal Differences
    - Question: So, you're making changes for Southern Indiana based on MISO which encompasses Canada to Gulf of Mexico. Doesn't this skew things?
        - Response: MISO provides a unique geographic accreditation to each Local Resource Zone, though it is still tied to the MISO peak.

Feedback and Discussion slide 92:

- Comment: I noticed a combination that may be cost effective. We worked on this during the prior CCGT case. That is repowering one of the Brown units coupled with the smaller CCGT. The new gas pipeline doesn't need to be double-counted. You could use one pipeline to serve both units.
- Question: When does wind and solar become dispatchable (with sufficient storage)?
    - Response: Storage round-trip efficiency is a net load to the system. Today's technology is not there yet. You'd have to add a lot of storage, but there would still be a net load. It depends on technology, consumer behavior, etc. Battery experts are researching this. I don't see it in the near term.
- Question: Would bigger installations of PV panels or turbines lead to less need for storage?
    - Response: That is a strategy people are looking at, particularly to take advantage of tax credits.
- Question: Why does solar capacity credit start at 50% and not 60% on Slide 87 MISO Renewable Penetration Trends? Also, can you show us specific data showing forecast for renewable and storage penetration?
    - Response: We took the average across the MISO Transmission Expansion Plan (MTEP) futures. The average installation grows from 6,000 MW in 2023 to about 25,000 MW by 2033. We extrapolated that trend line beyond 2033. On slide 91 Zone

6 Seasonal Accreditation, we used 50% during the first year of operation, per MISO ELCC figures.
    - Question: What is the basis for 0% capacity accreditation in winter?
        - Response: Peak hours are in the H20-H22 range when there is no solar production.

Jeffrey Huber (Managing Director, GDS Associates) - DSM Modeling in the IRP – Slides 93-103:

Slide 103 Feedback and Discussion:

- Comment: Thank you Vectren and Jeff for working with the CAC on this through the Oversight Board. We look forward to seeing how this all works through the IRP process.
- Question: About interruptible tariff (not part of this DSM analysis), will we continue that process?
    - Response: We're in the process of truing up our interruptible tariff with MISO in mid- to late-November, which would true up notification times.
- Question: I'm interested in economic curtailment.
    - Response: We're working on language changes (ongoing) and we'll get back to you on that.

Gary Vicinus (Pace Managing Director of Utilities) – Stakeholder Breakout Session Strategy Development – Slides 104-107:

- Instructions given: Examples: Impose an Renewable Portfolio Standard (RPS) of X% by X year, or a portfolio with no coal by X year, etc.
- See Slide 106 Portfolio Strategy Worksheet – use this for strategies and timeframes
- Group 1: Six strategies:
    1. Plants scheduled in 2016 IRP – Do that by 2024 and replace closures with renewable energy capacity
    2. Culley 3 be closed by 2030, also replaced by renewable energy
    3. Lobby to extend net metering at 1-to-1 ratio, no cap, by 2022
    4. Close gas-fired plants by 2030 and replace with renewable energy (solar)
    5. Maximize Energy Efficiency efforts immediately (by 2020) through incentives
    6. Increase storage in timeframes to accommodate bringing on renewable energy (~5 years, timed to retirements, focused on Behind the Meter solar)
- Group 2:
    1. Do what NIPSCO is doing. As resources retire, replace with renewable energy. (Clarification from stakeholder – NIPSCO in 2026 is adding a price on carbon, whereas Vectren Base Case is $0 for 20 years)
    2. Go for 100% renewable energy by end of 2030
    3. Have 100% reduction in CO_2 and equivalents at the end of 20 years
    4. Have other experts review how you're using our recommendations (to ensure it is being treated fairly in the modeling)
- Group 3:
    1. We want to access all the runs under the Nondisclosure Agreement (NDA).

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VECTREN PUBLIC STAKEHOLDER MEETING

DECEMBER 13, 2019

VECTREN
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WELCOME AND SAFETY SHARE

LYNNAE WILSON

INDIANA ELECTRIC CHIEF BUSINESS OFFICER

SAFETY SHARE

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Holiday Safety Tips

- Inspect electrical decorations for damage before use. Cracked or damaged sockets, loose or bare wires, and loose connections may cause a serious shock or start a fire
- Do not overload electrical outlets. Overloaded electrical outlets and faulty wires are a common cause of holiday fires. Avoid overloading outlets
- Use LED lights. Never connect more than three strings of incandescent lights. More than three strands can cause a fire
- Use battery-operated candles. Candles start almost half of home decoration fires (National Fire Protection Association - NFPA)
- Keep combustibles at least three feet from heat sources. Heat sources that are too close to a decoration are a common factor in home fires
- Protect cords from damage. To avoid shock or fire hazards, cords should never be pinched by furniture, forced into small spaces such as doors and windows, placed under rugs, located near heat sources, or attached by nails or staples
- Stay in the kitchen when something is cooking. Unattended cooking equipment is the leading cause of home cooking fires (NFPA).
- Turn off, unplug, and extinguish all decorations when going to sleep or leaving the house. Half of home fire deaths occur between the hours of 11pm and 7am (NFPA).

2019/2020 STAKEHOLDER PROCESS

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August 15, 2019	October 10, 2019	December 13, 2019	March 20, 2020[1]
• 2019/2020 IRP Process • Objectives and Measures • All-Source RFP • Environmental Update • Draft Reference Case Market Inputs & Scenarios	• RFP Update • Draft Resource Costs • Sales and Demand Forecast • DSM MPS/ Modeling Inputs • Scenario Modeling Inputs • Portfolio Development	• Draft Portfolios • Draft Reference Case Modeling Results • All-Source RFP Results and Final Modeling Inputs • Scenario Testing and Probabilistic Modeling Approach and Assumptions	• Final Reference Case and Scenario Modeling Results • Probabilistic Modeling Results • Risk Analysis Results • Preview the Preferred Portfolio

1 Updated

AGENDA

Time		
9:00 a.m.	Sign-in/Refreshments	
9:30 a.m.	Welcome, Safety Message	Lynnae Wilson, CenterPoint Energy Indiana Electric Chief Business Officer
9:50 a.m.	Follow-up Information Since Our Last Stakeholder Meeting	Matt Rice, Vectren Manager of Resource Planning
10:30 a.m.	Break	
10:40 a.m.	Draft Reference Case Results	Peter Hubbard, Manager of Energy Business Advisory, Pace Global
11:40 a.m.	Lunch	
12:40 p.m.	Final RFP Modeling Inputs	Matt Lind, Resource Planning & Market Assessments Business Lead, Burns and McDonnell
1:40 p.m.	Break	
1:50 p.m.	Portfolio Development	Matt Rice, Vectren Manager of Resource Planning
2:20 p.m.	Scenario Testing and Probabilistic Modeling	Peter Hubbard, Manager of Energy Business Advisory, Pace Global
2:50 p.m.	Next Steps	Matt Rice, Vectren Manager of Resource Planning
3: 00 p.m.	Adjourn	

MEETING GUIDELINES

1. Please hold most questions until the end of each presentation. Time will be allotted for questions following each presentation. (Clarifying questions about the slides are fine throughout)
2. For those that wish to participate remotely, please log in via the link provided Link to join in your RSVP and follow the phone instructions when prompted. To speak during the meeting, please make a request in the chat function, and we will open up your individual line.
3. If you wish to listen only, you may call in with the phone number provided in your RSVP: 1-415-655-0003 | Access code: 806 147 760. You will not be able to speak during the meeting utilizing this option.
4. There will be a parking lot for items to be addressed at a later time.
5. Vectren does not authorize the use of cameras or video recording devices of any kind during this meeting.
6. Questions asked at this meeting will be answered here or later.
7. We will do our best to capture notes but request that you provide written feedback (concepts, inputs, methodology, etc.) at IRP@CenterPointEnergy.com following the meeting. Additional questions can also be sent to this e-mail address.

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FOLLOW-UP INFORMATION SINCE OUR LAST STAKEHOLDER MEETING

MATT RICE

VECTREN MANAGER OF RESOURCE PLANNING

VECTREN COMMITMENTS FOR 2019/2020 IRP

By the end of this stakeholder meeting Vectren will have made significant progress towards the following commitments

- ✓ Utilizing an All-Source RFP to gather market pricing & availability data
- ✓ Including a balanced, less qualitative risk score card; draft was shared at the first public stakeholder meeting
- ✓ Performing an exhaustive look at existing resource options
- ✓ Using one model for consistency in optimization, simulated dispatch, and probabilistic functions
- ✓ Working with stakeholders on portfolio development
- ✓ **Modeling more resources simultaneously**
- ✓ **Testing a wide range of portfolios in scenario modeling and ultimately in the risk analysis**
- ✓ **Providing a data release schedule and provide modeling data ahead of filing for evaluation**
- ✓ **Striving to make every encounter meaningful for stakeholders and for us**

Vectren will continue to work towards the remaining commitments over the next several months

- Ensuring the IRP process informs the selection of the preferred portfolio
- Conducting a sensitivity analysis
- Including information presented for multiple audiences (technical and non-technical)

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2019/2020 IRP PROCESS

- Conduct an All Source RFP
- Create Objectives, Risk Perspectives and Scorecard Development
- Create Reference Case Assumptions and Scenario Development
- Portfolio Development Based on Various Strategies, Utilizing Optimization to Create a Wide Range of Portfolios and Refine with All Source RFP Data
- Portfolio Testing in Scenarios, Focused on Potential Regulatory Risks
- Portfolio Testing Using Probabilistic Modeling of 200 Potential Futures
- Utilize the Probabilistic Modeling to Conduct Sensitivity Analysis
- Populate the Risk Scorecard that was Developed Early in the Process and Evaluate Portfolios
- Select the Preferred Portfolio

TENTATIVE DATA RELEASE SCHEDULE

- Modeling files
  - Reference Case modeling files (confidential – available February 2020)
  - Scenarios modeling files (confidential – available April 2020)
  - Probabilistic modeling files (confidential – available May 2020)
- Sales and Demand Forecast
  - Report (not confidential – available now)
- RFP
  - Bid information (confidential)
  - Report (confidential – available March 2020)
- Various Power Supply Reports
  - Conversion (confidential – available February 2020)
  - Scrubber options (confidential – available February 2020)
  - ACE Study (confidential – available February 2020)
  - ELG (confidential – available February 2020)
  - Brown 1x1 CCGT (confidential – available March 2020)
- Pipeline cost assumptions (confidential – available February 2020)

STAKEHOLDER FEEDBACK

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Request	Response
Add a scenario or replace a scenario with a Carbon Dividend modeled after HB 763, which includes a CO_2 price in 2022 of $15, increasing by $10 per ton each year ($185 by 2039)	Our High regulatory case includes a high CO_2 fee and dividend. While there is no guarantee that a carbon dividend future would exactly mirror HB 763, we will run a sensitivity for portfolio development based on HB 763 to determine what type of portfolio it creates. Assuming that it is different than other portfolios that we are considering, we can include the portfolio in the risk analysis. We do not plan to create a 6th scenario
A cap and trade scenario is not a likely potential future	Cap and Trade is a real possibility. Beyond ACE, it was the only carbon compliance law in the US to date. The 80% reduction of CO_2 future, which is in alignment with the Paris Accord, is a reasonable potential future (our middle bound). Scenarios are not predictions of the future but provide plausible futures boundary conditions
It is premature to model a seasonal construct, referring to summer and winter (MISO) UCAP accreditation	As mentioned in the last meeting, MISO is moving to a seasonal construct. Vectren evaluated other potential calculations for accrediting solar with capacity in the winter. Determined that a weighted average of daily peak conditions could yield an 11% UCAP for solar in the winter, as opposed to 0%. Increased solar penetration would still reduce this amount of accreditation over time

STAKEHOLDER FEEDBACK

Request	Response
Referring to hydro studies cited at the 2nd stakeholder meeting, please clarify what the difference between estimated potential capacity, estimate of feasible capacity, and estimated optimal capacity is. Additionally, there was a request to increase the Vectren hydro modeling assumption from 50 MWs at each nearby dam to 100 MWs each	The DOE/NREL study, which provided estimated potential capacity, is a high level estimate of potential using generic modeling assumptions and not taking economics into consideration. The Army Corp of Engineers uses specific conditions on the Ohio to refine the DOE/NREL initial estimates into realistic project potential. 50 MWs at each dam is more in line with the range provided in the Army Corp of Engineers study. Vectren will evaluate two blocks of 50 MWs within scenario modeling and portfolio development
The NREL Life Cycle GHG study is dated	We had a discussion with First Solar on their perspective regarding lifecycle of greenhouse gas emissions for solar resources. An IEA study with updated assumptions on solar found a similar result to the NREL study for local solar resources. Additionally, Vectren likes the fact that NREL's study is fairly comprehensive. Vectren plans to utilize the NREL Study for estimated life cycle CO_2e for most resource types
NREL Life Cycle GHG study does not consider storage	Evaluating options
NREL Life Cycle GHG study does not consider gas resources and Vectren should simply utilize an alternate calculation for natural gas resources	The NREL study did consider gas resources. Various gas studies considered for the analysis included methane leaks as part of the study (see appendix)

STAKEHOLDER FEEDBACK

Request	Response
Add a CO_2 price to the Reference Case	We have added the mid-range CO_2 price to the Reference Case. ACE runs for 8 years and is replaced (see slide 20)
Your trended weather projections do not look anything like Purdue's	We reached out to Purdue University. They provided some clarification on the differences between their study and ours, including using different set points for heating and cooling degree days. Itron reviewed and estimated that the HDD trend is the same, while the CDD trend is nearly two times higher in the Purdue dataset. Utilizing the Purdue CDD trend would add approximately 40 MWs to Vectren's forecast over the next 20 years, which is well within our high bound forecast. We do not plan to update our load forecast, based on this analysis
Follow-up on updates to Industrial DR tariff	Report back progress in the next IRP stakeholder meeting
$5k for Aurora is paying for transparency	Met with CAC, Pace, and Energy Exemplar (Aurora) on Oct. 24th. To address CAC's concern, Pace will work to provide relevant input tables from modeling, which include model settings. Each table will need to be exported separately. Additionally each relevant help function page will be exported separately. While time consuming, Pace will work to accommodate this request for stakeholders. Modeling files will be shared later in the process as timely analysis takes precedent

MISO UPDATE

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- John Bear, CEO of MISO, recently testified before the Subcommittee on Energy. Reiterated the importance of the Renewable Integration Impact Assessment (RIAA) analysis
  - While MISO is fuel source neutral, they have learned that renewable penetration of 30% would challenge MISO's ability to maintain the planning reserve margin and operate the system within acceptable voltage and thermal limits
  - Maintaining reliability at 40% renewable level becomes significantly more complex. Currently MISO is studying 50% penetration level
  - Implications include tight operating conditions (need to utilize emergency procedures to manage reliability risk)
  - Requires a shift in market processes and protocols
    - We can no longer be confident that the system will be reliable year round based on peak demand in the summer. **All hours matter**
    - Resources must provide enough, and the right kinds of critical attributes needed to keep the system operating in a reliable, steady state, such as frequency response, voltage control, and black-start capability
    - We can no longer be confident that the existing transmission system can adapt to the new paradigm of smaller, decentralized intermittent renewable resources
  - Fleet of the future: improved availability, flexibility, and visibility. MISO is working to hold members responsible to deliver attributes and is developing incentives for these attributes

CCR / ELG – PROPOSED RULE SUMMARIES

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- CCR
  - Advances date the cease use of all unlined ponds by 2 months, from October 31, 2020 to **August 31, 2020**
  - Short-term extension available to November 30, 2020
  - Site-specific extension available which would allow continued use of pond until **October 15, 2023**. Requires submitting a demonstration and work plan to EPA for approval
  - Permanent Cessation of Boiler extension
    - AB Brown – use of pond until October 17, 2028 if closure is <u>completed</u> by same date
      - This extension option is not feasible for AB Brown due to size and scope of closure
    - FB Culley – use of pond until October 17, 2023 if closure is completed by same date
- ELG
  - No extension for Bottom Ash Transport Water (BATW)
  - Revised limits for BATW on an "as needed" basis
    - 10% volume discharge on a 30-day rolling average
  - Boilers retiring by 2028 would only be subject to TSS limits; however, the earlier CCR deadline to cease disposal by October 2023 is the driver for compliance at AB Brown

CCGT STUDY

- No firm bids were received for gas CCGTs and nothing was on/near our system
- FERC recently updated a rule that allows for an expedited process within the MISO Queue to replace existing resources at or below existing interconnection rights
- As part of the IRP, it is prudent to study options with regards to existing resources, which includes existing Vectren sites
- Currently performing a study to obtain a +/- 10% cost estimate for a small/midsized 1x1 CCGT (F-class and H-class) at the Brown site to be included in final IRP modeling (consistent with CCGT units included within the tech. assessment at +/- 50%)
- Benefits of the Brown site
  - Electric infrastructure in place to support a 400-500 MW unit
  - Would allow Vectren to utilize existing assets at the site
  - Would preserve tax base and jobs in Posey County

BAGS 2 RETIRED

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- Retiring Broadway Avenue Generating Station 2 (65 MWs of installed capacity) by the end of the year
  – Typical life is 30-40 years; Unit has been in service for 38 years
  – Highest heat rate (least efficient) of current generating fleet
  – Recent five year capacity factor just over 1%
  – Several million dollars needed for known repairs
  – High probability of additional expenses in the near future given current age and condition

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DRAFT REFERENCE CASE MODELING RESULTS

PETER HUBBARD

MANAGER OF ENERGY BUSINESS ADVISORY, PACE GLOBAL

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WIDE RANGE OF PORTFOLIOS

The final reference case is 1 of 15 potential portfolios that will be analyzed over the coming months. The preferred portfolio will be selected based on the results of the full risk analysis

Bridges

- 7) Gas Conversion ABB1
- 8) Gas Conversion ABB1 & ABB2
- 9) Gas Conversion + CCGT
- 10) BAU 2029

Scenario Based

- 2) Low Regulatory
- ***3) Reference Case***
- 4) High Tech
- 5) 80% CO_2 Reduction
- 6) High Regulatory

Diverse

- 11) Small CCGT with renewables and coal
- 12) Mid CCGT with renewables and coal

Status Quo

- 1) Business as Usual (BAU)

Risk Analysis

Renewables Focused

- 13) Close All Fossil by 2030
- 14) Renewables + flexible gas (close coal by 2034 and no CCGT)
- 15) HB 763

FINAL DRAFT REFERENCE CASE INPUTS

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Input	Unit	2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039
Coal (ILB mine)	2018$/MMBtu	1.78	1.66	1.64	1.63	1.61	1.61	1.59	1.58	1.59	1.59	1.58
CO2	2018$/ton	0.00	0.00	0.00	0.00	3.57	5.10	6.63	7.65	9.18	11.22	14.79
Gas (Henry Hub)	2018$/MMBtu	2.77	2.76	3.06	3.24	3.38	3.49	3.62	3.78	3.96	4.09	4.17
Vectren Peak Load	MW	1,115	1,102	1,168	1,176	1,183	1,192	1,200	1,209	1,219	1,229	1,239
Customer-Owned Solar DG Capacity*	MW	9.3	14.6	20.7	27.1	34.2	41.7	49.6	57.7	66.3	75.1	84.3
EV Peak Load**	MW	0.4	2.0	9.8	13.8	17.8	21.8	25.9	30.0	34.2	38.3	42.3
Energy Efficiency and Company DG	MW	6.0	9.2	15.7	22.6	28.8	33.1	39.0	45.2	48.8	50.5	47.6
Demand Response	MW	35.2	51.7	52.7	61.6	64.4	67.3	70.1	73.0	75.8	78.7	81.5
Wind (200 MW)	2018$/kW	1,334	1,330	1,328	1,326	1,324	1,324	1,324	1,324	1,326	1,328	1,330
Solar (100 MW)	2018$/kW	1,414	1,264	1,205	1,168	1,130	1,096	1,064	1,038	1,012	993	973
Li-Ion Battery (50 MW, 4 hr)	2018$/kW	2,088	1,811	1,654	1,518	1,452	1,391	1,342	1,301	1,263	1,232	1,201
Flow Battery (50 MW, 6 hr)	2018$/kW	2,968	2,665	2,450	2,242	2,116	1,996	1,892	1,803	1,719	1,651	1,586
Gas CC F-Class (442 MW with DF)	2018$/kW	1,301	1,291	1,275	1,261	1,251	1,242	1,233	1,224	1,216	1,207	1,199
Gas CT F-Class (237 MW)	2018$/kW	712	707	697	688	683	677	672	667	662	657	653
USC Coal w/ CCS	2018$/kW	5,621	5,536	5,424	5,309	5,201	5,097	4,992	4,891	4,794	4,698	4,605

** Res/Com Demand Impact = 0.295*
*** EV Coincident Factor = 0.211*

Revised from last meeting

DRAFT REFERENCE CASE EXISTING RESOURCE OPTIONS

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			2023					2026	2029	2039
Unit	**Fuel**	**Installed Net Capacity (MW)**	**Upgrade Path 1 *(FGD, ELG, CCR, ACE)***	**Upgrade Path 2 *(ELG, CCR, ACE)***	**Convert to Gas**	**Continue Agreement / Exit Agreement**	**Retire**	**Exit Agreement**		
ABB1	Coal	245	Option	Option	Option	n/a	Option	n/a	If Upgrade Path 2, unit retires in 2029	If Upgrade Path 1 or Convert, unit to run to 2039
ABB2	Coal	245	Option	Option	Option	n/a	Option	n/a	If Upgrade Path 2, unit retires in 2029	If Upgrade Path 1 or Convert, unit to run to 2039
ABB3	Gas	85								Unit to run to 2039
ABB4	Gas	85								Unit to run to 2039
FBC2	Coal	90	n/a	Option	Option	n/a	Option	n/a	n/a	If Upgrade Path 2 or Convert, unit to run to 2039
FBC3	Coal	270								Unit to run to 2039
W4	Coal	150	n/a	n/a	n/a	Option	n/a	Exit	n/a	n/a
OVEC	Coal	32								Ownership share to run to 2039
Benton	Wind	30								PPA for 30 MW thru 2028
Fowler	Wind	50								PPA for 50 MW thru 2030
Troy	Solar	50								Self-build solar to run to 2039

DRAFT REFERENCE CASE NEW RESOURCE OPTIONS

Type	Resource	Limitations	Capacity Options			
RE and Storage	Hydroelectric	Max 2 units	50 MW			
	Wind Energy	400 MW per year	200 MW			
	Wind plus Storage	150 MW per Year	50 MW wind (10 MW/40 MWh battery)			
	Solar Photovoltaic	500 MW per year	10 MW	50 MW	100 MW	
	Solar plus Storage	150 MW per Year	50 MW solar (10 MW / 40 MWh battery)			
	Lithium-Ion Battery Storage	300 MW per year	10 MW / 40 MWh	50 MW / 200 MWh		
	Flow Battery Storage	400 MW per Year	10 MW / 60 MWh	10 MW / 80 MWh	50 MW / 300 MWh	50 MW / 400 MWh
Demand Side Management*	Low Income Energy Efficiency	Required	0.7 MW			
	Optional Energy Efficiency	7 optional resources	Bin 1: 2.2 MW	Bin 2: 2.3 MW	Bin 3: 2.4 MW	Bin 4: 2.5 MW
			Bin 5: 2.2 MW	Bin 6: 2.3 MW	Bin 7: 0.5 MW	
	Demand Response	1 required, 1 optional	Bin 1: 21.1 MW	Bin 2: 5.8 MW		
Coal	Supercritical with CCS	Max 1 unit	500 MW			
	Ultrasupercritical with CCS	Max 1 unit	750 MW			
Waste to Energy	Chipped Wood Biomass	3 units per year	50 MW			
	Landfill Gas	3 units per year	4.5 MW			
Combined Heat & Power	2x 9MW Recip Wartsila	4 units per year	18 MW			
	1 x Titan 250 CTG	4 units per year	20 MW			
Combined Cycle	1x1 F Class CCGT Unfired	1 Per Year	357 MW			
	1x1 F Class CCGT Fired	1 Per Year	443 MW			
	1x1 G/H Class Unfired	1 Per Year	410 MW			
	1x1 G/H Class Fired	1 Per Year	511 MW			
Simple Cycle	1x E Class Frame SCGT	Max 3 units	85 MW			
	1x F Class Frame SCGT		237 MW			
	1x G/H Class Frame SCGT		279 MW			

* EE and DR bins are modeled as supply-side resources and are divided into 2020-2023, 2024-2026, and 2027-2039; Shown here is the max reduction averaged from 2020 to 2039

Note: Simple cycle aeroderivatives have been excluded from the resource options due to high pressure gas requirements. Reciprocating engines were excluded based on cost.

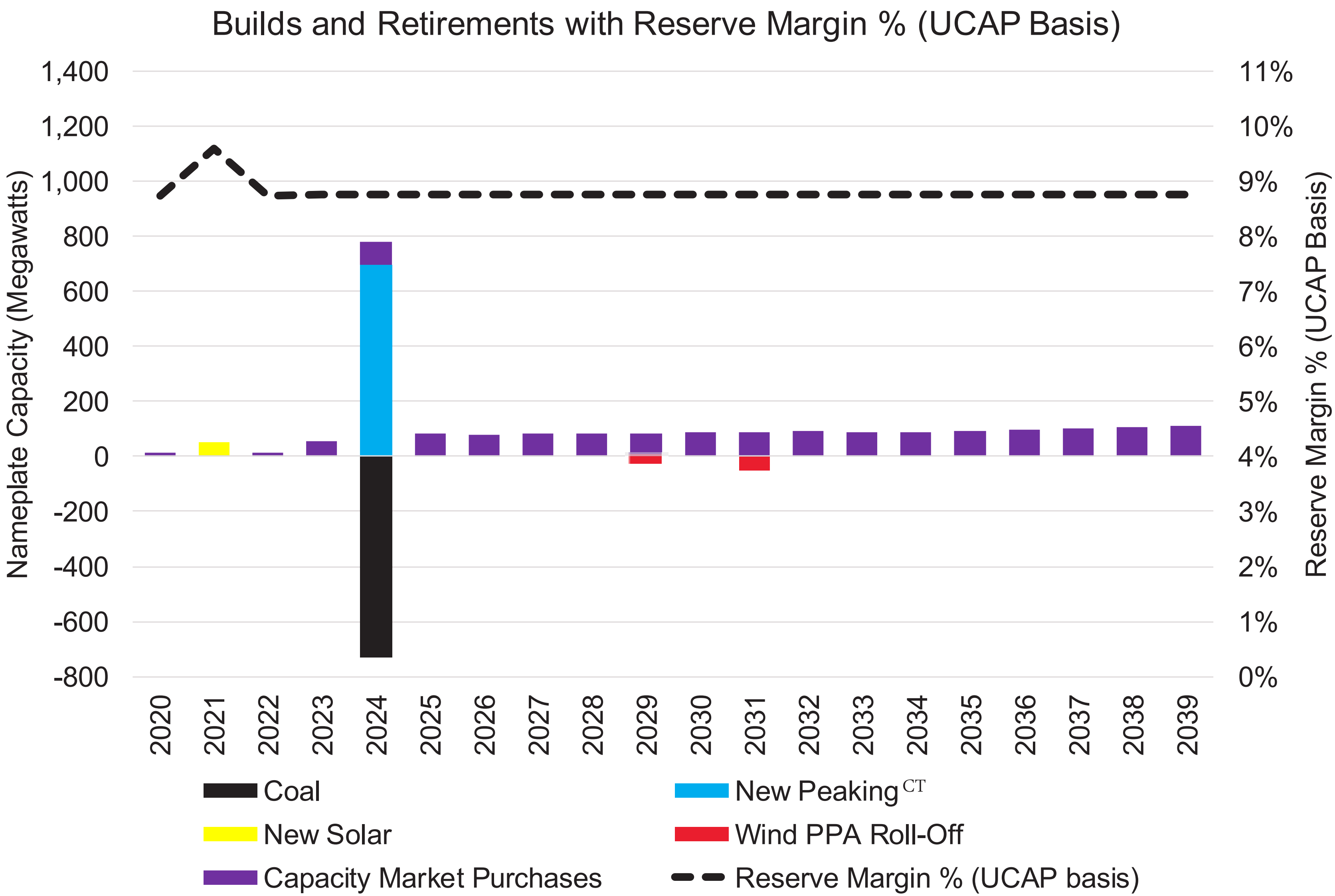
DRAFT REFERENCE CASE MODELING PARAMETERS

- Maximum of 3 gas CTs (E/F/H class) are allowed as early as 1/1/2024
- Maximum of 1 gas CC is allowed as early as 6/1/2024. 2x1 CCGT (600-800 MW) is not included as a resource option
- Aeroderivative CTs are excluded from the resource options due to requirements for high-pressure gas supply. Reciprocating engines were excluded based on cost
- Capacity market purchases 2020-2023 are limited to 300 MW per year, after which they are limited to 180 MW per year
- Renewable energy builds can be as much as 400 MW wind per year, 500 MW solar per year, 300-400 MW storage per year, and 150 MW RE+storage per year, while hydroelectric plants are limited to 2 in total

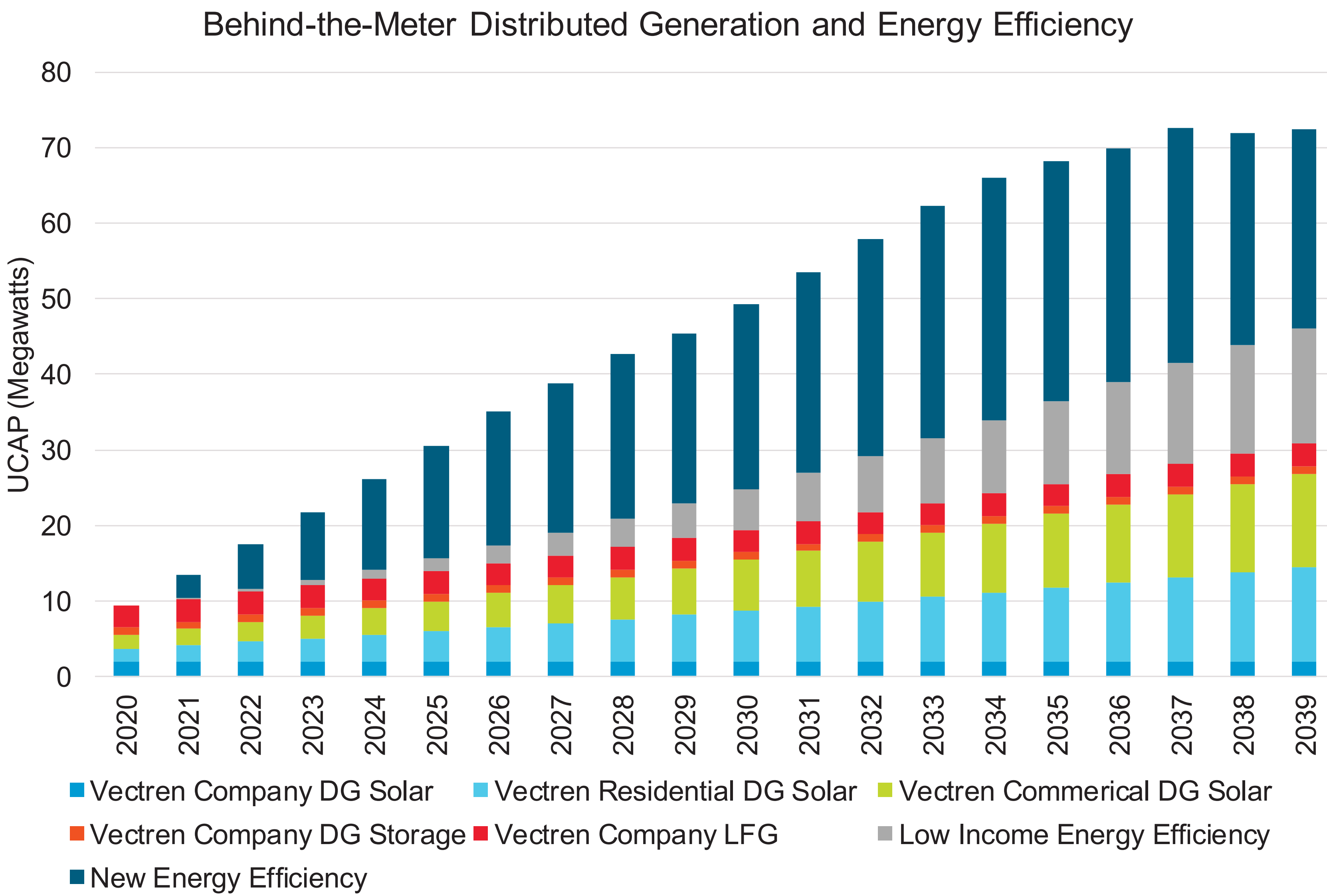
DRAFT REFERENCE CASE PERFORMANCE CHARACTERISTICS

- All coal units except FB Culley 3 are retired at the end of 2023
- The 3 combustion turbine replacements for retired coal capacity operate at an average capacity factor of 7% over the forecast period
- The Planning Reserve Margin target (UCAP basis) is 8.9%. Apart from the CT's that replace coal capacity, the target is adhered to via capacity market purchases that average 90 MW from 2023-2039 or 8% of Vectren coincident (to MISO) peak demand
- Prior to coal retirements, Vectren is a net exporter of energy into MISO. After the coal retirements, Vectren would become a net importer of energy
- Relative to the first year of analysis (2019), CO_2 emissions decline by 47% in the year following coal retirements and decline by 61% by 2039
- Energy Efficiency was selected and equates to approximately 1% of sales

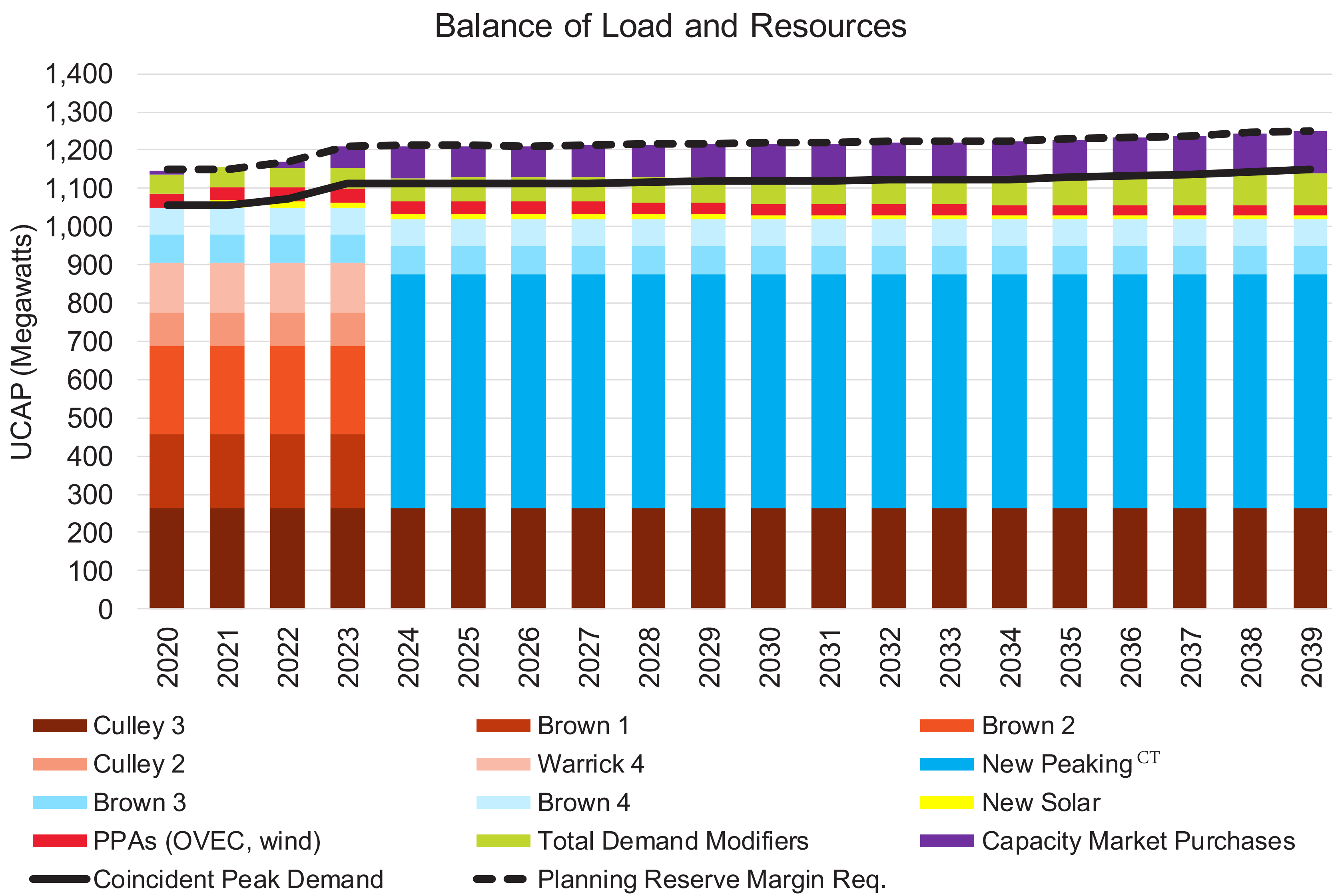
DRAFT REFERENCE CASE SEES 3 F-CLASS CT'S (697 MW) REPLACE 730 MW OF COAL CAPACITY



DRAFT REFERENCE CASE DISTRIBUTED GENERATION AND ENERGY EFFICIENCY



DRAFT REFERENCE CASE PORTFOLIO



SCENARIO MODELING CONSIDERATIONS

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- Reference Case modeling will be updated. Final results may vary
  - RFP results will be included
  - 1x1 CCGT costs will be refined with +/-10% estimates
  - Pipeline costs will be refined for CT options
- Other scenarios with lower costs for renewables and Energy Efficiency may select more of these resources
- Reference Case results show the least cost portfolio given the determined future. This portfolio may not ultimately be least cost once subjected to probabilistic modeling (200 future states)
- Vectren will select a portfolio among approximately 15 based on the results of the full risk analysis

DRAFT FGD SCRUBBER SENSITIVITY ANALYSIS

- All FGD scrubber options for replacing the Dual Alkali system were found to have significantly higher NPVs relative to the Reference Case
- Early results indicate that the Limestone Inhibited Oxidation scrubber has the lowest portfolio NPV of these 4 technologies
  - Four Flue Gas Desulfurization (FGD) scrubber technologies were evaluated in the reference case
  - Note that some options cause other environmental control systems to be modified or replaced. These cost estimates are included in the analysis.
  - Each of the four options was examined in an otherwise identical portfolio and modeled to 2039
- The lowest portfolio NPV of each option will be utilized for the Business as Usual (BAU) portfolio

FGD Scrubber Option
Ammonia Based (NH_3)
Circulating Dry Scrubber (CDS)
Limestone Forced Oxidation (LSFO)
Limestone Inhibited Oxidation (LSIO)

Ammonia Based and LSFO have the potential for future by-product sales.

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FINAL RFP MODELING INPUTS

MATT LIND

RESOURCE PLANNING & MARKET ASSESSMENTS
BUSINESS LEAD, BURNS AND MCDONNELL

RFP PROCESS UPDATE

- Received Proposals
- Initial Proposal Review
- Clarified Information with Bidders
- Group Proposals
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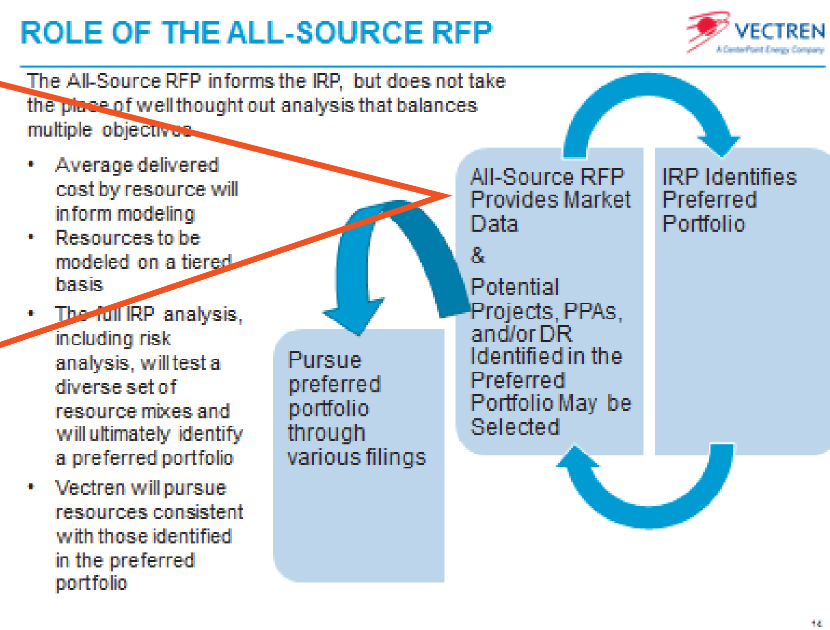
- Evaluation of Proposals
- Aggregated Group Data for IRP
- Receive Results from IRP
- Due Diligence and Negotiations
- Definitive Agreements Executed
- File Petitions with Regulatory Bodies



RFP PROPOSALS

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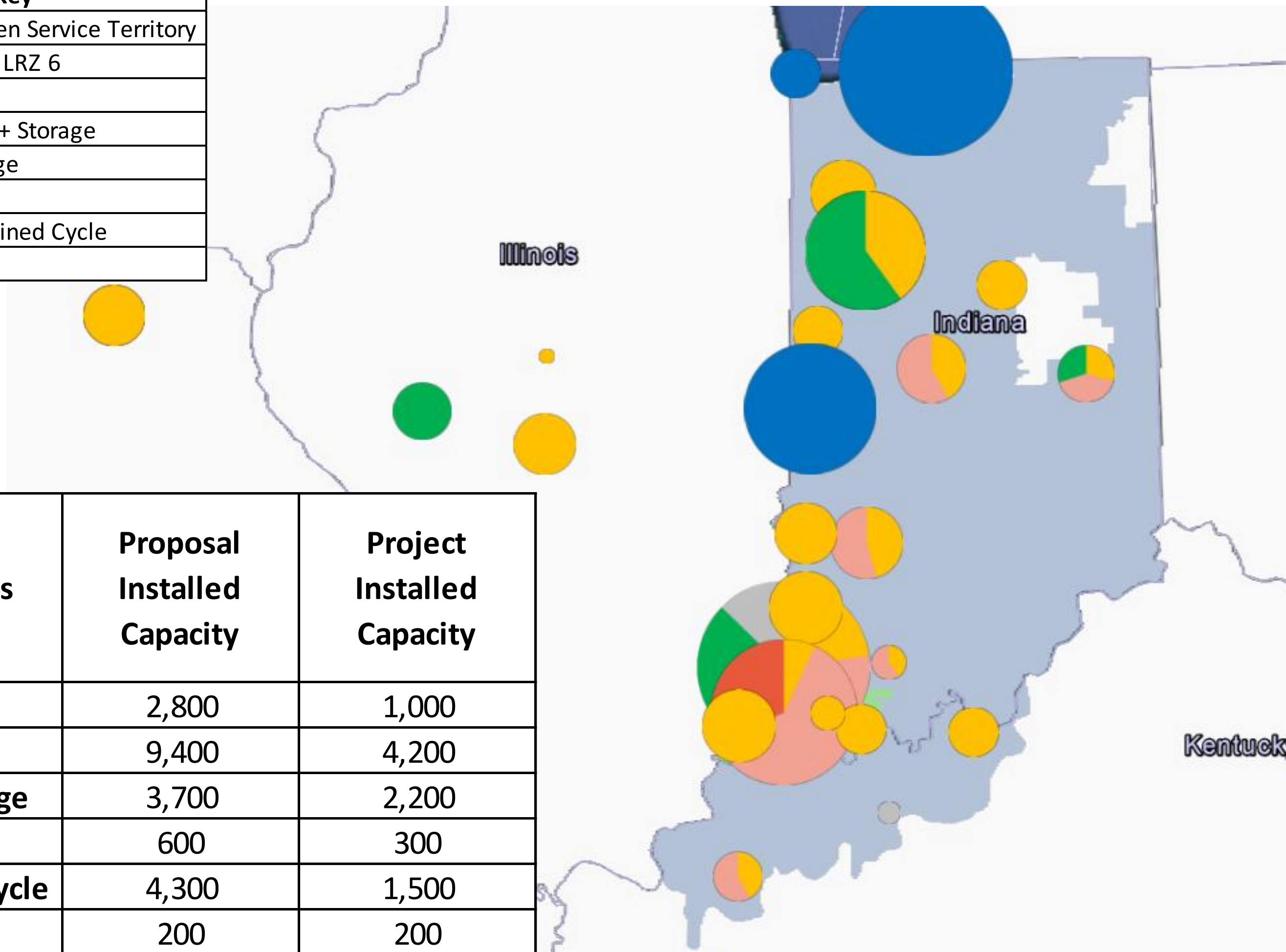
Key	
(light green)	Vectren Service Territory
(light blue)	MISO LRZ 6
(yellow)	Solar
(pink)	Solar + Storage
(red)	Storage
(green)	Wind
(blue)	Combined Cycle
(grey)	Coal



2019 RFP Responses (MW)	Proposal Installed Capacity	Project Installed Capacity
Wind	2,800	1,000
Solar	9,400	4,200
Solar + Storage	3,700	2,200
Storage	600	300
Combined Cycle	4,300	1,500
Coal	200	200
LMR/DR	100	100
System Energy	300	100
Total	**21,400**	**9,600**

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RFP PROPOSALS - TIER 1

- Received Proposals
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- Group Proposals
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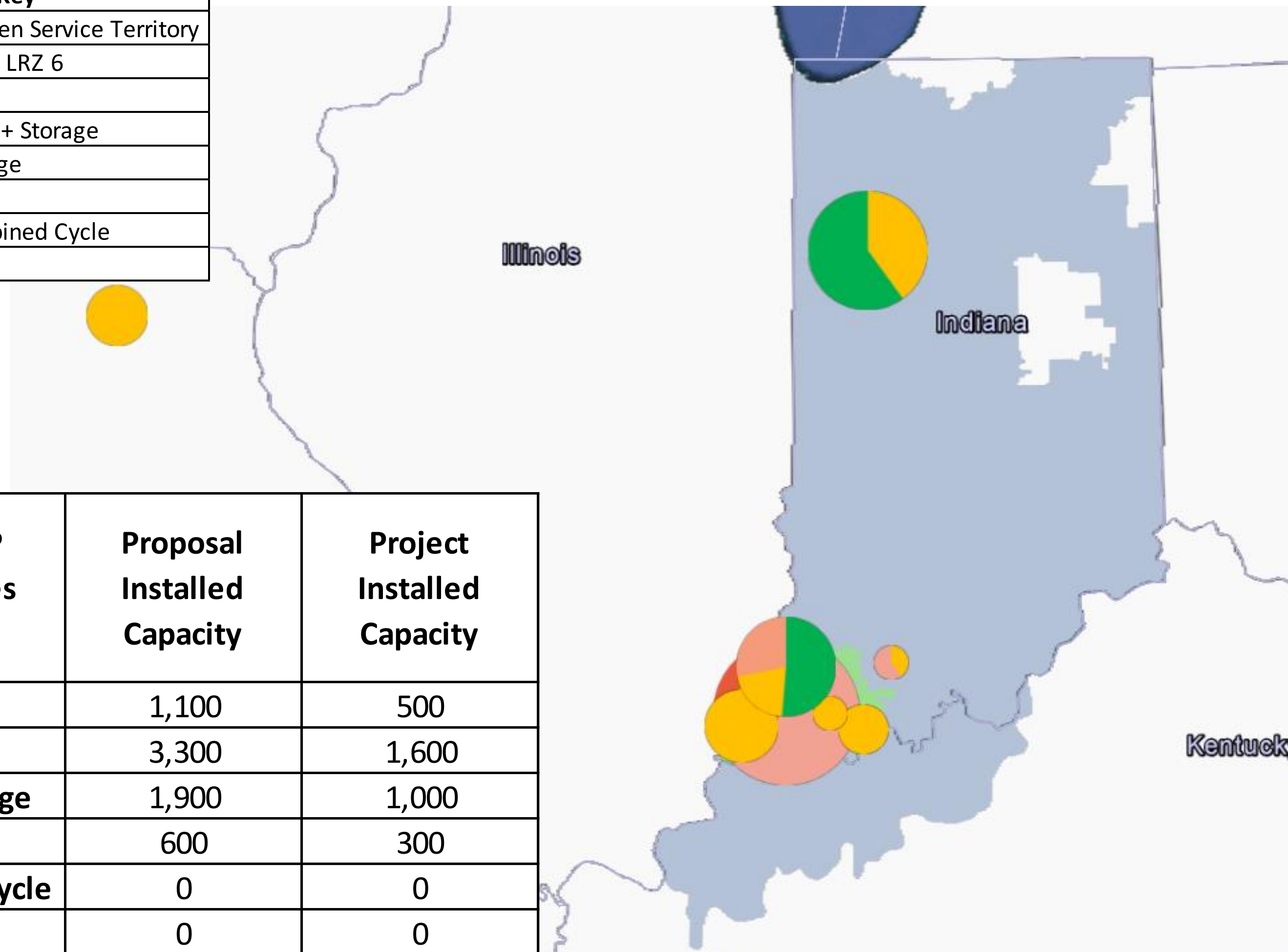
Key	
	Vectren Service Territory
	MISO LRZ 6
	Solar
	Solar + Storage
	Storage
	Wind
	Combined Cycle
	Coal



2019 RFP Responses (MW)	Proposal Installed Capacity	Project Installed Capacity
Wind	1,100	500
Solar	3,300	1,600
Solar + Storage	1,900	1,000
Storage	600	300
Combined Cycle	0	0
Coal	0	0
LMR/DR	100	100
System Energy	0	0
Total	**7,000**	**3,500**

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PROPOSAL GROUPING

- Received Proposals
- Initial Proposal Review
- Clarified Information with Bidders
- **Group Proposals**
- Interconnection & Network Upgrade Analysis
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	Grouping[1]	RFP Count	Tier 1	Tier 2
1	Coal PPA	2	0	2
2	LMR/DR PPA	1	1	0
3	CCGT PPA	2	0	2
4	CCGT Purchase	5	0	5
5	Wind Purchase	2	0	2
6	12-15 Year Wind PPA	9	4	5
7	20 Year Wind PPA	2	1	1
8	Storage Purchase	4	4	0
9	Storage PPA	4	4	0
10	Solar + Storage PPA	6	5	1
11	Solar + Storage Purchase	9	5	4
12	Solar + Storage Purchase/PPA	4	1	3
13	Solar Purchase/PPA	6	1	5
14	12-15 Year Solar PPA	8	3	5
15	20 Year Solar PPA	16	10	6
16	25-30 Year Solar PPA	9	3	6
17	Solar Purchase	18	7	11
N/A	Energy Only	3	0	3
	Total	**110**	**49**	**61**

110 Proposals

Tier 1
- Binding Pricing
- Delivered to SIGE.SIGW OR On System

IRP Inputs

Tier 2
- Non-Binding Pricing
- Congestion / delivery risk

Potential IRP Inputs Based on Evaluation

- Total installed capacity of RFP bids in Tier 1 ~5X greater than Vectren's peak load
- Resource options from the technology assessment will supplement these options as needed

1. Updated Tier 1 & Tier 2 classification based on interactions with bidders

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TRANSMISSION INTERCONNECTION COSTS

- Received Proposals
- Initial Proposal Review
- Clarified Information with Bidders
- Group Proposals
- **Interconnection & Network Upgrade Analysis**
- Evaluation of Proposals
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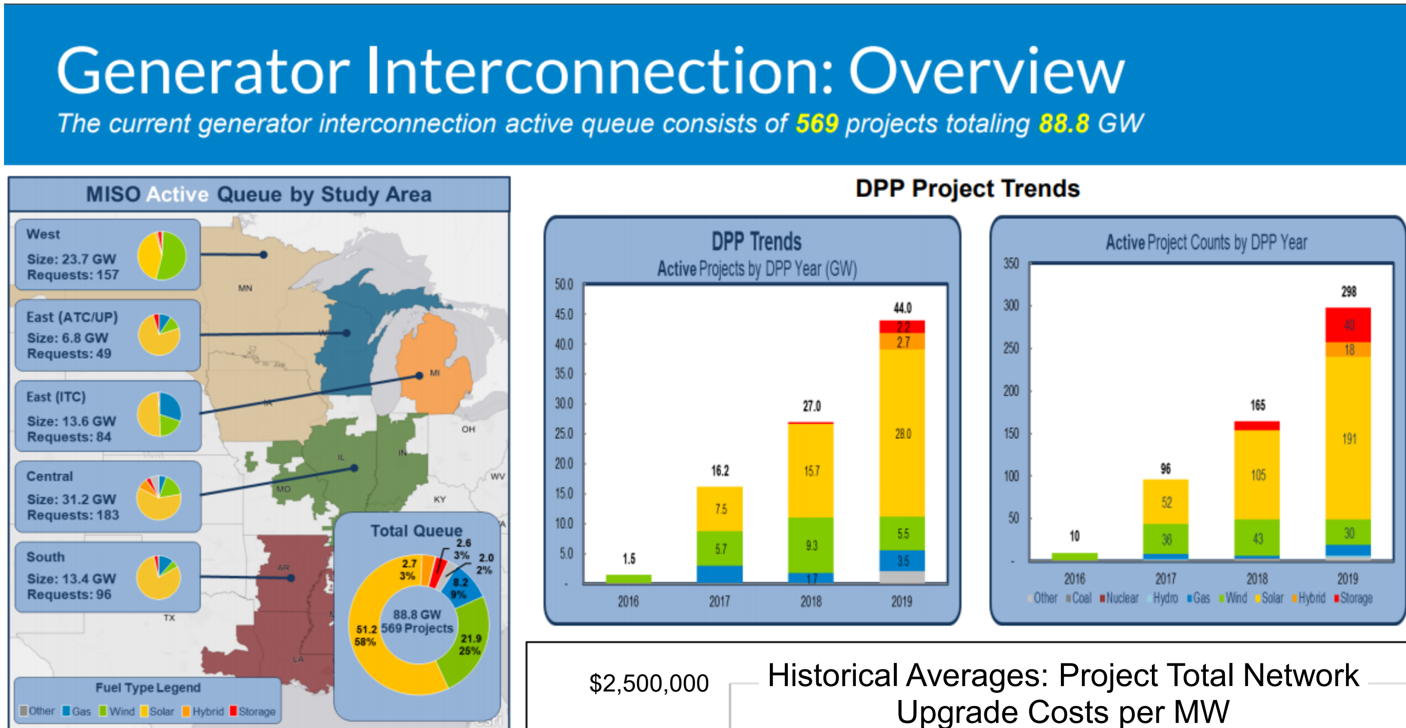
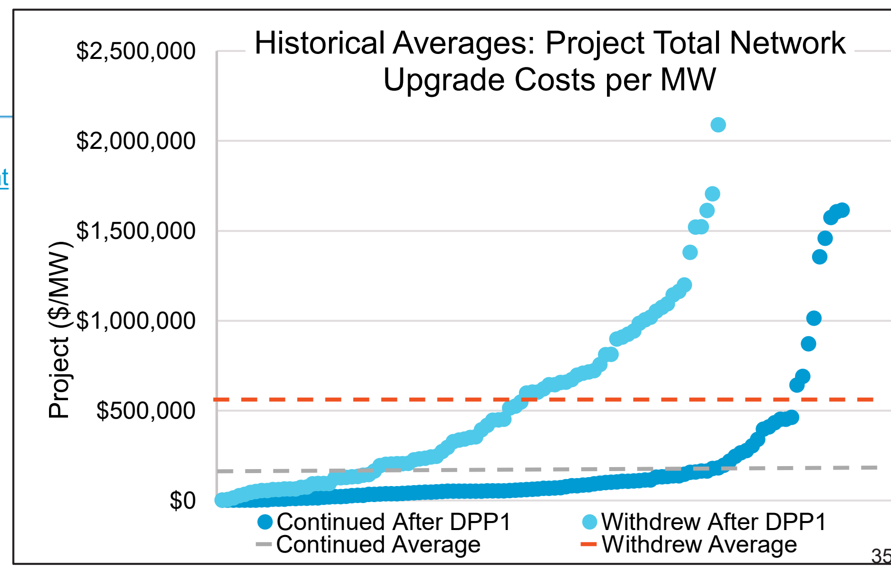


https://www.misoenergy.org/planning/policy-studies/Renewable-integration-impact-assessment



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TIER 1 COST SUMMARY

- Received Proposals
- Initial Proposal Review
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	Bid Group	# Proposals	# Projects	Proposal ICAP (MW)	Project ICAP (MW)	Capacity Weighted Average LCOE ($2019/MWh)	Capacity Weighted Purchase Price ($/kW)[2]
1	Coal PPA	0					
2	LMR/DR PPA	0					
3	CCGT PPA	0					
4	CCGT Purchase	0					
5	Wind Purchase	0					
6	12-15 Year Wind PPA	4	1	800	200		
7	20 Year Wind PPA	1	1	300	300		
8	Storage Purchase	4	2	305	152	$157	
9	Storage PPA	4	2	305	152	$135	
10	Solar + Storage PPA	5	3	902	526	$44	
11	Solar + Storage Purchase	5	3	862	486	TBD[1]	$1,417[3]
12	Solar + Storage Purchase/PPA	1	1	110	110		
13	Solar Purchase/PPA	1	1	80	80		
14	12-15 Year Solar PPA	3	2	350	225	$32	
15	20 Year Solar PPA	10	8	1,522	1,227	$35	
16	25-30 Year Solar PPA	3	2	400	275	$34	
17	Solar Purchase	7	6	902	732	TBD[1]	$1,262

1. The method for realizing tax incentives is being reviewed by Vectren
2. $/kW costs are in COD$, purchase option cost is the purchase price unsubsidized by applicable tax incentives and does not reflect ongoing operations and maintenance costs
3. Cost based on simultaneous MW injectable to the grid

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RFP PROCESS UPDATE

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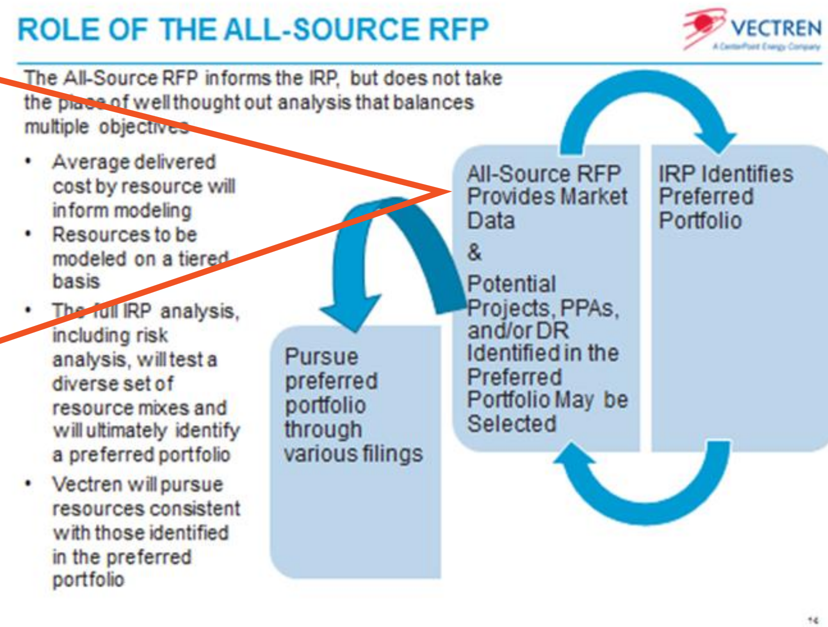

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PORTFOLIO DEVELOPMENT

MATT RICE

VECTREN MANAGER OF RESOURCE PLANNING

STAKEHOLDER PORTFOLIO FEEDBACK

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Request	Response
Small CCGT and conversion at Brown	We will run this portfolio with generic assumptions, but need to acknowledge some challenges. Should this portfolio look attractive, additional study would be needed around air permits, water use, and use of the switchyard. Additionally, this option does not benefit from expedited study at MISO due to capacity beyond current levels at the Brown site
HR 763 Portfolio	Will run a sensitivity to create a portfolio based on HR 763 CO_2 price assumptions and compare to other portfolios. If significantly different, we include in the risk analysis
100% RPS by 2030 Portfolio	Will include this portfolio
NIPSCO like portfolio	We understand the environmental perspective that this means no new fossil and close coal as soon as possible. NIPSCO currently has a gas CCGT and two gas peaker plants. Each utility has different circumstances. We do not plan to run a portfolio that completely mirrors NIPSCO
Close all Coal by 2024	We plan to move forward with approved upgrades for Culley 3 and therefore, do no plan to run this portfolio. We will include a portfolio that closes Culley 3 by 2030 and by 2034 in another portfolio
CT and Renewables, Close all coal by 2030	Will include a similar portfolio
Business as Usual (BAU) portfolio	Will include this portfolio
BAU Until 2029 Portfolio	Will include this portfolio
100% RPS by 2039	Will include a similar portfolio

STAKEHOLDER PORTFOLIO FEEDBACK

Request	Response
Lobby to Extend Net Metering (Remove cap)	If that the net metering law were to be updated to full, traditional net metering, Vectren's load forecast would decline. The IRP takes into account a low load forecast within probabilistic modeling and deterministic scenarios. Portfolios will be developed and tested in low load conditions
Distributed gen (rooftop solar + battery storage)	This option would require an extensive study to be conducted with attributes similar to an EE program. We know from experience that building distributed solar and storage is costly, complicated, and requires risk mitigation. We do not plan to run this portfolio. This could be evaluated in future IRPs
Various bridge portfolios to provide off ramps	We will model both short-term and long-term bridge options

WIDE RANGE OF PORTFOLIOS

All portfolios considered include stakeholder input, directly or indirectly.

Bridges
- Gas Conversion ABB1
- Gas Conversion ABB1 & ABB2
- Gas Conversion + CCGT
- BAU 2029

Scenario Based
- Low Regulatory
- Reference Case
- High Tech
- 80% CO2 Reduction
- High Regulatory

Diverse
- Small CCGT with renewables and coal
- Mid CCGT with renewables and coal

Status Quo
- Business as Usual (BAU)

Risk Analysis

Renewables Focused
- Close All Fossil by 2030
- Renewables + flexible gas (close coal by 2034 and no CCGT)
- HB 763

We will consider short term bridge options (extension of W4 contract, market capacity purchase, short term ppa, etc.) for portfolio development in all scenarios and in other portfolios where it makes sense

STATUS QUO

- The Business As Usual portfolio can be considered a reference portfolio
  - Vectren ends joint operations of W4 in 2024
  - Includes known costs to comply with known EPA rules (ELG/CCR, ACE, 316b) to continue to run Vectren coal plants through 2039
  - Resource need will be optimized based on least cost modeling (All resources available)

Stakeholder Input:
- Fully explore options at AB Brown plant

Business As Usual (BAU)

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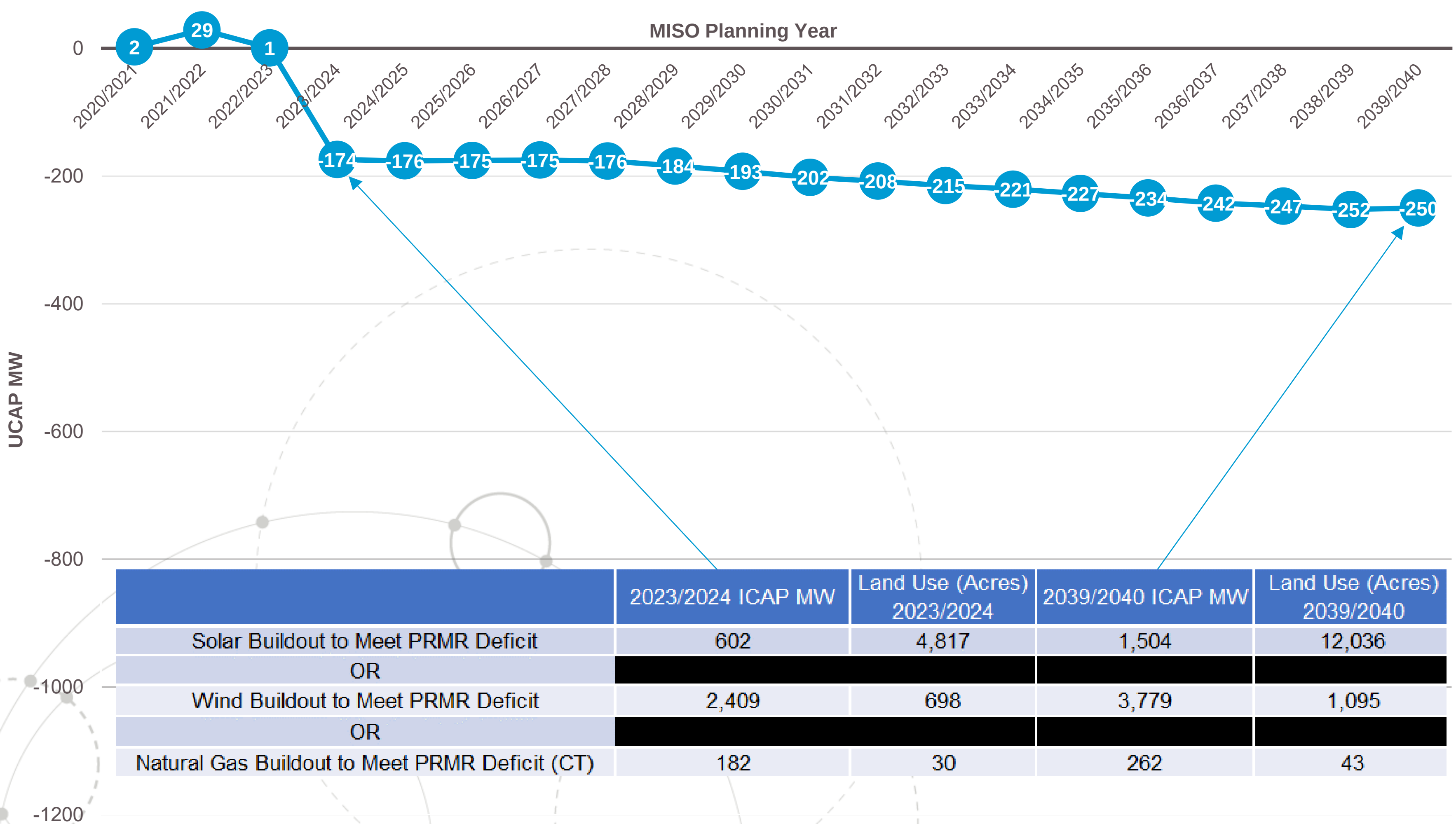
PLANNING RESERVE MARGIN REQUIREMENT SURPLUS\DEFICIT - BAU



	2023/2024 ICAP MW	Land Use (Acres) 2023/2024	2039/2040 ICAP MW	Land Use (Acres) 2039/2040
Solar Buildout to Meet PRMR Deficit	602	4,817	1,504	12,036
OR				
Wind Buildout to Meet PRMR Deficit	2,409	698	3,779	1,095
OR				
Natural Gas Buildout to Meet PRMR Deficit (CT)	182	30	262	43

PRMR - Planning Reserve Margin Requirement

SCENARIO BASED PORTFOLIOS

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- Scenarios were created with stakeholder input. A portfolio will be created for each potential deterministic future based on least cost optimization. Insights will be gathered:
  - Potential selection of long and short-term bridge options
  - How resource mixes change given varying futures
  - Range of portfolio costs
- Once run, Vectren will utilize insights to help shape portfolio development
- Portfolios will be compared for similarities and differences. If each varies significantly, they will all be included in the risk analysis
- Insights gained may be included in developing other portfolios

Stakeholder Input:
- Reference Case CO_2
- Lower renewables and storage costs
- CO_2 Fee and Dividend

Scenario Based
Low Reg.
Reference Case
High Tech
80% CO_2
High Reg.

BRIDGES

- Vectren is considering various bridge options, including converting coal units to gas
  - Convert AB Brown 1 & 2 by 2024 and run for 10 years. Close FB Culley 2 and end joint operations of Warrick 4 by 2024. Optimize for need (all resources available)
  - Convert AB Brown 1 and retire AB Brown 2 by 2024 + add a small CCGT in 2025. Optimize for need (All resources available). Short term bridge options will be considered
- Vectren will also create a portfolio that continues operation of existing coal units through 2029. We will allow the model to optimize (all resources available) beyond 2030

Stakeholder Input:
- Fully consider gas conversion
- Consider running coal until 2030
- Don't run coal beyond 2030
- Include a portfolio that converts ABB1 and adds a small CCGT
- Consider flexibility

- Gas Conversion
- Gas Conversion + CCGT
- BAU 2029

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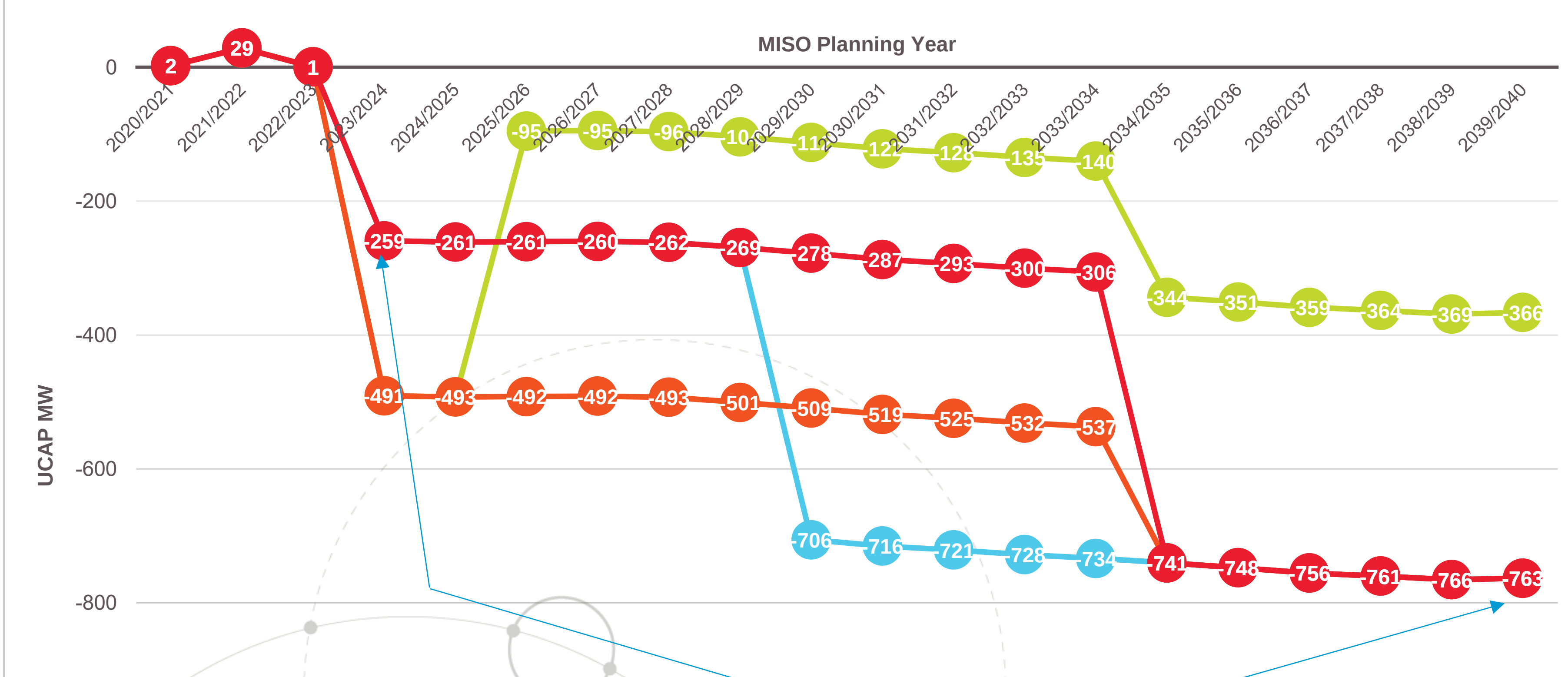
PLANNING RESERVE MARGIN REQUIREMENT SURPLUS\DEFICIT - BRIDGE



Bridge - Convert Brown 1 & Brown 2	2023/2024 ICAP MW	Land Use (Acres) 2023/2024	2039/2040 ICAP MW	Land Use (Acres) 2039/2040
Solar Buildout to Meet PRMR Deficit	897	7,176	4,594	36,754
OR				
Wind Buildout to Meet PRMR Deficit	3,589	1,040	11,541	3,345
OR				
Natural Gas Buildout to Meet PRMR Deficit (CCGT)	272	44	800	131

PRMR - Planning Reserve Margin Requirement

DIVERSE

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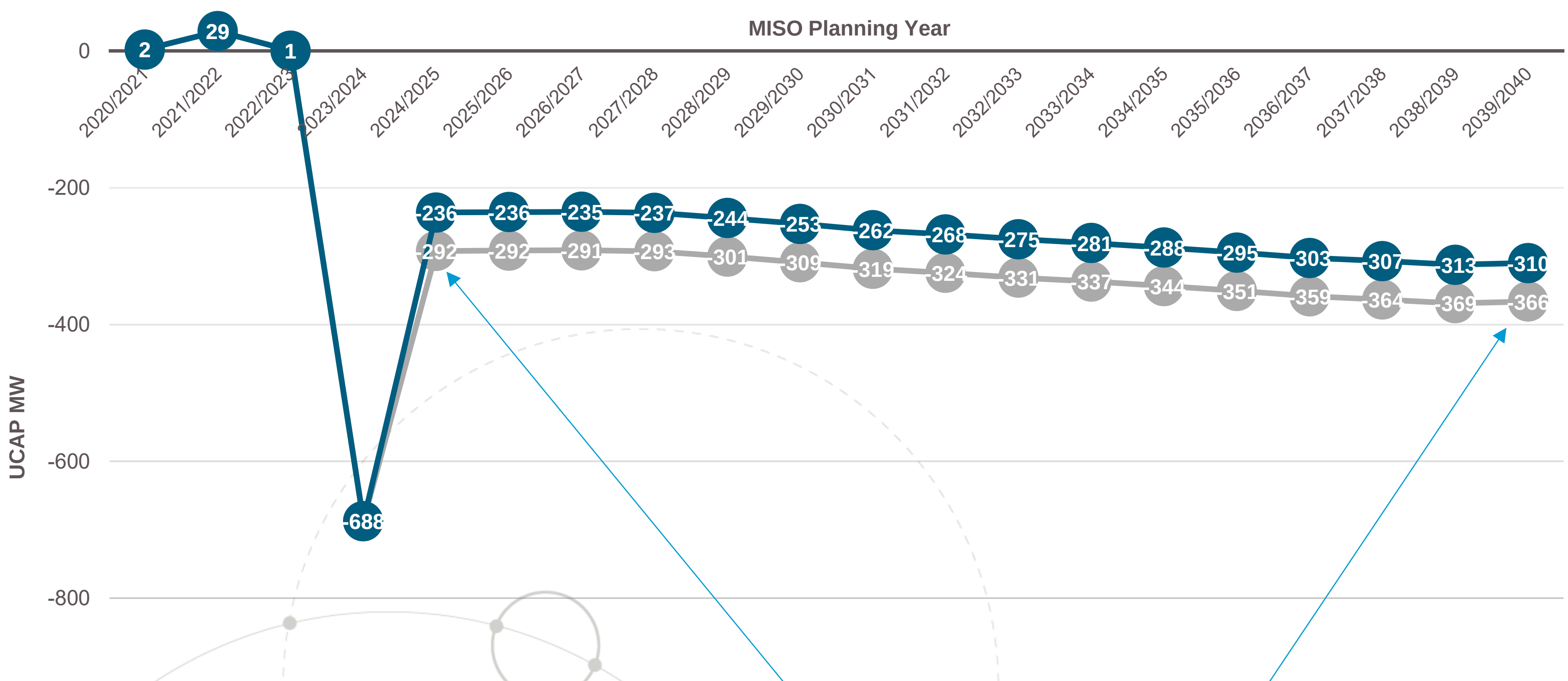
- One of Vectren's objectives is resource diversity. As such, Vectren is evaluating portfolios that contain some coal, some gas, and some renewables/DSM/storage options
  - Small CCGT ~400 MWs at the Brown site will be included, along with Culley 3. Optimize with renewables, DSM, and storage for remaining need
  - Mid-sized CCGT ~500 MWs will be included at the Brown site, along with Culley 3. Optimize with renewables, DSM, and storage for remaining need
- A 2x1 CCGT (600-800 MW) will not be considered in portfolio development
- The Brown site offers several advantages: existing interconnection rights, reuse of some equipment and facilities, tax base for Posey county, and jobs for existing employees
- Short term bridge options will be considered

Stakeholder Input:
- Gas plant too large for a small utility
- Did not consider smaller gas plant options in the risk analysis

-Small CCGT with renewables and coal
-Mid-sized CCGT with renewables and coal

PLANNING RESERVE MARGIN REQUIREMENT SURPLUS\DEFICIT - DIVERSE



Diverse 400 MW CCGT	2024/2025 ICAP MW	Land Use (Acres) 2024/2025	2039/2040 ICAP MW	Land Use (Acres) 2039/2040
Solar Buildout to Meet PRMR Deficit	1,065	8,518	2,205	17,642
OR				
Wind Buildout to Meet PRMR Deficit	4,065	1,178	5,540	1,606
OR				
Natural Gas Buildout to Meet PRMR Deficit (CCGT)	306	50	384	63

PRMR - Planning Reserve Margin Requirement

RENEWABLES FOCUSED

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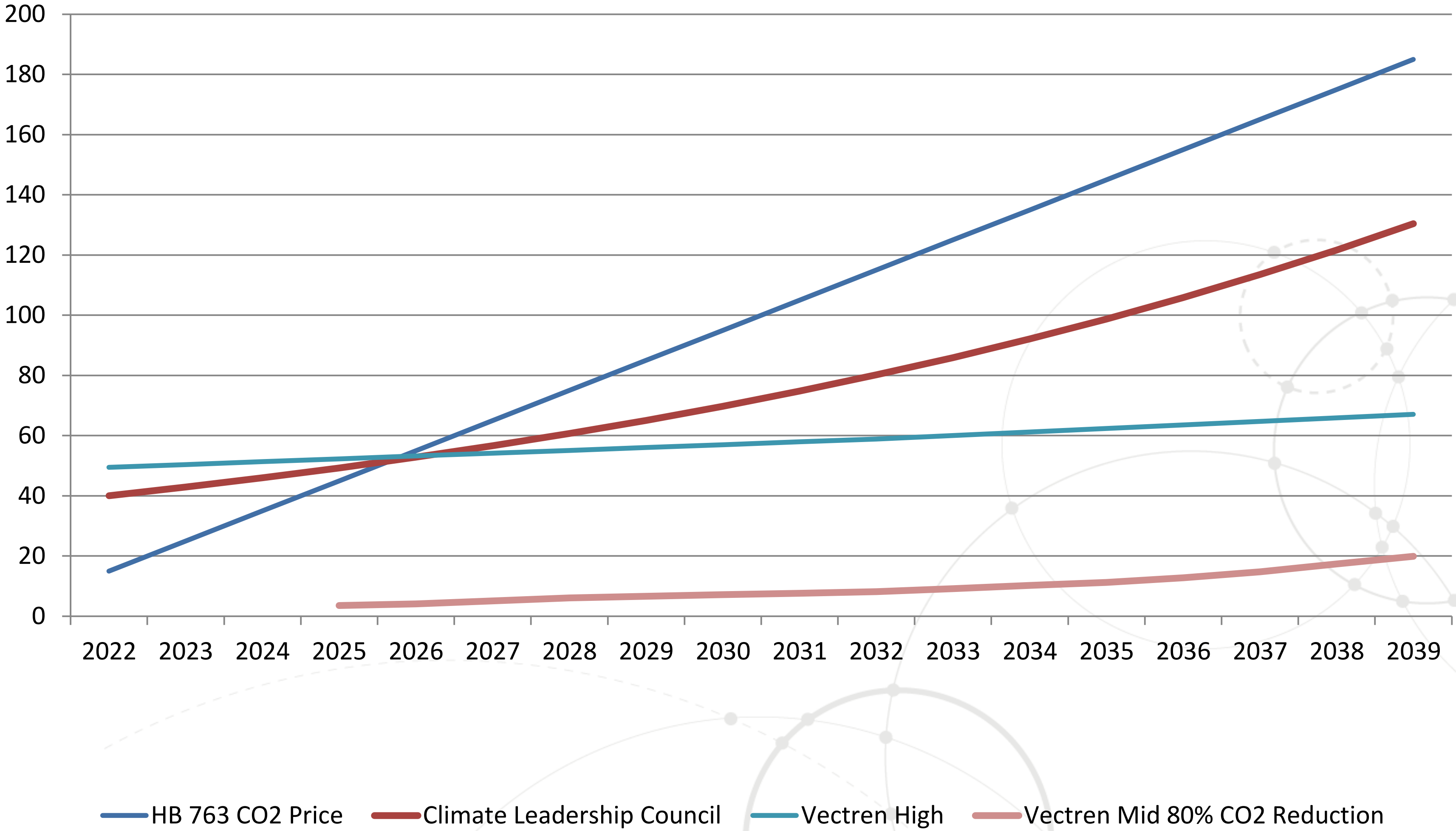
- Vectren continues to fully explore renewable resources through market pricing and portfolio development
  - Close all fossil generation by 2030. Will require voltage support. Optimize for renewables, demand response, energy efficiency, and storage
  - Close all coal by 2034 (All but Culley 3 are closed in 2024). Optimize for renewables, demand response, energy efficiency, and Storage. Flexible gas (CTs) will be allowed within the optimization for capacity (No CCGTs)
  - Build a portfolio based on House Bill 763, which includes a \$15 CO_2 price, escalating to \$185 by 2039. Compare and determine if portfolio is sufficiently different from other renewables portfolios. Optimize for need

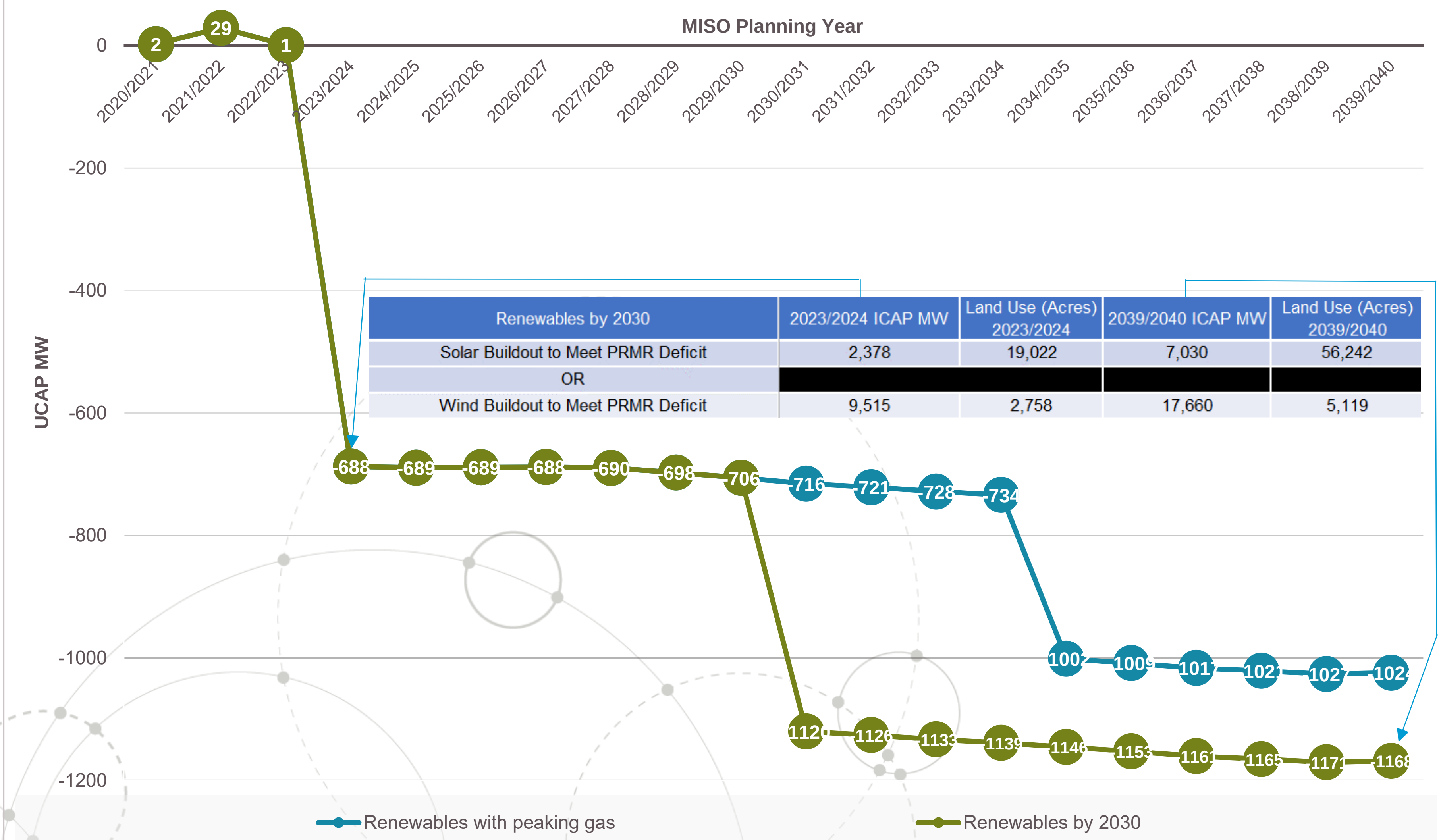
Stakeholder Input:
- Fully consider renewable resources
- 100% renewable by 2030
- Consider flexible gas and renewables
- Include a scenario on HB763

- Close All Fossil by 2030
- Renewables + flexible gas (close all coal by 2034)
- HB 763

CO_2 PRICE RANGES WITH HB 763



PLANNING RESERVE MARGIN REQUIREMENT SURPLUS\DEFICIT - RENEWABLES



Renewables by 2030	2023/2024 ICAP MW	Land Use (Acres) 2023/2024	2039/2040 ICAP MW	Land Use (Acres) 2039/2040
Solar Buildout to Meet PRMR Deficit	2,378	19,022	7,030	56,242
OR				
Wind Buildout to Meet PRMR Deficit	9,515	2,758	17,660	5,119

PRMR - Planning Reserve Margin Requirement

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SCENARIO TESTING AND PROBABILISTIC MODELING

PETER HUBBARD

MANAGER OF ENERGY BUSINESS ADVISORY, PACE GLOBAL

PORTFOLIOS WILL BE TESTED BOTH IN SCENARIOS AND PROBABILISTIC FRAMEWORK

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Deterministic Modeling (Scenarios) and Probabilistic Modeling (Stochastics) Provide Complementary Analysis

Probabilistic Modeling is the basis for Portfolio Risk Analysis and Balanced Scorecard results

Advantages

- Exhaustive potential futures can be analyzed
- Uses impartial statistical rules and correlations

Disadvantages

- Link between statistical realizations and the real world can be difficult to understand

Deterministic Modeling complements Stochastics; Portfolios will be simulated in each Scenario

Advantages

- Well-suited for testing a wide range of regulatory req's
- Deterministic modeling is transparent, easy to understand

Disadvantages

- Does not capture the full range of key inputs
- Does not capture volatility
- Time consuming to run several potential futures

Market Driver	Varied Stochastically
Load	✔
Natural Gas Prices	✔
Coal Prices	✔
CO2 Prices	✔
Capital Costs for New Entry	✔

LOW REGULATORY CASE INPUTS

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Input	Unit	2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039
Coal (ILB mine)	2018$/MMBtu	1.78	1.66	1.64	1.63	1.61	1.61	1.59	1.58	1.59	1.59	1.58
CO2	2018$/ton	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gas (Henry Hub)	2018$/MMBtu	2.77	2.76	4.10	5.12	5.20	5.62	5.60	5.95	6.12	6.23	6.85
Vectren Peak Load	MW	1,115	1,102	1,217	1,311	1,314	1,352	1,357	1,390	1,381	1,386	1,423
Customer-Owned Solar DG Capacity*	MW	9.3	14.6	21.6	30.2	38.0	47.3	56.1	66.3	75.1	84.7	96.8
EV Peak Load**	MW	0.4	2.0	10.2	15.4	19.8	24.7	29.3	34.5	38.7	43.2	48.6
Energy Efficiency and Company DG	MW	6.0	9.2	15.7	22.6	28.8	33.1	39.0	45.2	48.8	50.5	47.6
Demand Response	MW	35.2	51.7	52.7	61.6	64.4	67.3	70.1	73.0	75.8	78.7	81.5
Wind (200 MW)	2018$/kW	1,334	1,330	1,328	1,326	1,324	1,324	1,324	1,324	1,326	1,328	1,330
Solar (100 MW)	2018$/kW	1,414	1,264	1,205	1,168	1,130	1,096	1,064	1,038	1,012	993	973
Li-Ion Battery (50 MW, 4 hr)	2018$/kW	2,088	1,811	1,654	1,518	1,452	1,391	1,342	1,301	1,263	1,232	1,201
Flow Battery (50 MW, 6 hr)	2018$/kW	2,968	2,665	2,450	2,242	2,116	1,996	1,892	1,803	1,719	1,651	1,586
Gas CC F-Class (442 MW with DF)	2018$/kW	1,301	1,291	1,275	1,261	1,251	1,242	1,233	1,224	1,216	1,207	1,199
Gas CT F-Class (237 MW)	2018$/kW	712	707	697	688	683	677	672	667	662	657	653
USC Coal w/ CCS	2018$/kW	5,621	5,536	5,424	5,309	5,201	5,097	4,992	4,891	4,794	4,698	4,605

** Res/Com Demand Impact = 0.295*
*** EV Coincident Factor = 0.211*

Revised from last meeting

HIGH TECHNOLOGY CASE INPUTS

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Input	Unit	2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039
Coal (ILB mine)	2018$/MMBtu	1.78	1.66	1.49	1.27	1.25	1.25	1.25	1.25	1.25	1.25	1.25
CO2	2018$/ton	0.00	0.00	0.00	1.20	2.06	2.38	2.94	3.89	5.46	6.85	8.50
Gas (Henry Hub)	2018$/MMBtu	2.77	2.76	2.82	2.33	2.13	2.04	2.13	2.02	2.12	2.07	2.20
Vectren Peak Load	MW	1,115	1,102	1,217	1,311	1,314	1,352	1,357	1,390	1,381	1,386	1,423
Customer-Owned Solar DG Capacity*	MW	9.3	14.6	21.6	30.2	38.0	47.3	56.1	66.3	75.1	84.7	96.8
EV Peak Load**	MW	0.4	2.0	10.2	15.4	19.8	24.7	29.3	34.5	38.7	43.2	48.6
Energy Efficiency and Company DG	MW	6.0	9.2	15.7	22.6	28.8	33.1	39.0	45.2	48.8	50.5	47.6
Demand Response	MW	35.2	51.7	52.7	61.6	64.4	67.3	70.1	73.0	75.8	78.7	81.5
Wind (200 MW)	2018$/kW	1,334	1,330	1,249	1,167	1,123	1,160	1,152	1,166	1,139	1,142	1,143
Solar (100 MW)	2018$/kW	1,414	1,264	1,120	975	964	942	897	877	818	809	818
Li-Ion Battery (50 MW, 4 hr)	2018$/kW	2,088	1,811	1,513	1,214	1,156	1,096	1,042	965	928	901	894
Flow Battery (50 MW, 6 hr)	2018$/kW	2,968	2,665	2,220	1,774	1,678	1,538	1,408	1,231	1,268	1,124	1,020
Gas CC F-Class (442 MW with DF)	2018$/kW	1,301	1,291	1,275	1,261	1,251	1,242	1,233	1,224	1,216	1,207	1,199
Gas CT F-Class (237 MW)	2018$/kW	712	707	697	688	683	677	672	667	662	657	653
USC Coal w/ CCS	2018$/kW	5,621	5,536	5,424	5,309	5,201	5,097	4,992	4,891	4,794	4,698	4,605

** Res/Com Demand Impact = 0.295*
*** EV Coincident Factor = 0.211*

Revised from last meeting

80% REDUCTION CASE INPUTS

VECTREN
A CenterPoint Energy Company

Input	Unit	2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039
Coal (ILB mine)	2018$/MMBtu	1.78	1.66	1.49	1.27	1.25	1.25	1.25	1.25	1.25	1.25	1.25
CO2	2018$/ton	0.00	0.00	0.00	3.57	5.10	6.63	7.65	9.18	11.22	14.79	19.89
Gas (Henry Hub)	2018$/MMBtu	2.77	2.76	3.06	3.24	3.38	3.49	3.62	3.78	3.96	4.09	4.17
Vectren Peak Load	MW	1,115	1,102	1,131	1,060	1,025	1,039	1,038	1,038	1,053	1,053	1,065
Customer-Owned Solar DG Capacity*	MW	9.3	14.6	20.0	24.4	29.6	36.3	42.9	49.5	57.3	64.3	72.5
EV Peak Load**	MW	0.4	2.0	9.5	12.4	15.4	19.0	22.4	25.8	29.5	32.8	36.4
Energy Efficiency and Company DG	MW	6.0	9.2	15.7	22.6	28.8	33.1	39.0	45.2	48.8	50.5	47.6
Demand Response	MW	35.2	51.7	52.7	61.6	64.4	67.3	70.1	73.0	75.8	78.7	81.5
Wind (200 MW)	2018$/kW	1,334	1,330	1,249	1,167	1,123	1,160	1,152	1,166	1,139	1,142	1,143
Solar (100 MW)	2018$/kW	1,414	1,264	1,120	975	964	942	897	877	818	809	818
Li-Ion Battery (50 MW, 4 hr)	2018$/kW	2,088	1,811	1,513	1,214	1,156	1,096	1,042	965	928	901	894
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** Res/Com Demand Impact = 0.295*
*** EV Coincident Factor = 0.211*

Revised from last meeting

HIGH REGULATORY CASE INPUTS

VECTREN
A CenterPoint Energy Company

Input	Unit	2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039
Coal (ILB mine)	2018$/MMBtu	1.78	1.66	1.49	1.27	1.25	1.25	1.25	1.25	1.25	1.25	1.25
CO2	2018$/ton	0.00	0.00	50.40	52.28	54.17	56.05	57.94	60.06	62.41	64.77	67.12
Gas (Henry Hub)	2018$/MMBtu	2.77	2.76	4.39	6.03	7.10	8.37	7.17	8.40	8.95	8.75	8.63
Vectren Peak Load	MW	1,115	1,102	1,168	1,176	1,183	1,192	1,200	1,209	1,219	1,229	1,239
Customer-Owned Solar DG Capacity*	MW	9.3	14.6	20.7	27.1	34.2	41.7	49.6	57.7	66.3	75.1	84.3
EV Peak Load**	MW	0.4	2.0	9.8	13.8	17.8	21.8	25.9	30.0	34.2	38.3	42.3
Energy Efficiency and Company DG	MW	6.0	9.2	15.7	22.6	28.8	33.1	39.0	45.2	48.8	50.5	47.6
Demand Response	MW	35.2	51.7	52.7	61.6	64.4	67.3	70.1	73.0	75.8	78.7	81.5
Wind (200 MW)	2018$/kW	1,334	1,330	1,249	1,167	1,123	1,160	1,152	1,166	1,139	1,142	1,143
Solar (100 MW)	2018$/kW	1,414	1,264	1,120	975	964	942	897	877	818	809	818
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Revised from last meeting

PROBABILISTIC MODELING PROVIDES THE BASIS FOR IRP SCORECARD METRICS

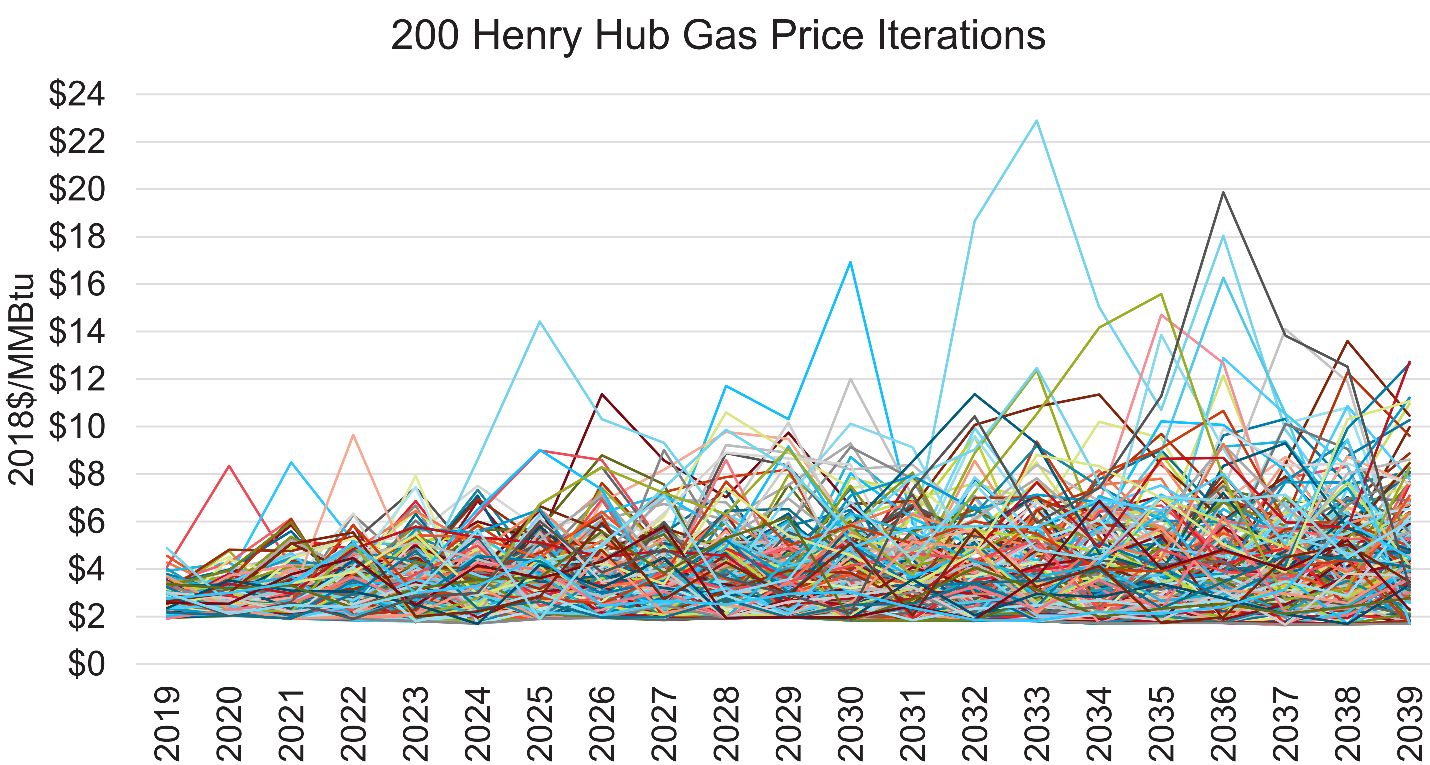
VECTREN
A CenterPoint Energy Company

- By measuring each portfolio's performance across 200 iterations, we can quantify each of the measures associated with IRP objectives
- This provides a direct comparison of portfolio performance that will be summarized in the Balanced Scorecard

IRP Objective	Measure	Unit
Affordability	20-Year NPVRR	$
Price Risk Minimization	95th percentile value of NPVRR	$
Environmental Risk Minimization	Life Cycle Greenhouse Gas Emissions	Tons CO_2e
Market Risk Minimization	Energy Market Purchases or Sales outside of a +/- 15% Band	%
	Capacity Market Purchases or Sales outside of a +/- 15% Band	%
Future Flexibility	Uneconomic Asset Risk	$

PROBABILISTIC MODELING

- Probabilistic modeling helps to measure risk from 200 potential future paths for each stochastic variable
- By running each portfolio through 200 iterations, each portfolio's performance and risk profile can be quantified across a wide range of potential futures



PROBABILISTIC VARIABLES AND DRIVERS

1. Load

- Peak Load
- Average Load

Driver Variables:

- EV and Solar DG (also modeled stochastically)
- Weather
- GDP/ Personal Income
- Expert view on low, mid & high cases

2. Natural Gas

- Henry Hub
- Regional gas basis

Modeling based on:

- Historical Volatility
- Historical Mean Reversion
- Historical Correlation
- Expert view on low, mid & high cases

3. Coal

- ILB
- PRB
- CAPP & NAPP

Modeling based on:

- Historical Volatility
- Historical Mean Reversion
- Historical Correlation
- Expert view on low, mid & high cases

4. CO2

- National CO2 price

Modeling based on:

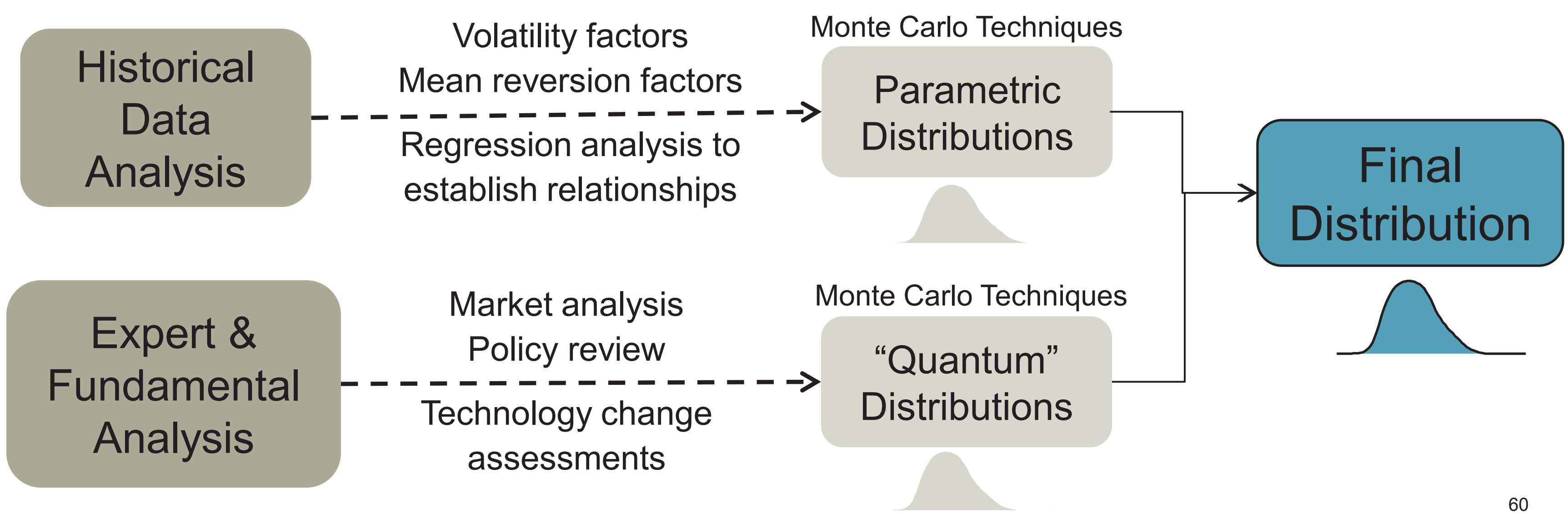
- Analysis of price required for Paris Agreement compliance
- Social cost of carbon analysis
- Expert view on low, mid & high cases

5. Capital Cost

- Relevant technologies included

Modeling based on:

- Expert view on low, mid & high cases



VECTREN
A CenterPoint Energy Company

NEXT STEPS

MATT RICE

VECTREN MANAGER OF RESOURCE PLANNING

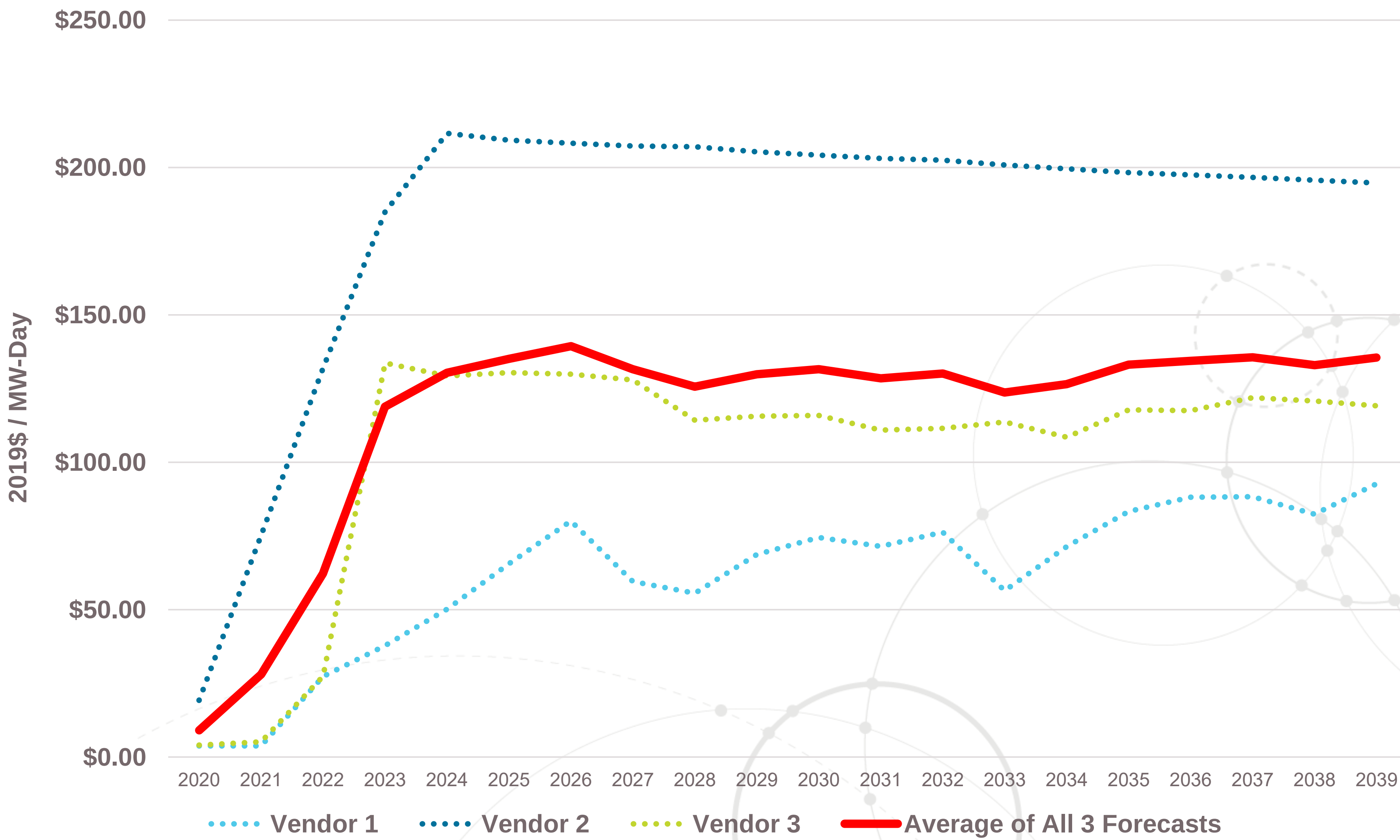
NEXT STEPS

There is a tremendous amount of work to be done between now and our next meeting in March

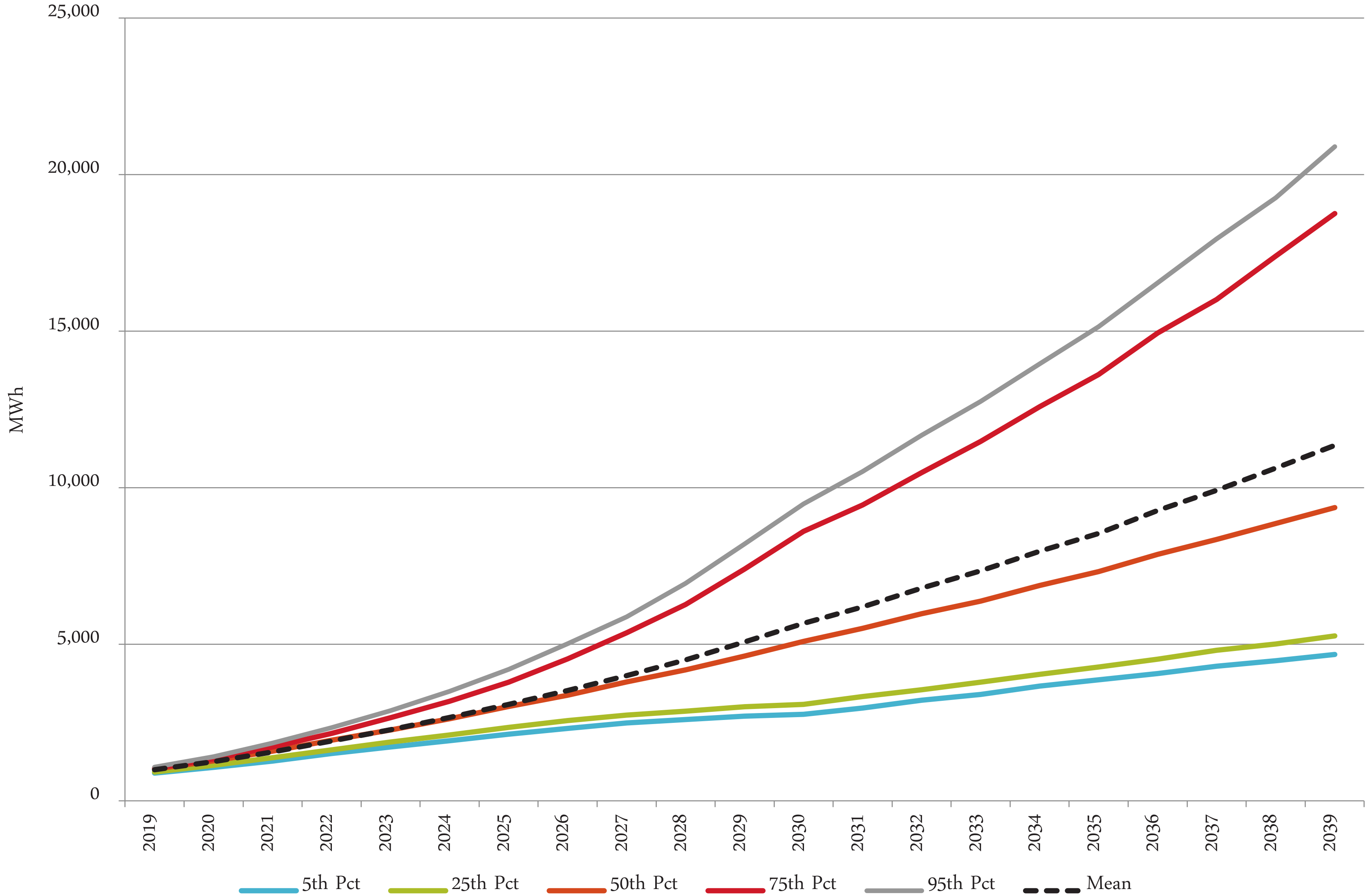
- Finalize all modeling inputs
- Update Reference Case modeling, including RFP results
- Develop scenario based portfolios
- Finalize additional portfolios with insights produced through scenario modeling
- Test portfolios within scenarios and probabilistic modeling
- Analyze results
- Select the preferred portfolio

APPENDIX

CONSENSUS CAPACITY PRICE FORECAST

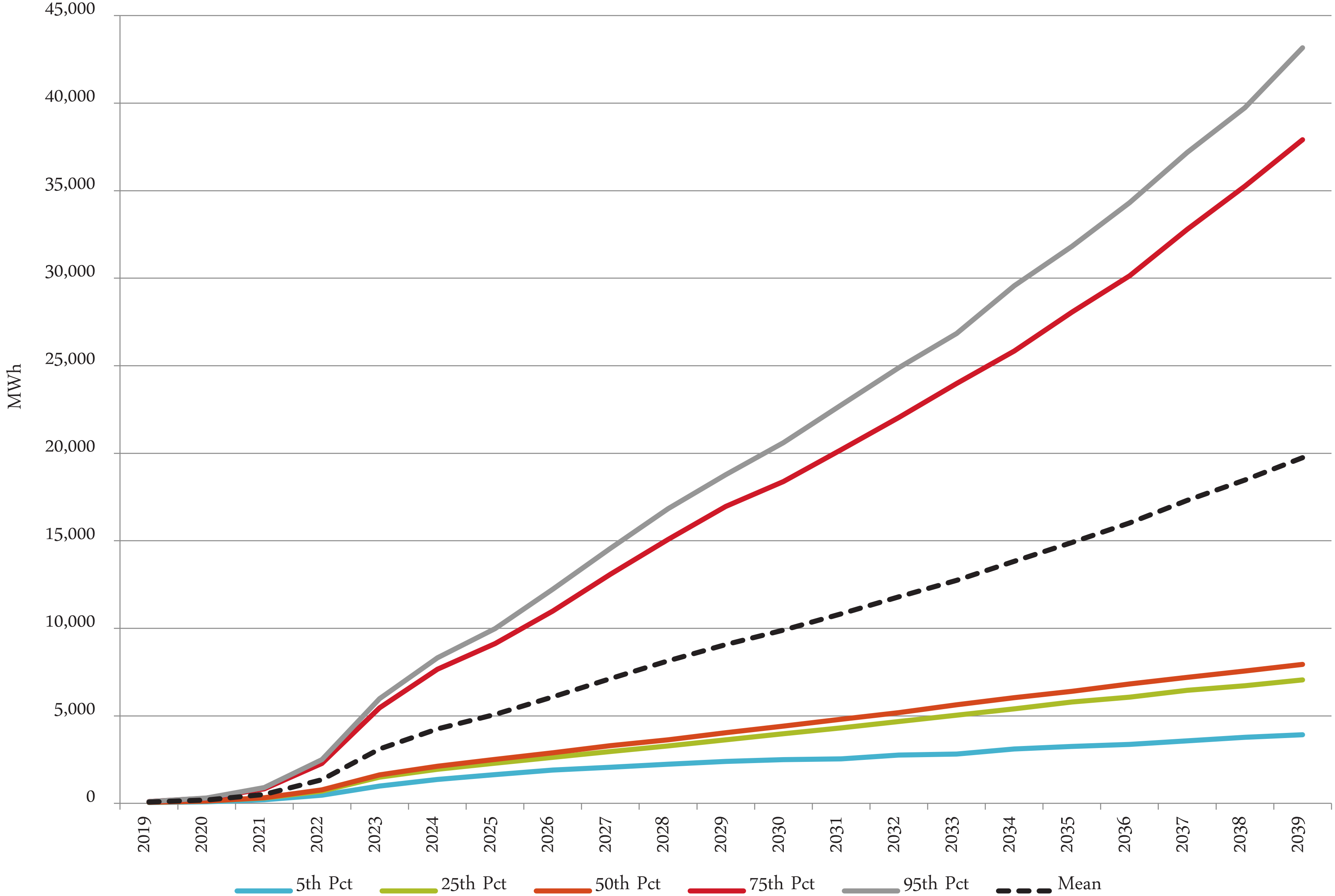


VECTREN SOLAR DISTRIBUTED GENERATION IS A DECREMENT TO VECTREN LOAD

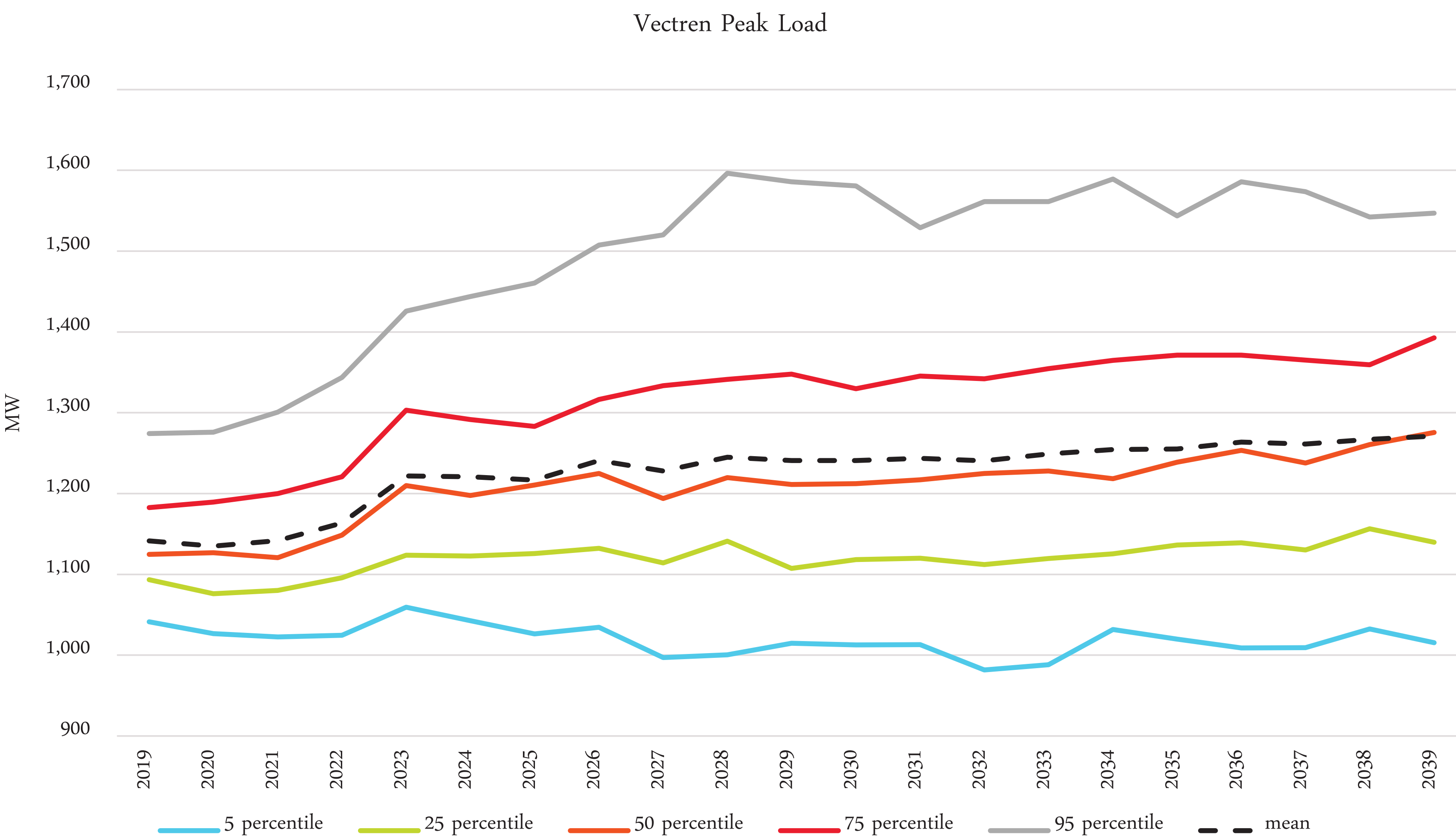


CenterPoint Energy
Cause No. 45501
Petitioner's Exhibit 4
MAR WP1 (Public)

VECTREN ELECTRIC VEHICLE LOAD IS AN INCREMENTAL TO VECTREN LOAD



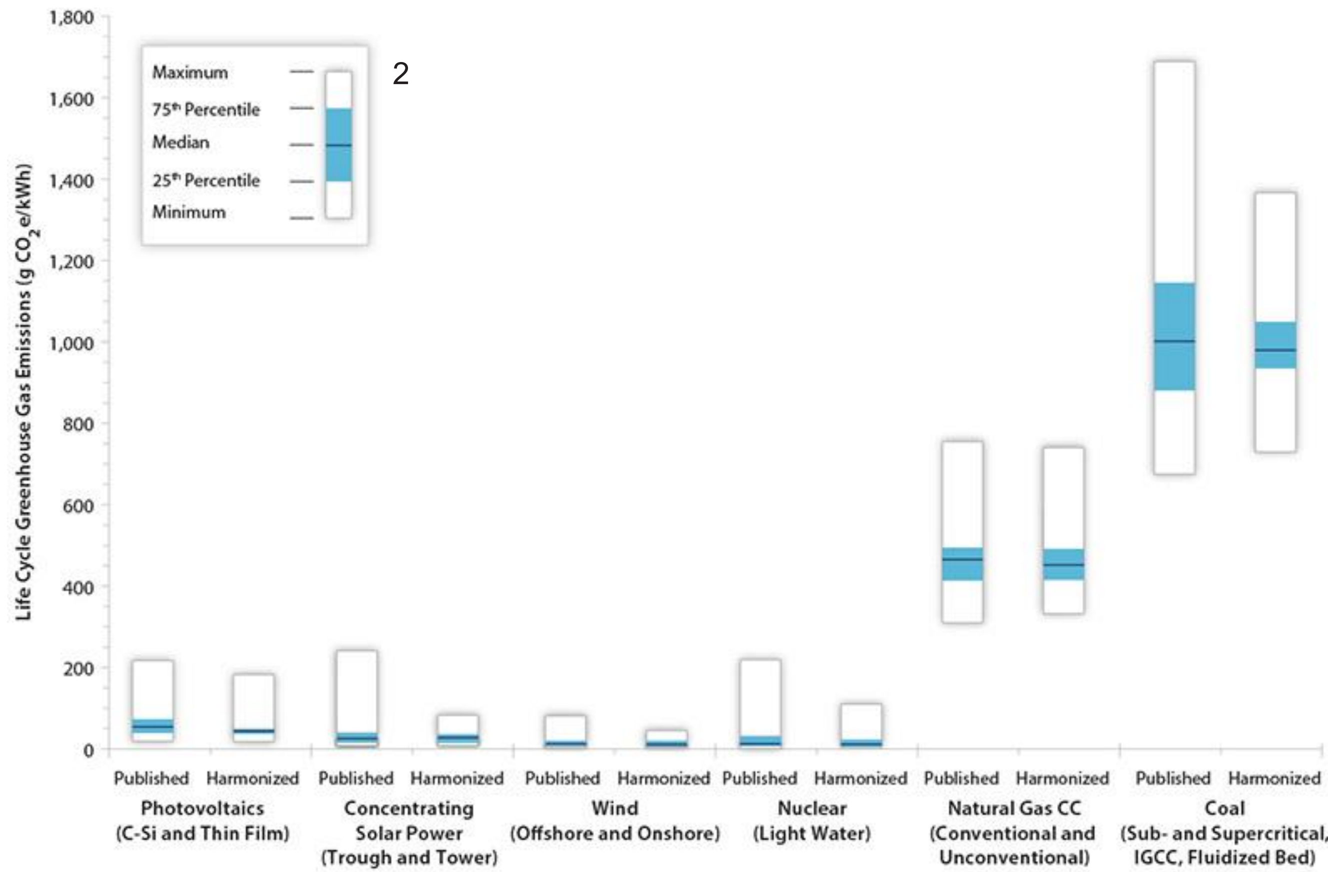
DISTRIBUTIONS: VECTREN PEAK LOAD (NET OF SOLAR DG, EV LOAD)



LCA FOR NATURAL GAS ELECTRICITY GEN.

Multiple studies were considered for the NREL study from July 2014[1]

- Methane leakage was considered. Methane emissions rates ranged from 0.66% to 6.2% CH_4 loss/NG produced[1]
- The study noted that there is the possibility of differences in the definition of methane leakage. Some studies include fugitive emissions; some included vented emissions; others might additionally also include methane from combustion
- The NREL study is meant to provide an estimate of life cycle green house gas emissions for various resources. The study did not attempt to fine tune the analysis to a common definition of methane leakage



	Photovoltaics	Concentrating Solar Power	Wind	Nuclear	Natural Gas CC	Coal
Estimates	46	36	126	99	61	164
References	17	10	49	27	45	53

*CC = combined cycle

1 Source: Harmonization of Initial Estimates of Shale Gas Life Cycle Greenhouse Gas Emissions for Electric Power Generation, 2014 Table 1 Page 3 https://www.pnas.org/content/pnas/111/31/E3167.full.pdf
2 Source: https://www.nrel.gov/analysis/assets/images/lca_harm_ng_fig_2.jpg

Vectren 2019 IRP
3rd Stakeholder Meeting Minutes Q&A
December 13, 2019, 9:00 a.m. – 3:00 p.m.

Lynnae Wilson (CenterPoint Energy Indiana Electric Chief Business Officer) – Welcome and Safety Message (holiday safety tips) and Vectren introductions.

Subject Matter Experts in the room: Matt Rice, Cas Swiz, Nick Kessler, Rina Harris, Jason Williams, Angie Casbon Scheller, Matt Lind, Kyle Combes, Jamie Bundren, Alyssia Oshodi, Natalie Hedde, Ryan Wilhelmus, Justin Joiner, Justin Hage, Bob Heidorn, Wayne Games, Christine Keck, Brad Ellsworth, Angie Bell, Tom Bailey, Steve Rawlinson, Ryan Abshier.

Stakeholders: Approximately 37 stakeholders attended in person. List of affiliations include the following:

Bowen Engineering
Citizens Action Coalition (CAC)
Earth Charter Indiana
Indiana Coal Council (ICC)
Indiana Utility Regulatory Commission (IURC)
Orion Renewable Energy Group LLC
Office of Utility Consumer Counselor (OUCC)
Sierra Club
Southwest Indiana Chamber of Commerce
State Utility Forecasting Group (SUFG)
Tri-State Creation Care
Valley Watch
Vermillion Rise Mega Park
Vote Solar

Approximately 38 registered to attend the webinar; several participated. Those registered included representatives from:

Advanced Energy Economy
AEP
Boardwalk Pipeline Partners
Development Partners Group
Earth Justice
Energy and Policy Institute
Energy Futures Group
EQ Research
First Solar
Hoosier Energy
ICC
Indiana Distributed Energy Alliance
Inovateus Solar LLC

IPL

IURC

Lewis & Kappes

Midwest Energy Efficiency Alliance (MEEA)

Morton Solar, LLC

NextEra

Orion Renewable Energy Group LLC

OUCC

Sierra Club

Solarpack Development, Inc.

Whole Sun Designs Inc.

Matt Rice (Vectren Manager of Resource Planning) Reviewed Stakeholder Process and Presented Follow-up Information Since Our Last Stakeholder Meeting - Slides 4-17.

- Slide 4: Matt Rice noted that the date for the next stakeholder meeting has been moved to March 20, 2020.
- Slide 12 Stakeholder Feedback\Questions:
    - Request: In CO_2 life cycle analysis I want you to capture all greenhouse gas emissions associated with a process. Specifically, when burning coal, you should capture green house gas emissions associated with coal hauling vehicles, as well as the emissions associated with manufacturing coal handling equipment.
        - Response: What you describe is the purpose of using a life cycle analysis. It considers mining the coal, transporting it, burning it, etc. but we would need to refer to the study to clarify [if manufacture of equipment is included].
    - Question: Regarding the size of the hydro resources available for selection in the model, if other hydro owners evaluate local dams and identify there is more potential than 50 MW's will you consider changing the size of hydro resources in the model?
        - Response: We plan to stick with 50 MW's for the size of hydro resources but keep in mind the IRP is a guide, and if hydro is selected as a resource [in the preferred portfolio] we would then initiate further evaluation of the potential of local dams and refine the projected output.
    - Question: You are going to model 50 MW's but will you perform an analysis to determine what size dam would work properly?
        - Response: Hydro would need to be selected first before further analysis is completed.
    - Statement: Modeling 50 MW's seems arbitrary and it seems that you want to dismiss it.
        - Response: Hydro will be evaluated within the model along with all other resources.
    - Statement: Regarding methane leakage I urge you to include the results from the Science Magazine article from 18 months ago. It is more current than the National Renewable Energy Laboratory (NREL) study being used.
        - Response: Life cycle analysis of carbon is one of many factors we are using to select a preferred portfolio. The NREL study is the best study we can find to show the relative differences among resources. When we spoke with NREL, we told them how we intended to use the study, and they agreed that their study was appropriate for our analysis. We can set up a separate meeting to discuss if needed.
- Slide 11 Stakeholder Feedback:

    - Question: Can you tell me who you spoke with at MISO that indicated they are moving toward a seasonal construct?
        - Response: Based on conversations with MISO personnel and public presentations it is clear to us that MISO is planning to move to a seasonal construct [or other mechanisms to adapt to intermittent, renewable resources] in the coming years. We can schedule a group call to make sure we are all on the same page if needed.
    - Question: Can you share the documents you are looking at that indicate MISO is moving toward a seasonal construct.
        - Response: Yes, we will provide them.
- Slide 13 Stakeholder Feedback:
    - Statement: I appreciate that you are willing to export inputs and assumptions from Aurora to share with stakeholders that don't want to pay $5k for a read only license but I am concerned that the information exported will be difficult to interpret.
        - Response: There is a help function in the read only copy, and we will try to print as much of that information as we can to help provide a work around, but we cannot provide a read only copy [free of charge] of all the models we use to all stakeholders that want a copy. We will work to provide the transparency that is needed with this workaround.
- Slide 14 Stakeholder Question:
    - Questions: Can you explain the planning process between MISO and a utility? What does it mean that MISO is fuel source neutral? Isn't the planning reserve margin based on information you provide in your planning?
        - Response: Fuel source neutral means MISO doesn't care what fuel sources (coal, gas, solar, wind, hydro, etc.) we use to meet customer needs. They provide us with the planning reserve margin requirement.
        - Response: The planning reserve margin is the surplus power we need above expected customer peak demand. It is based on [load and performance] information of all resources in MISO.

Peter Hubbard (Manager of Energy Business Advisory, Pace Global) Presented Draft Reference Case Modeling Results - Slides 18-29.

- Slide 20 Stakeholder Questions:
    - Question: On slide 20 I don't see hydro. Is it included?
        - Response: This is not an all-inclusive list. It is included and is shown on slide 22.
    - Question: Can you explain what customer owned Distributed Generation (DG) capacity represents?
        - Response: It represents how much capacity is expected from solar installed by Vectren customers, over time in the reference case. These values can vary in different scenarios.
    - Question: Does this estimate include batteries?
        - Response: There could be a battery behind the customer owned solar, but this just represents the solar capacity.
- Slide 21 Stakeholder Question:
    - Question: Did House Bill 6 in Ohio have an impact on Vectren's ownership, operation, or cost of Ohio Valley Electric Corporation (OVEC) that would impact Vectren customers?
        - Response: No.
- Slide 22 Stakeholder Questions:
    - Question: Shouldn't hydro capacity be 100 MW's?
        - Response: It is 50 MW's for each resource, and 2 resources are available for selection (100 MW's total).
    - Question: How did you determine the solar and wind capacity limitations?
        - Response: It is based on what is a reasonable expectation for how many MW's can be constructed and brought on line in a year.
- Slide 24 Stakeholder Question:

- Question: Regarding CO_2 does your analysis include the potential use of the low sulfur diesel fuel that could be produced from the proposed coal to diesel facility in Spencer County?
  - Response: This analysis only includes natural gas as a fuel source [for resources that can be fired by natural gas or diesel].
- Statement: There is probably more carbon produced transforming coal to diesel than there is transforming oil to diesel.
  - Response: The Spencer County project is external to the IRP analysis.

- Slide 20 Stakeholder Questions:
  - Question: The amount of customer owned solar DG would depend upon net metering and how much customers are compensated. Are you putting caps on net metering and solar?
    - Response: The DG (solar) is looked at from a probabilistic point of view that determines what levels of DG could exist on the low end and on the high end. It captures a range of inputs for the model.
    - Response: We are also considering a low load forecast within scenarios that will produce a portfolio. We are considering a range. The assumptions in the reference case are based on existing law.
  - Question: So, you will only be as favorable to the homeowner as the law makes you be?
    - Response: We are modeling a wide range of load forecasts. Solar DG is accounted for as a reduction in load in the model. We've included existing law in the reference case but will also look at high and low bounds.
  - Question: When determining the cost of natural gas, do you assume the gas will come from CenterPoint Energy in Houston?
    - Response: There are several different sources for gas, so it would not necessarily come from CenterPoint. It would be on a low-cost basis and would come from one of the interstate gas pipelines.
  - Question: Does most of the gas come from the Texas area?
    - Response: It depends on the pipeline. Many pipelines that are in this area come from the Gulf Coast, but some come from other sources. The gas could from other areas (i.e. Pennsylvania).
    - Response: We have a diverse mix of gas interstate pipelines in Indiana. The gas could come from Canada, Ohio, New York, Pennsylvania, Colorado, or the Gulf Coast.
  - Question: Since a lot [of gas] comes from the Gulf Cost, is it figured in that climate change is likely to create record floods. The Houston area has had two 500-year floods in recent years. I assume more frequent and drastic flooding will impact the ability of the pipelines to work (for people to get to their jobs to do it). I hope that when you figure the cost and reliability of natural gas is, you consider the factor in the impact of climate change.
    - Response: When you look at the 2 flooding events in Houston, Vectren customers did not have an interruption. When you look at the interstate pipeline and the planning involved the diversity really helps [maintain reliability].
- Stakeholder Question:
  - Question: In April 2019, the IURC denied your proposal for an 850 MW gas plant. If the request for proposal that comes to fruition as a result of this IRP also gets rejected by the IURC will you continue to recommend oversized gas plants that favor CenterPoint's interests?
    - Response: Today, we are laying out the portfolios that we are considering. A large gas plant is not included. When you look at the planning reserve margin requirement graph [for the reference case] there is not a build larger than the requirement.
    - Response: It is important to note that meeting the planning reserve margin requirement is a capacity issue. When we retire base load coal capacity, we need to replace capacity. The model is picking gas peaking units, not a combined cycle [gas plant], which runs a lot. [In the reference case] the peaking

units are only projected to run 7% of the time. 90+% of the time other MISO units are being selected to run (create energy). When we evaluate all 15 portfolios through the risk analysis, the reference case may be low cost for capacity, but it is not a great energy selection. This leads to exposure to volatility of the energy market. The reference case is an option, but there are [up to] 14 other portfolios with 200 iterations of each, and all will be run through the risk analysis. That will lead us to a preferred plan. The preferred plan will perform [well] across all scenarios and [potential] costs.

- Slide 25 Stakeholder Question:
  - Question: How did you come up with 697 MWs to replace 730 MWs of coal capacity?
    - Response: The three combustion turbines selected by the model are 230 MW's each. The balance is made up for by purchasing capacity from the market.
- Slide 22 Stakeholder Question:
  - Question: Why is there a single 200 MW capacity option for wind energy? Is that a realistic capacity option viewed relative to the capacity of Vectren's existing wind resources (i.e., 30 MW and 50 MW)?
    - Response: Many wind farms are much larger than the 30 and 50 MW's that Vectren currently has contracted. The 200 MW size is reasonable from a tech assessment point of view, but it could be smaller.
- Stakeholder Question:
  - Question: What pipeline costs were included in the reference case modeling?
    - Response: Pipeline costs were included. Costs are subject to refinement but were included in the reference case.
- Slide 22 Stakeholder Question:
  - Question: Why did you constrain the reference case? It seems like it makes the most sense to let the model do as much optimization as possible.
    - Response: There are operational and commercial constraints that need to be considered. The analysis is meant to be least cost but subject to reasonable considerations.
  - Comment: I've seen other utilities use a max reserve margin instead of resource specific constraints. For renewables it does matter because the cost changes by year pending tax credits. Rather than you telling us it is reasonable, it would be nice if we could evaluate if it is reasonable too.
    - Response: We are preparing to put Request for Proposals (RFP) information into the model so we can evaluate what projects are out there and see if we need to change the limitations.
- Slide 23 Stakeholder Question:
  - Question: Why are aeroderivatives excluded from the model? I've seen that they are modeled in Puerto Rico, so why isn't is an option to Vectren?
    - Response: The required pressure is 900 psi which is higher than other potential resources. They have a higher pipeline cost and they are smaller resources [expensive] so we decided to screen them out.
  - Question: Do you have any data on the pipeline cost differences?
    - Response: It is subject to non-disclosure agreement but we can discuss.
  - Question: CenterPoint could hold the contract to supply gas to any unit that Vectren may build. Is that something you intend to do an RFP for?
    - Response: Currently, our practice is to go out for bid for fuel source supply for our generating facilities.
- Tri-State Creation Care (along with the Sierra Club) presented a petition with approximately 600 signatures encouraging Vectren to take future risk of CO_2 emissions on future generations into consideration. Emphasis was added that this is a moral decision to stop CO_2 production; it is not just an economic decision.
- A residential customer presented a petition of approximately 600 people effected by a large [600 acre] solar project in Vanderburgh County, requesting that Vectren consider land use in portfolio development. Emphasis was added that solar plants are large, industrial facilities and should be

zoned as such. Vectren should maximize use of brownfield sites and not pursue large solar projects on productive farm land near residential homes.

Matt Lind (Resource Planning & Market Assessments Business Lead, Burns and McDonnell) Presented Final RFP Modeling Inputs - Slides 30-37.

- Slide 36 Stakeholder Question
    - Question: Is cost incorporated over the life of the asset including initial build cost and O&M?
        - Response: It includes initial build and O&M.
    - Question: Some resources, depending on the fuel source, will have an increase in price that will be difficult to model. I suspect that as some resources become more scarce their cost will increase exponentially. How are those types of variables accounted for?
        - Response: In the RFP we are focused on specific projects. To the extent that some of these resources are going to burn fuel, the IRP risk analysis will consider and evaluate that.
- Stakeholder Comment
    - Comment: Every day a river or aquifer is destroyed, and the cost can't be determined; it can't be replaced.
        - Response: Thank you for your comment. In the IRP, the assumption is that all resources meet existing regulations which include costs associated with avoiding instances that you described.
- Slide 34 Stakeholder Question
    - Question: Was there a particular duration in hours [for storage] that made it into Tier 1 where as others didn't?
        - Response: Duration did not go into categorizing resources into tier 1 or tier 2. It was based on [firm bids and] if the energy was settled at Vectren's load node or located on their system. There was not a distinction on duration to qualify for tier 1.
- Slide 36 Stakeholder Question
    - Question: How does the project shown in group 13 [Solar Purchase/PPA] compare to projects in group 14 [12-15 Year Solar PPA]? Is that where you are purchasing from homeowners?
        - Response: No. That project was a hybrid where some portion of it would be owned and some would be a PPA with the developer. There was only one bid in that category, so we didn't show cost to keep it confidential.
- Slide 36 Stakeholder Question
    - Question: Is solar+storage only charged by solar? How are you accounting for carbon footprint if charged by the grid?
        - Response: With solar+storage and how tax credits are structured, it is favorable to charge based on renewable energy. It is bid specific; they may have the ability to be grid charged and discharged to the grid.
        - Response: Carbon is accounted for in the energy price. We are still determining the best way to apply the life cycle of carbon analysis to storage.

Matt Rice (Vectren Manager of Resource Planning) Presented Portfolio Development - Slides 38-51.

- Slide 40 Stakeholder Question
    - Question: If the net metering cap were to be doubled, tripled, or quadrupled do you have a factor that incorporates the increase in the cap into different portfolios?
        - Response: Indirectly, yes. We will run a scenario that has a lower load than the reference case.
    - Comment: But the lower load would vary based on what the cap is.

        - Response: If there is something that induces more solar on rooftops, that would result in a reduction to our load. We are considering reduction to load within the scenarios and probabilistic modeling.
    - Comment: But the lower load could be 5-20% lower so you don't know what that reduction is.
        - Response: Our bounds are very wide.
- Slide 41 Stakeholder Question
    - Question: How many portfolios do you think this will end up being?
        - Response: We are planning for up to 15.
- Slide 50 Stakeholder Comment:
    - Comment: Thank you for including the HB 763 but on the chart on slide 50 the cost should be $45 in 2025 and $205 by 2039.
        - Reply: Thank you, please see me at the end of the day.
- Slide 43 Stakeholder Question
    - Question: Why does it take so much solar ICAP (installed capacity) to meet 174 MW UCAP (accredited capacity of approximately 29%)? I thought MISO offered 50% accreditation starting off but could be even higher, particularly with tracking.
        - Response: As more solar penetrates the MISO footprint, the solar is netted out which shifts the [net] peak hour out into the evening hours. Then resources other than solar must serve that net peak load. The projection for UCAP declines over time as more solar penetrates the MISO footprint.
    - Question: In California the same thing has happened, but the simple solution is to add 4 hours of storage to get the solar back to a high capacity value. In your lists you include solar+storage but in these lists you didn't include solar+storage as a potential buildout.
        - Response: We are just showing these as reference points. We will evaluate solar+storage consistent with the bids received in our RFP.
- Stakeholder Feedback:
    - Comment: In Germany they put a lot of solar on rooftops and we should do that here. There are a lot of buildings here that don't have solar.
        - Response: That is an option, but it is more expensive and more complex. We have seen this with the Urban Living Research Center. We had to work with the developer on the design of the building to make sure it would support the amount of solar we wanted to install on it. We are modeling utility scale [universal solar] that is much more cost effective.
- Stakeholder Question
    - Question: Can you explain how peak load can shift to the evening?
        - Response: It is the net peak that shifts which is the peak load less the renewable generation (how MISO calculates). The remaining load must be served by something that is dispatchable.
- Stakeholder Question:
    - Question: When you are projecting into the future, do you extend today's values into the future or have other sources?
        - Response: It depends on the input. Some inputs we develop ourselves, some by others but we are diligent to have a basis for all assumptions that are fed into the models.
- Stakeholder Question:
    - Question: How does Vectren's profitability plan into the analysis?
        - Response: When each portfolio is analyzed, it will have a net present value [over the planning period]. The net present value includes a rate of return on resources that we own.
- Stakeholder Statement:
    - Statement: In the last IRP you chose a large CCGT which was going to be highly profitable because it was a large capital investment. It doesn't seem like there is an incentive to go to the lowest cost because profits would be lower.

        - Response: In the last IRP each scenario produced a gas plant as the lowest cost option to serve customer load. In a few slides we will show that affordability is one of the objectives in this IRP to be balanced against other objectives.
- Stakeholder Question:
    - Question: You said that hydro is very expensive initially but it seemed like you said we can't carry that cost over the 50-100 years that it would operate?
        - Response: We will need to review the tech assessment and see what the life is expected to be and put it in the notes. [Upon review, 40 years is included in the tech. assessment. It would not necessarily lower cost by extending the life to 50-100 years as this would take further capital investment that is not included in our estimate.]

Peter Hubbard (Manager of Energy Business Advisory, Pace Global) Presented Scenario Testing and Probabilistic Modeling - Slides 52-60.

- Stakeholder Question:
    - Question: Are there any incremental solutions where you reassess every 2 years and add resources as needed?
        - Response: Every three years the IRP analysis is revisited and updated based on current assumptions.
- Slide 55 Stakeholder Question:
    - Question: In the high regulatory case how were the natural gas prices determined?
        - Response: It is based on a fracking ban. We used historical pricing (pre-shale gas boom) and sustained those high gas prices throughout the forecast (the 95^{th} percentile every year of the forecast).
- Slide 58 Stakeholder Question:
    - Question: There is more to environmental risk minimization than greenhouse gas emissions. There is ecosystem destruction from coal mining and fracking as well as health issues from burning those fuels. How are you modeling those factors?
        - Response: It isn't just carbon; CO_2 equivalent considers emissions involved from cradle to grave for each technology. Additionally, we are also assuming compliance with EPA regulations. We are accounting for a lot of potential impacts.
- Slide 54-57 Stakeholder Question\Comment:
    - Question: Are you modeling variable O&M probabilistically?
        - Response: We are modeling fuel and CO_2 emissions probabilistically. We are not varying non-fuel variable O&M probabilistically.
    - Question: The list shows CO_2 prices and capital cost (will be varied). I am concerned because I don't think we have enough data to develop a stochastic distribution for CO_2 price. For capital costs, the RFP should provide certainty for those costs and you should be able to extrapolate those costs going forward.
        - Response: The RFP response will tighten up the short-range distribution of capital costs. There is less uncertainty in the short term. However, over 20 years we don't know where those costs will go. The capital cost could be higher or lower than the reference case in the long term.
    - Comment: I think the only thing that lends itself to stochastics are load and fuel prices. I don't think you should test capital costs and CO_2 prices.
        - Response: Thank you for your feedback.
- Stakeholder Question:
    - Question: In essence the IRP is a 3-year plan because you will have another IRP in 3 years. What is going to be done in the next three years that becomes irreversible?
        - Response: Long term there is a bit of uncertainty that goes into this but the IRP incorporates specific market feedback on what the short term might look like. In the very short term, it is based on real figures the market can provide. There is a wide range of technologies that came out of the RFP, and you want to look at

how they perform in the long term. We will look at how they perform in a wide range of conditions.

- Feedback: I think this process is a short-term planning process but would prefer that it be a long-term planning process.
  - Response: We are looking at a wide range of portfolios, and in each case, we are looking at how those portfolios will perform over a 20-year horizon.

- Stakeholder Question:
  - Question: Have you asked your rate payers if they would be willing to pay a higher rate for renewable energy?
    - Response: Yes. We do survey our customers to understand their needs. There is a segment of the population that is willing to pay more for renewables.
- Stakeholder Question:
  - Question: Vectren ratepayers pay some of the highest rates in the state for a fleet primarily fueled by fossil fuels. I wonder why there is a high value on fossil fuels when utilities that are opting for renewables have lower rates.
    - Response: We are working on a long-term plan, and affordability will be on the scorecard.
  - Question: Has affordability not been on the scorecard in the past? Why do we pay higher rates than others in the state?
    - Response: Affordability is always on the scorecard for the IRP.
- Stakeholder Question:
  - Question: Does Vectren have a renewable energy rider? If not, that could be a consideration and a benchmark to see how many customers are interested in renewable energy.
    - Response: We do not [currently have a renewable energy rider]. We performed an analysis on community solar in recent years to gauge the interest of our customers. At the time, there was slight interest, but we will look at this again as we move forward.
- Stakeholder Comment:
  - Comment: The CAC disagrees that renewable energy riders can gauge customer interest in renewable energy. Buying into these programs does not change the energy portfolio of the utility serving that customer.
    - Response: Thank you for your feedback.
- Slide 16 Stakeholder Question:
  - Question: There was a mention that there weren't any bids received for combined cycle units. I thought I had heard through press releases that you did receive bids for Combined Cycle Gas Turbine (CCGT) projects. Is purchasing power from independent sources woven into your analysis?
    - Response: On slide 32 it shows that we did have some bids for CCGT projects, but they did not qualify to be considered tier 1 projects based on the criteria to be a firm bid, be on our system, or have a delivered price. We are evaluating attractive tier 2 bids and are performing congestion analysis to determine the congestion cost to get the energy to our customers.
- Slide 33 Stakeholder Question:
  - Question: Why are some of the values [in the table] on slide 33 shown on the screen different than the handouts?
    - Response: There was a typo on the slide that we originally posted/printed for this meeting. What is on the screen is accurate. We will post an update to the website.

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VECTREN PUBLIC STAKEHOLDER MEETING

JUNE 15, 2020

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WELCOME AND SAFETY SHARE

LYNNAE WILSON

INDIANA ELECTRIC CHIEF BUSINESS OFFICER

SAFETY SHARE – FIREWORK SAFETY

In 2017, eight people died (half children and young adults under age 20) and over 12,000 were injured badly enough to require medical treatment after fireworks-related incidents

- According to the National Fire Protection Association, sparklers alone account for more than 25% of emergency room visits for fireworks injuries

If consumer fireworks are legal to buy where you live and you choose to use them, be sure to follow the following safety tips:

- Never allow young children to handle fireworks
- Older children should use them only under close adult supervision
- Never use fireworks while impaired by drugs or alcohol
- Anyone using fireworks or standing nearby should wear protective eyewear
- Never hold lighted fireworks in your hands
- Only use them away from people, houses and flammable material
- Only light one device at a time and maintain a safe distance after lighting
- Do not try to re-light or handle malfunctioning fireworks
- Soak both spent and unused fireworks in water for a few hours before discarding
- Keep a bucket of water nearby to fully extinguish fireworks that don't go off or in case of fire

Source: https://www.nsc.org/home-safety/tools-resources/seasonal-safety/summer/fireworks

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MEETING GUIDELINES, AGENDA, AND FOLLOW-UP INFORMATION

MATT RICE

VECTREN MANAGER OF RESOURCE PLANNING

AGENDA

Time		
1:00 p.m.	Welcome, Safety Message	Lynnae Wilson, Indiana Electric Chief Business Officer
1:10 p.m.	Meeting Guidelines and Stakeholder Process Review	Matt Rice, Manager of Resource Planning
1:20 p.m.	Presentation of the Preferred Portfolio	Lynnae Wilson, Indiana Electric Chief Business Officer & Matt Rice, Manager of Resource Planning
1:50 p.m.	Portfolio Analysis and Balanced Scorecard	Peter Hubbard, Pace Global, Siemens Energy Business Advisory
2:20 p.m.	Next Steps	Justin Joiner, Director of Power Supply Services
2:30 p.m.	Stakeholder Questions/Comments	
3:30 p.m.	Adjourn	

MEETING GUIDELINES

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- Meeting participants must enter their name when logging into WebEx to facilitate question responses and improve communication
- Please type all questions into the chat function
  - If you would like to follow-up on your question, please use the raise hand function (to the right of your name on the participant list). Your phone line will be opened
  - One follow up question at a time will be allowed to give everyone an opportunity to have their questions answered
  - Any unanswered questions will be addressed after the meeting
  - Additional questions can be sent to: IRP@CenterPointEnergy.com
- Stakeholders may request 2 minutes at the end of the meeting to offer any additional comments. Those that have signed up ahead of the meeting will go first.

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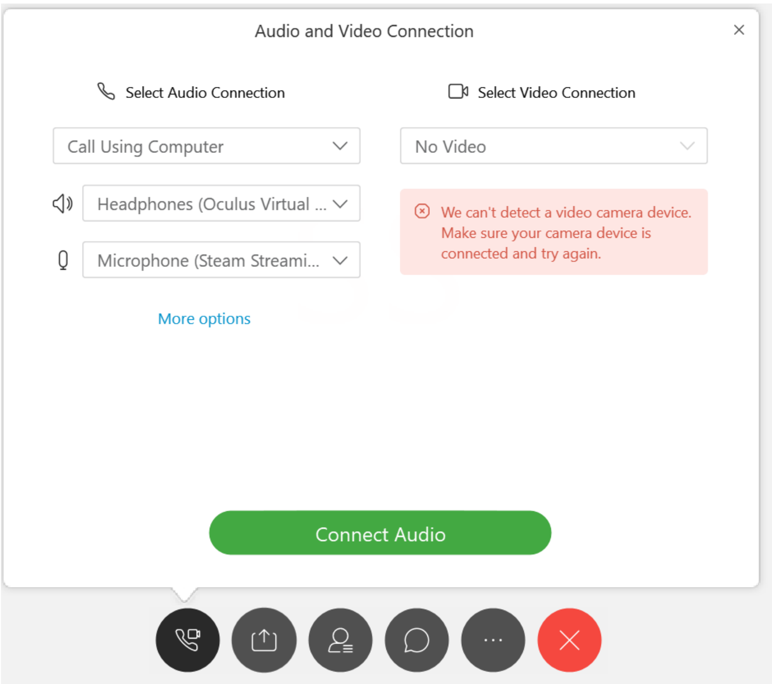
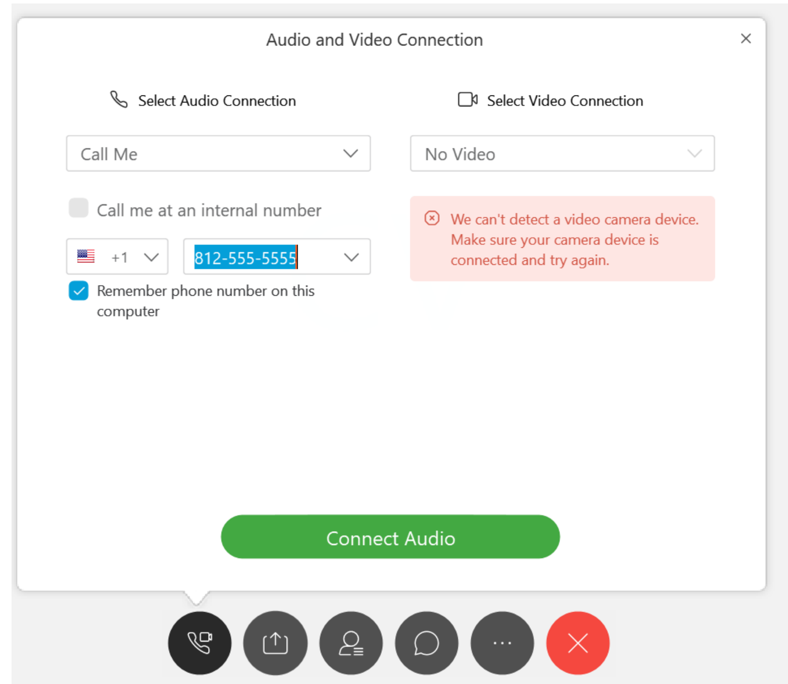
HOW TO CONNECT AUDIO



or

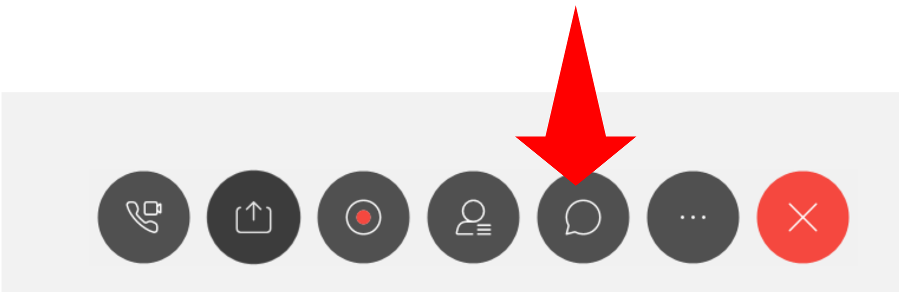


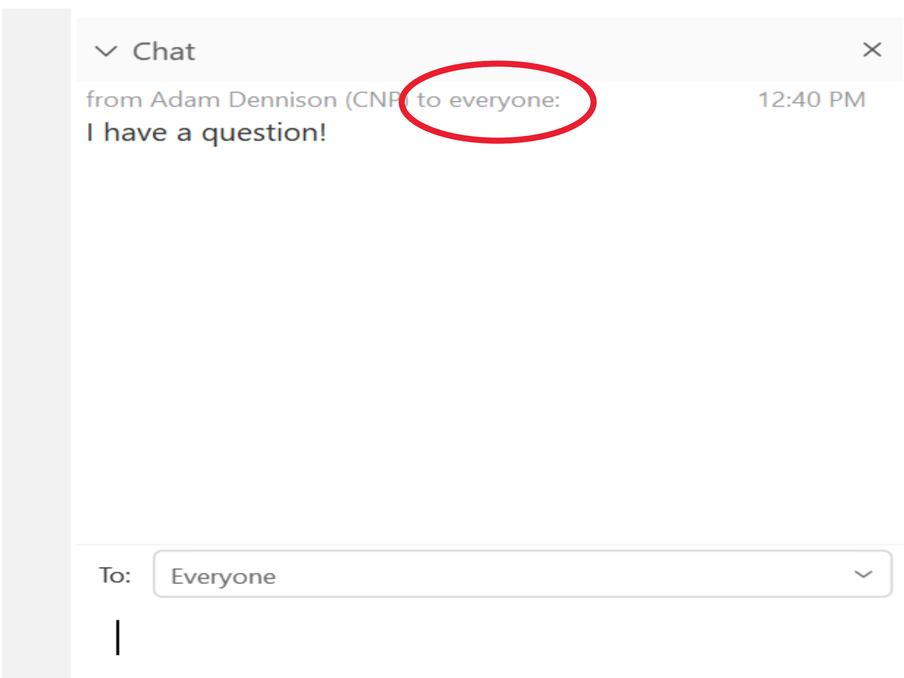
Call Using Computer if you would like to use your computer's microphone and speakers

Call Me if you would like to use a phone to connect. Enter in phone number and WebEx automatically call

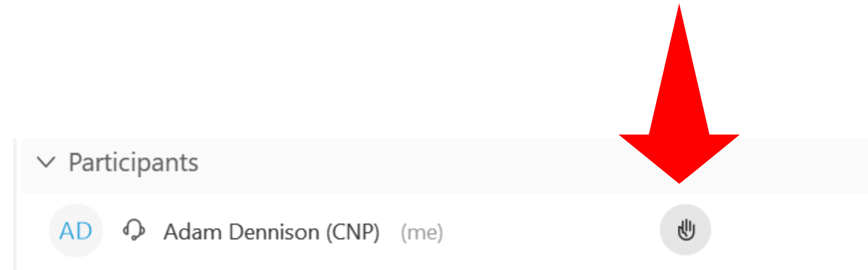
HAVE A QUESTION?

Ask “everyone” in chat.

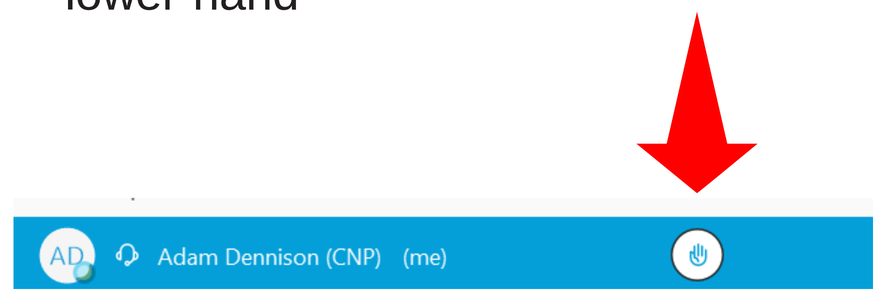




Raise Hand for a Follow-up



After question has been answered, lower hand



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2019/2020 STAKEHOLDER PROCESS

August 15, 2019	October 10, 2019	December 13, 2019	June 15, 2020
• 2019/2020 IRP Process • Objectives and Measures • All-Source RFP • Environmental Update • Draft Reference Case Market Inputs & Scenarios	• RFP Update • Draft Resource Costs • Sales and Demand Forecast • DSM MPS/ Modeling Inputs • Scenario Modeling Inputs • Portfolio Development	• Draft Portfolios • Draft Reference Case Modeling Results • All-Source RFP Results and Final Modeling Inputs • Scenario Testing and Probabilistic Modeling Approach and Assumptions	• Final Reference Case and Scenario Modeling Results • Probabilistic Modeling Results • Risk Analysis Results • Preview the Preferred Portfolio

1. All Source RFP
2. Create Objectives, Risk Perspectives and Scorecard Development
3. Create Reference Case Assumptions and Scenario Development
4. Portfolio Development
5. Portfolio Testing in Scenarios, Focused on Potential Regulatory Risks
6. Portfolio Testing Using Probabilistic Modeling of 200 Potential Futures
7. Conduct Sensitivity Analysis
8. Evaluate Portfolios
9. Select the Preferred Portfolio

VECTREN COMMITMENTS FOR 2019/2020 IRP

- ✓ Utilized an All-Source RFP to gather market pricing & availability data
- ✓ Included a balanced, less qualitative risk score card; draft was shared at the first public stakeholder meeting
- ✓ Performed an exhaustive look at existing resource options
- ✓ Used one model for consistency in optimization, simulated dispatch, and probabilistic functions
- ✓ Worked with stakeholders on portfolio development
- ✓ Modeled more resources simultaneously
- ✓ Tested a wide range of portfolios in scenario modeling and ultimately in the risk analysis
- ✓ Conducted a sensitivity analysis
- ✓ Provided a data release schedule and provide modeling data ahead of filing for evaluation
- ✓ Ensured the IRP process informs the selection of the preferred portfolio
- ✓ Included information presented for multiple audiences (technical and non-technical)
- ✓ Strived to make every encounter meaningful for stakeholders and for us

BACKGROUND

Vectren continually monitors major developments in the energy industry. While the IRP is developed at a point in time, Vectren works to evaluate current and expected future environments. Recently, several developments have helped to shape our view on what to expect in the near, mid, and long-term.

– The generation mix continues to transition towards renewables and gas resources due to economics

– Evolving MISO market rules to ensure reliability, signaling future incentives for resources that are dispatchable, flexible, and visible

– Energy storage is an emerging flexible resource with great potential. Price continues to come down, but there are still no cost-effective long duration storage options

– The need for flexibility to mitigate risk in an uncertain future

– Customer desire for local renewable resources while maintaining reliability

– Guidance from recent Commission orders and the Director’s Report that called for diversity, local resources, risk mitigation, and flexibility

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PREFERRED PORTFOLIO

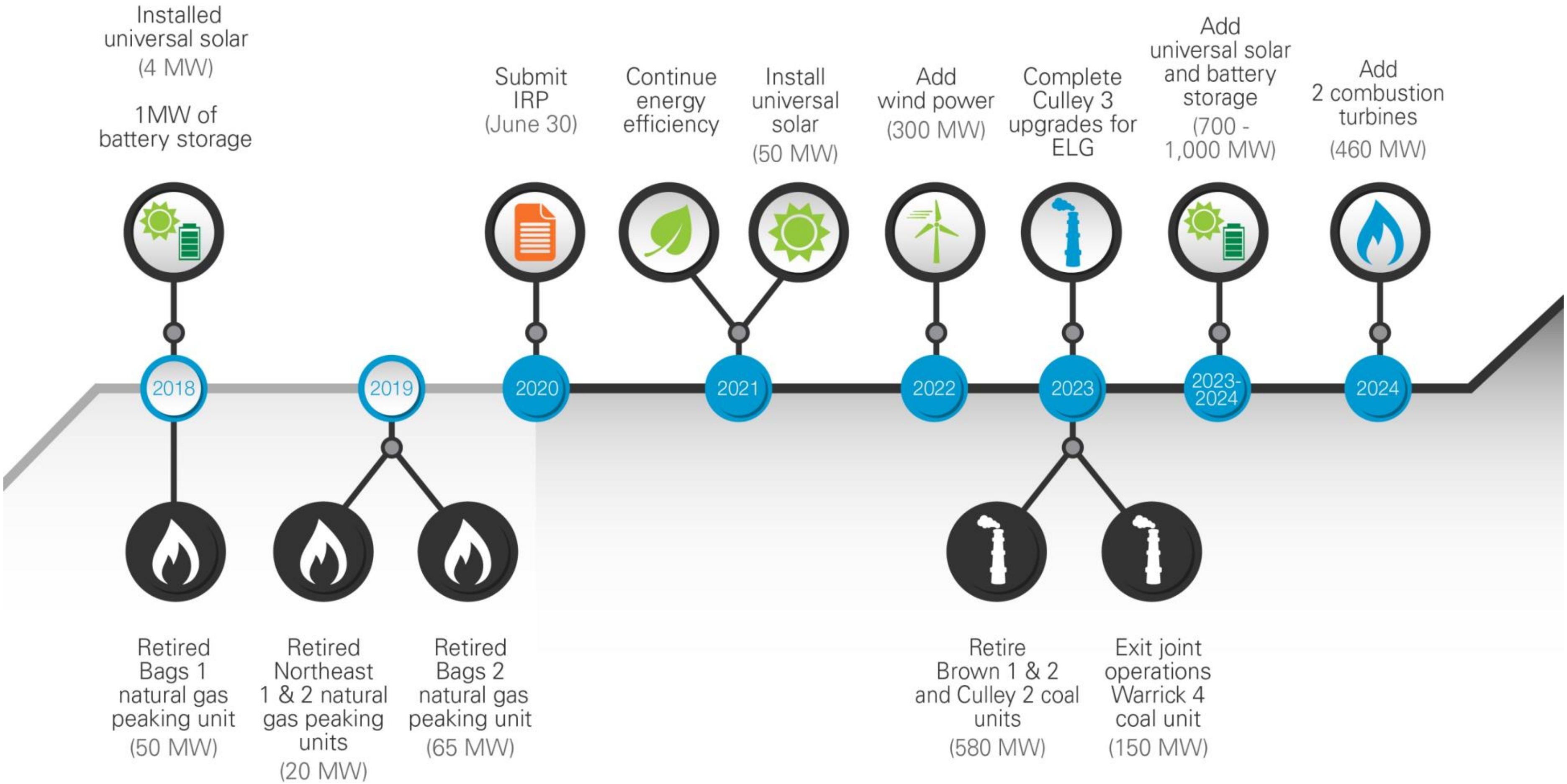
LYNNAE WILSON

INDIANA ELECTRIC CHIEF BUSINESS OFFICER

MATT RICE

VECTREN MANAGER OF RESOURCE PLANNING

VECTREN PREFERRED IRP PORTFOLIO[1]



Bags = Broadway Avenue Gas Turbines
ELG = Effluent Limitations Guidelines
MW = Megawatt

[1]Subject to change based on availability and approval

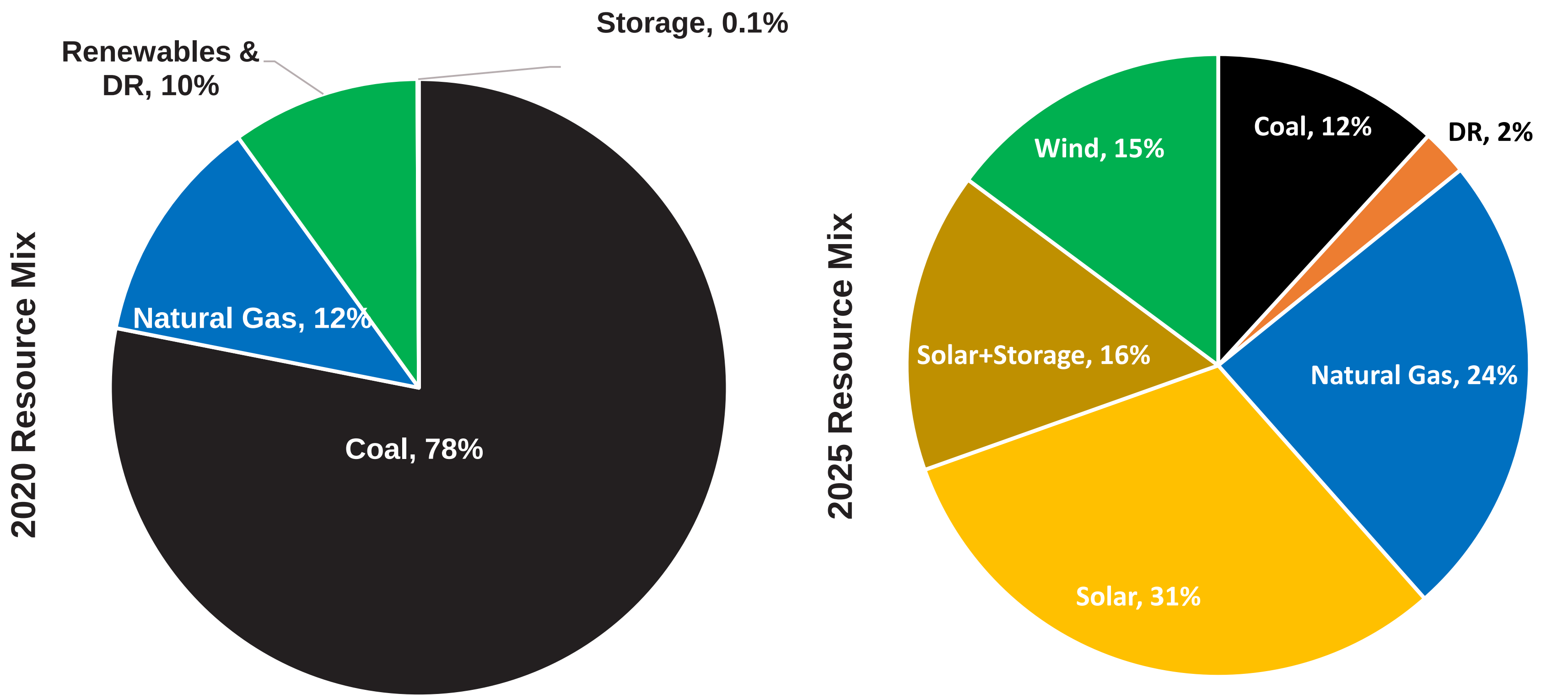
WHY WAS THIS PORTFOLIO CHOSEN?

- Preferred portfolio[1] replaces 730 MWs of coal with approximately 700-1,000 MWs of Solar & Solar + Storage, 300 MWs of Wind, 460 MWs of gas Combustion Turbines (CT) and 30 MWs of Demand Response (DR) (aka High Technology Portfolio[2])
- Preferred portfolio provides the following characteristics:
  - Reliability: dispatchable capacity and energy that is available on demand
  - Cost effective: net present value (NPV) that is among the lowest portfolios in the near, mid, and long-term; saving up to $320 million over the next 20 years
  - Flexibility: ability to meet future load needs via additional resources, including renewables
  - Diversity: capacity and energy from a blend of renewables, coal and natural gas
  - Regulatory risk mitigation and sustainability: a lower NPV and reduces CO_2 nearly 75% by 2035 over 2005 levels
  - Timely: CTs can come online in 2024, thereby reducing market reliance and in-service lag, to replace coal generation that retires in 2023

[1]Large build out of renewable generation helps to replace energy from coal generation., while combustion turbines help to replace a portion of dispatchable capacity from the coal units.
[2] The preferred portfolio was created utilizing the High Technology future scenario. The preferred portfolio is also referenced as the High Technology Portfolio throughout this presentation.

PREFERRED PORTFOLIO RESOURCE MIX

Shift in total installed capacity from 90% fossil to 36%, while renewables and DR increase from 10% to 64%. Near term transition to a diverse set of resources better positions Vectren for the future by 2025, while maintaining the reliability that our customers expect



PREFERRED PORTFOLIO SAVINGS VS. BAU TO 2039 PORTFOLIO

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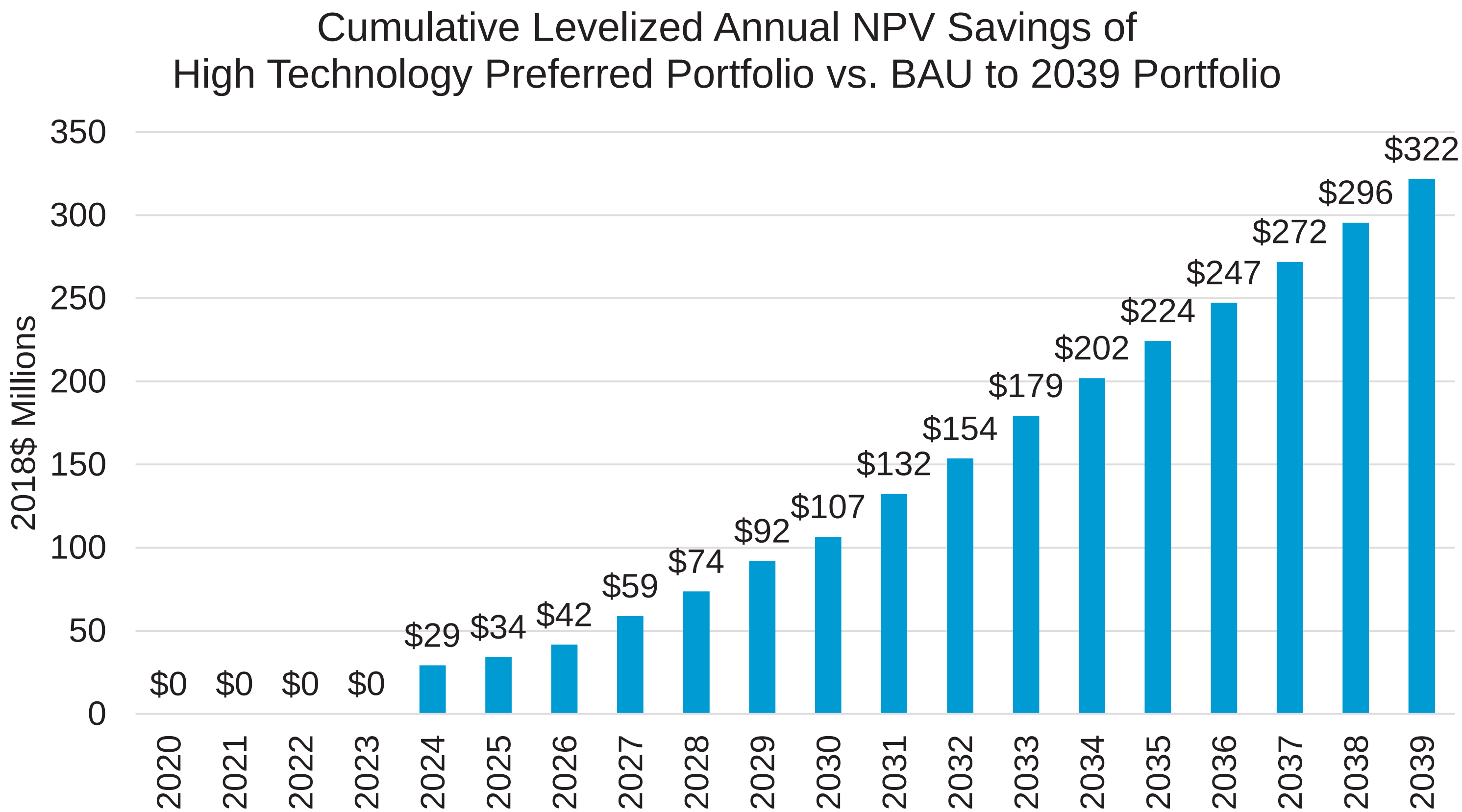
The High Technology (preferred) portfolio provides an annual average savings of $20 million (2024-2039) compared to the Business as Usual to 2039 portfolio and a cumulative savings of more than $320 million in constant NPVRR 2018$.



DIFFERENT DIRECTION FROM 2016 IRP

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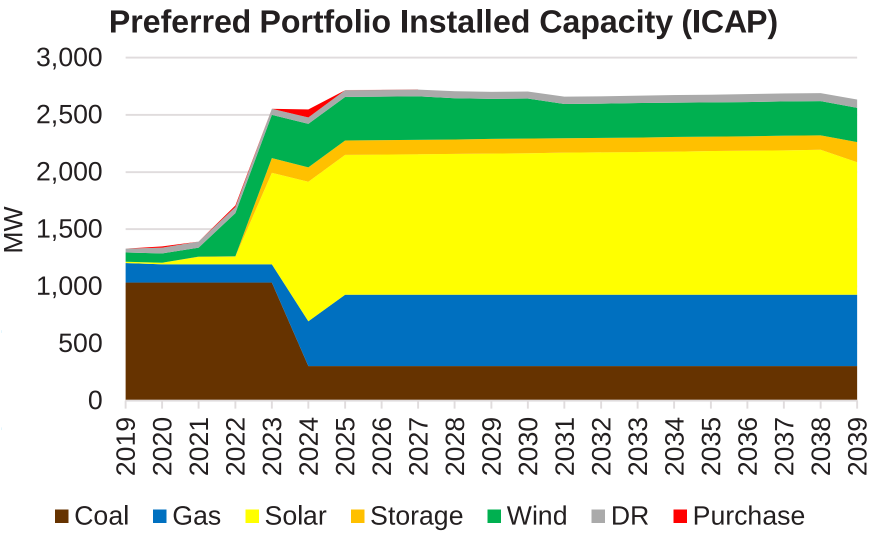
In 2016, Vectren selected a Large 2x1 CCGT (700-850 MWs). In 2020, the preferred portfolio includes a large build out of renewable resources, providing low cost energy, backed up by 2 highly flexible combustion turbines that provide low cost capacity.

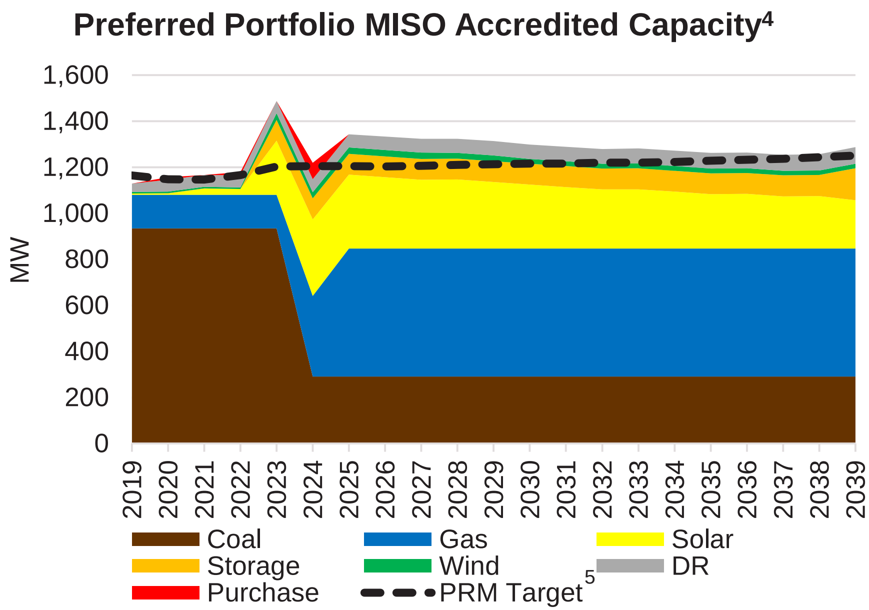
- Lower relative customer impact than many of the portfolio options
- More diverse set of resources, including wind, solar, battery energy storage, EE, DR, gas, and coal
- Faster construction than a CCGT, offsetting market risk more quickly
- Less greenhouse gas emissions and water usage
- Lower dependence on expected market sales to lower cost to customer
- Better support in a high intermittent solar penetration environment (faster ramp)
- Modern CTs have a better heat rate than existing Vectren CTs and coal units

PREFERRED PORTFOLIO ADDITIONS AND RETIREMENTS

2025-2026 Planning Year	ICAP (MW)	% ICAP	Accred-itation[1]	2025-2026 UCAP (MW)	% UCAP
Coal	302	12%	96%	290	22%
DR[1]	62	2%	100%	62	5%
Natural Gas	622	24%	89%	553	41%
Solar[2]	796	31%	26%	207	16%
Solar+ Storage[3]	400	16%	48%	194	15%
Wind	380	15%	7%	28	2%
Total Resources	2,562	100%		1,333	100%

1 ≈35 MWs at risk due to MISO operational changes
2 Solar accreditation may vary depending on penetration
3 UCAP credit includes 90 MW 4-hour battery. Modeled as 126 MW 3-hour battery, consistent with bids
4 Unforced Capacity (UCAP)
5 Assumes coincident peak factor of 95.99%, PRM% 8.9%, and Transmission losses of 1.7%





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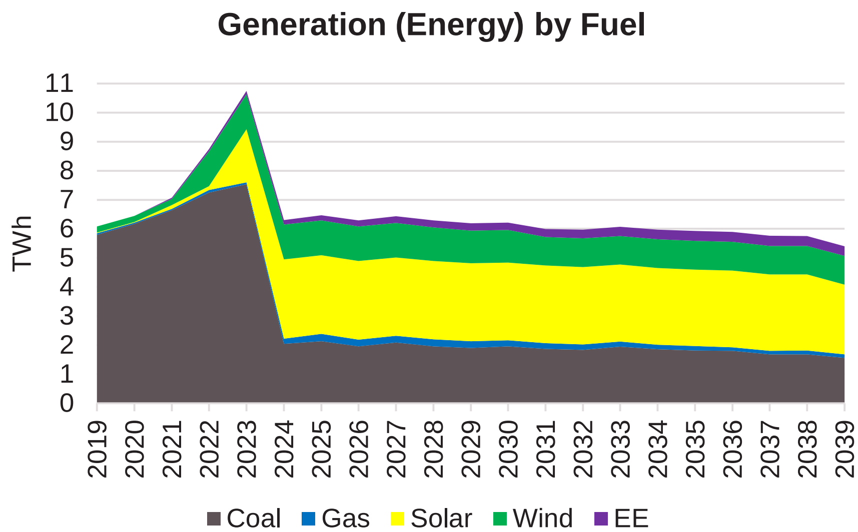
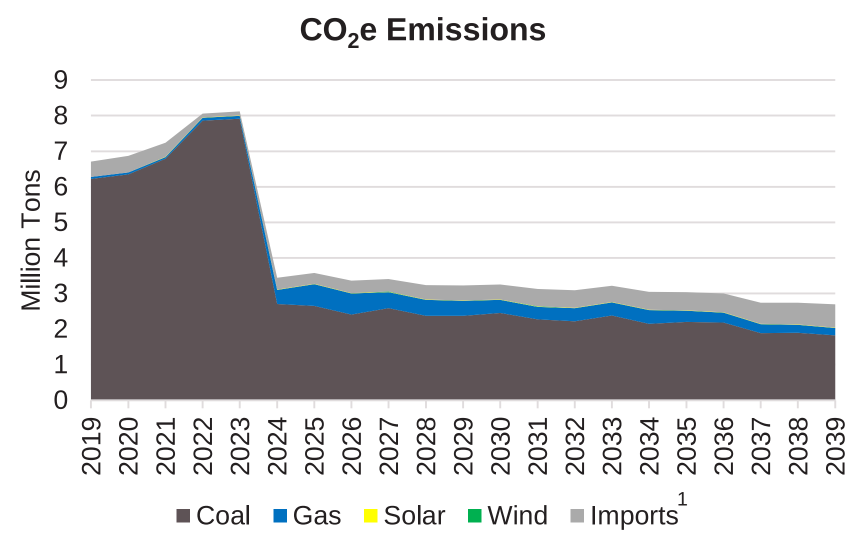
PREFERRED PORTFOLIO ANNUAL GENERATION AND EMISSIONS

- Generation will shift significantly from coal to renewable resources in the near term, reducing variable fuel costs. Nearly two thirds of total energy produced by 2025 will come from renewable resources.
- The coal retirements and exit by December 31, 2023 result in a significant decline in lifecycle CO_2e emissions. Market imports are estimated to comprise a quarter of portfolio CO_2e emissions by the end of the forecast period

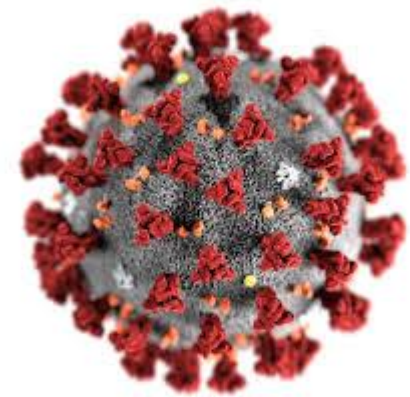




[1] Not produced by Vectren generating resources. Estimate based on projected market reliance, MISO buildout, and NREL lifecycle GHG study

COVID AND THE PLAN

- Vectren will continue to monitor the COVID-19 situation
- Too soon to understand all of the long term impacts; however, the plan is well positioned to meet customer needs in the near, mid, and long-term
  - Flexible
    - Mix of owned resources and term-based PPAs
  - Performed well across multiple future states
  - Numerous resources in spread over several locations and most resources can be operated remotely
  - Less costly to customers than the status quo



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RISK ANALYSIS

PETER HUBBARD

PACE GLOBAL, MANAGER SIEMENS ENERGY BUSINESS ADVISORY

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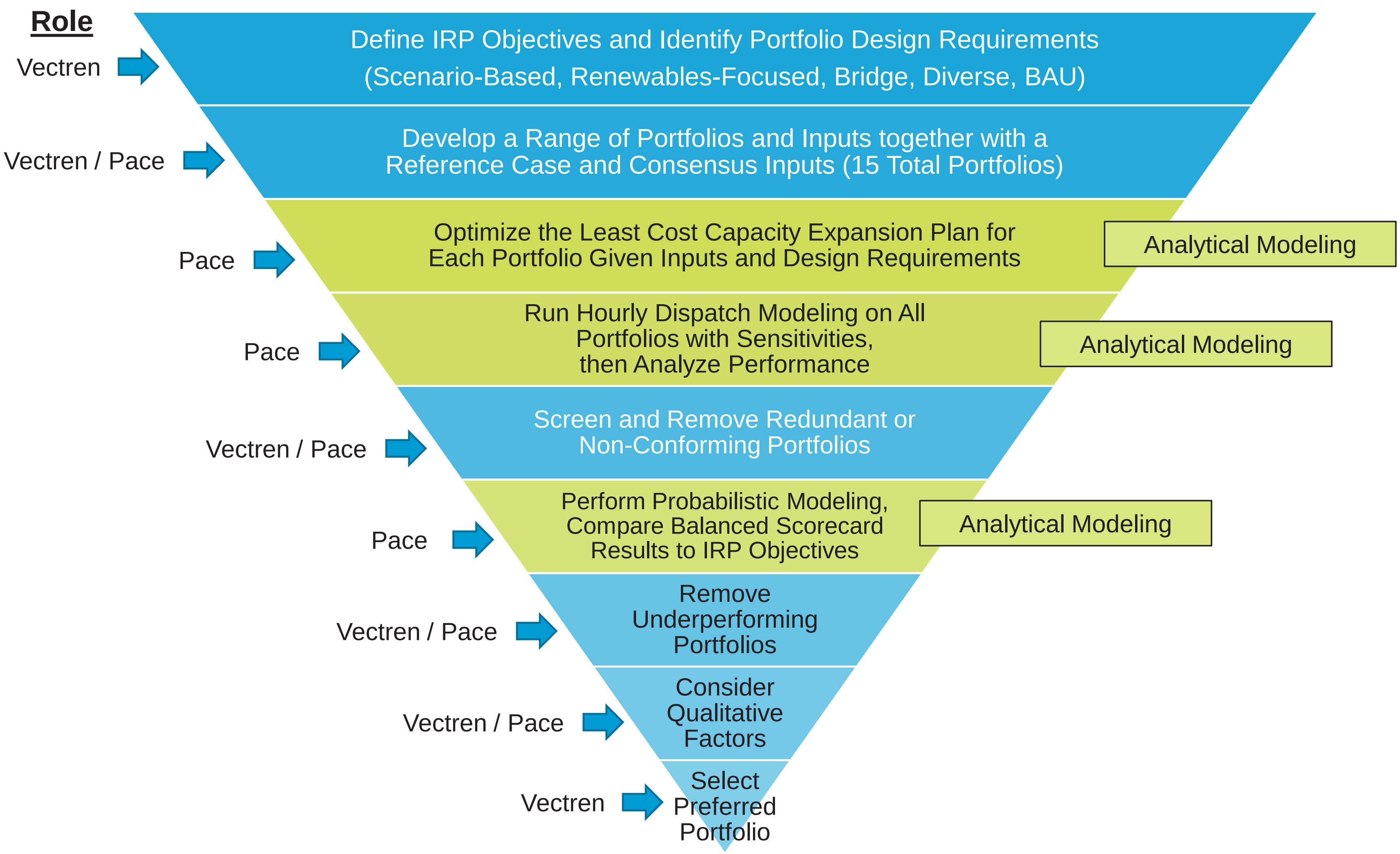
IRP PORTFOLIO EVALUATION AND SELECTION PROCESS



STRUCTURED SCREENING PROCESS TO ADDRESS ISSUES EFFICIENTLY

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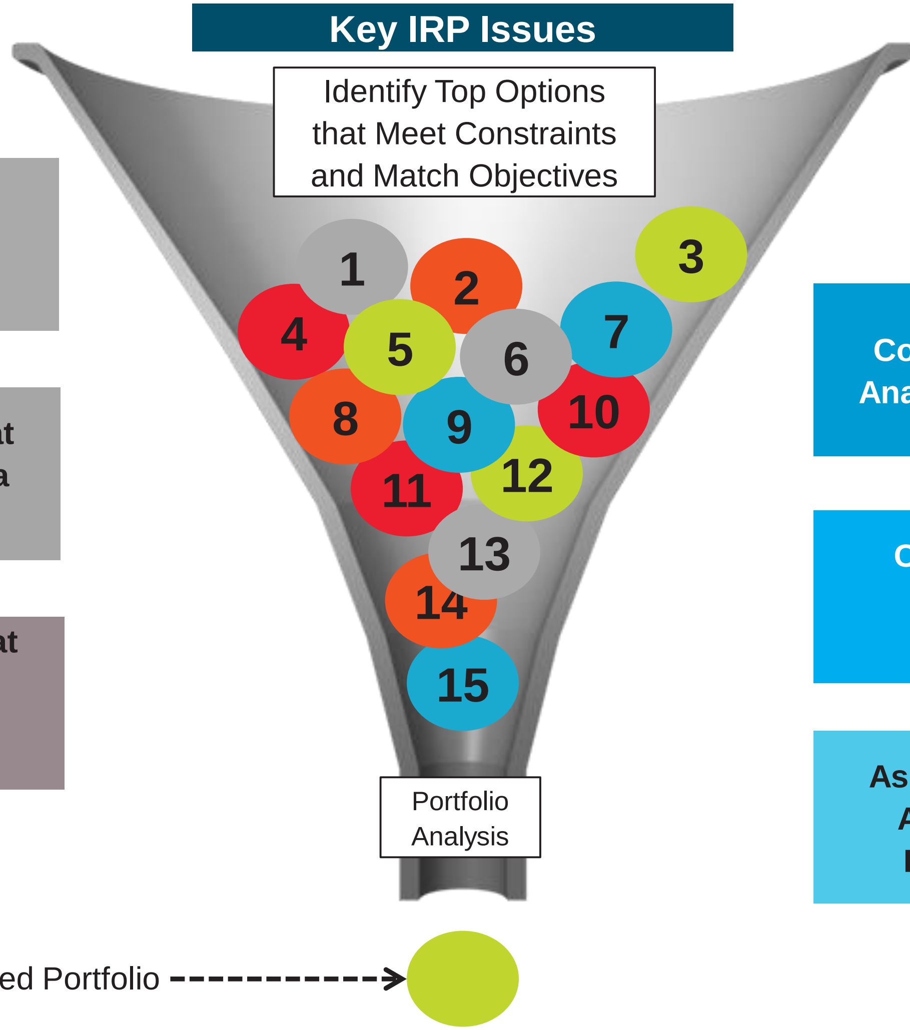
Task

Identify Portfolios (15)

Eliminate Portfolios that do not meet key criteria (10 remain)

Eliminate Portfolios that Exhibit Poorer Performance (4 remain)



Select Preferred Portfolio

Approach

Conduct Deterministic Analysis of 15 portfolios

Conduct Stochastic Analysis (200 iterations)

Assess Most Important Attributes to Select Preferred Portfolio

15 OPTIMIZED PORTFOLIOS DEVELOPED

Portfolio	Group	Portfolio
1	Reference	Optimized Portfolio in Reference Case conditions
2	BAU	Business as Usual to 2039
3		Business as Usual to 2029
4	Bridge	ABB1 Conversion to Gas
5		ABB1 + ABB2 Conversions to Gas
6		ABB1 Conversion to Gas + Small CCGT
7	Diverse	Diverse with Renewables, Coal, Small CCGT
8		Diverse with Renewables, Coal, Medium CCGT
9	Renewables	Renewables + Flexible Gas
10		All Renewable by 2030 (No Fossil)
11		HB 763 (High CO_2 Price)[1]
12	Scenario-Based	Optimized Portfolio in Low Regulatory conditions, Dispatched with Ref Case
13		Optimized Portfolio in High Technology conditions, Dispatched with Ref Case
14		Optimized Portfolio in 80% Reduction conditions, Dispatched with Ref Case
15		Optimized Portfolio in High Regulatory conditions, Dispatched with Ref Case

1 Created based upon stakeholder request. Utilized reference case assumptions with updated CO_2 price based on House Bill 763

STRATEGIES CONSISTENT ACROSS MAJORITY OF PORTFOLIOS

The full analytical process informed the development of several strategies that are consistent across portfolios:

- Optimized results
  - Pursue universal solar capacity of up to ~1,000 MW through 2024
  - Pursue universal wind capacity of up to 300 MW by 2023
  - Retire A B Brown 1 and 2 and F B Culley 2 units by the end of 2023
- Pursue Energy Efficiency at 1.25% of eligible sales (+ Low Income measures) for the first three years and Demand Response resources (Summer Cycler switch out to Wi-Fi thermostats). Applied to all portfolios.
  - Did not want to rely solely on reference case conditions to decide the appropriate level of EE. The reference case selected 0.75% EE, while other scenarios selected 1.25%
  - 1.25% More consistent with historic levels
  - 1.25% vs 0.75% increases NPVRR by only 0.15%

SUMMARY RESULTS FROM ALL PORTFOLIO DETERMINISTIC RUNS

- Renew
- Gas
- Coal
- EE,DG
- Purchase

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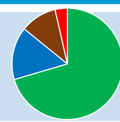
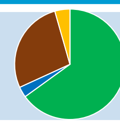
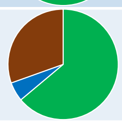
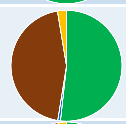
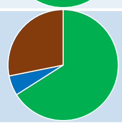
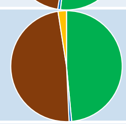
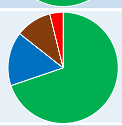
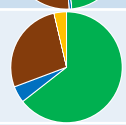
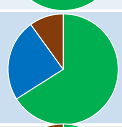
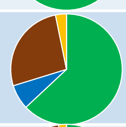
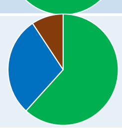
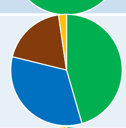
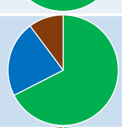
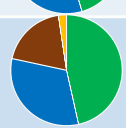
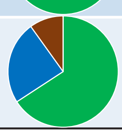
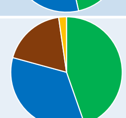
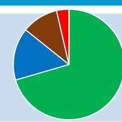
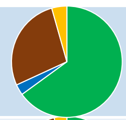
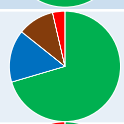
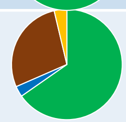
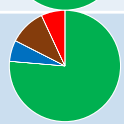
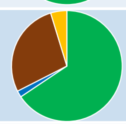
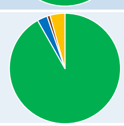
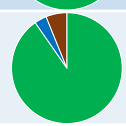
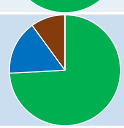
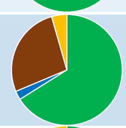
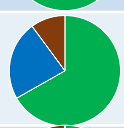
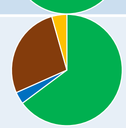
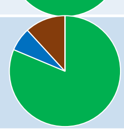
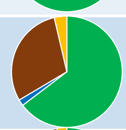
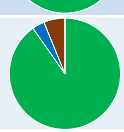
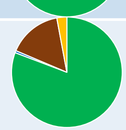
	Portfolio	Portfolio Capacity Mix in 2026	Generation in 2026	NPV $Billion * (% vs. Ref Case)	Net Sales as % of Generation	Average Capacity Mkt Purchases (2024-39)
Ref.	Reference Case			$2.625	7%	138 MW
BAU	Business as Usual to 2039			$3.140 (+19.6%)	23%	0 MW
	Business as Usual to 2029			$2.835 (+8.0%)	19%	102 MW
Bridge	Gas Conversion ABB1			$2.727 (+3.9%)	9%	133 MW
	Gas Conversion ABB1 + ABB2			$2.887 (+10.0%)	11%	56 MW
	Gas Conversion ABB1 + CCGT			$2.954 (+12.6%)	37%	16 MW
Diverse	Diverse Small CCGT			$2.763 (+5.2%)	38%	23 MW
	Diverse Medium CCGT			$2.785 (+6.1%)	41%	18 MW

Increasing CCGT size added cost and market exposure without an increase in portfolio reliability or other value

* Deterministic NPV not used for final Affordability metric

SUMMARY RESULTS FROM ALL PORTFOLIO DETERMINISTIC RUNS

- Renew
- Gas
- Coal
- EE,DG
- Purchase

	Portfolio	Portfolio Capacity Mix in 2026	Generation in 2026	NPV $Billion * (% vs. Ref Case)	Net Sales as % of Generation	Average Capacity Mkt Purchases (2024-39)
Ref.	Reference Case			$2.625	7%	138 MW
Renewables	Renewables + Flexible Gas			$2.600 (-1.0%)	6%	135 MW
	Renewable 2030			$2.679 (+2.1%)	10%	170 MW
	HB 763			$1.425 (-45.7%)	105%	10 MW
Scenario	Low Regulatory			$2.762 (+5.2%)	46%	12 MW
	High Technology (Preferred Portfolio)			$2.686 (+2.3%)	6%	4 MW
	80% Reduction			$2.642 (+0.7%)	36%	203 MW
	High Regulatory			$4.196 (+59.9%)	117%	10 MW

Unrealistic Net Sales Revenue

High Net Sales

Market Exposure

High Cost and High Net Sales

* Deterministic NPV not used for final Affordability metric

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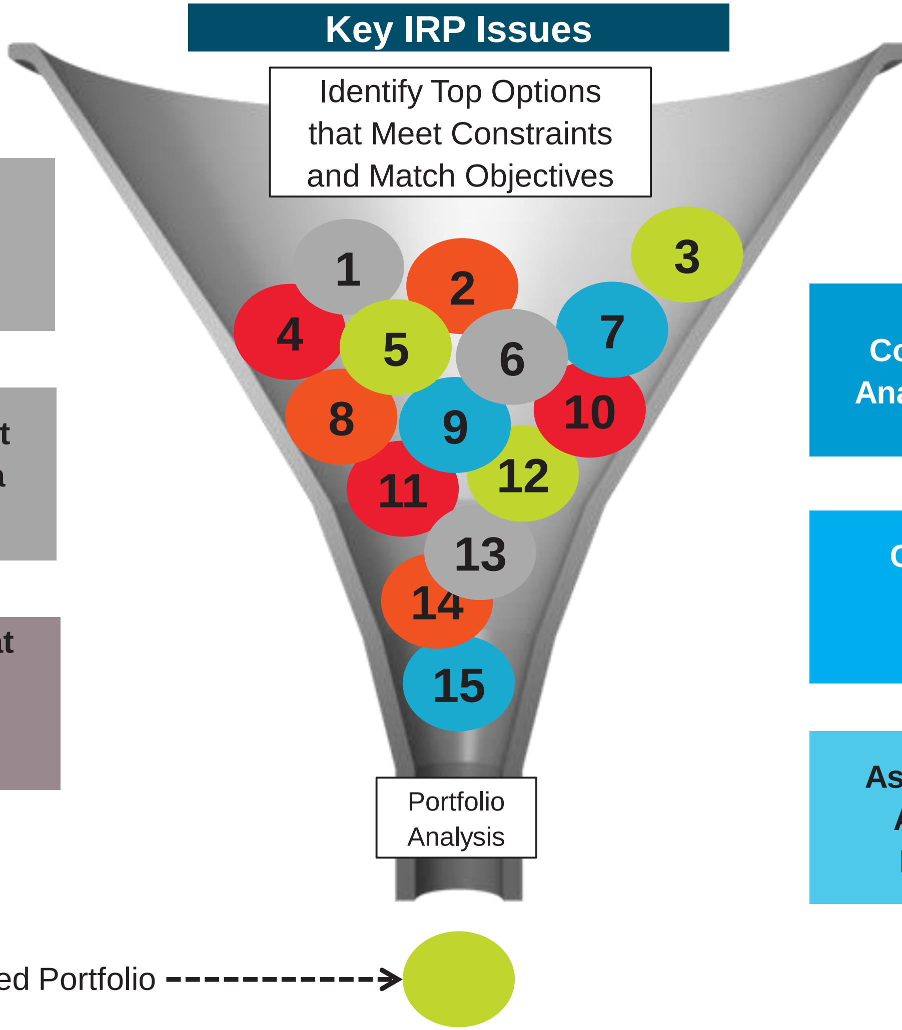
STRUCTURED SCREENING PROCESS TO ADDRESS ISSUES EFFICIENTLY

Task

Identify Portfolios (15)

Eliminate Portfolios that do not meet key criteria (10 remain)

Eliminate Portfolios that Exhibit Poorer Performance (4 remain)



Select Preferred Portfolio

Approach

Conduct Deterministic Analysis of 15 portfolios

Conduct Stochastic Analysis (200 iterations)

Assess Most Important Attributes to Select Preferred Portfolio

SENSITIVITIES WERE CONDUCTED TO FURTHER UNDERSTAND AND REFINE THE PORTFOLIOS

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- Each portfolio was optimized on a seasonal peak demand construct to ensure resource adequacy as peak capacity credit declines for renewables. All portfolios had sufficient seasonal resources
- Solar costs were increased 30% to determine continued economic selection and were found to be economic
- Sensitivities on the Reference Case by replacing the only CT capacity with battery storage:
  - Replacing the CT with battery storage increased portfolio costs by $51 million
  - CT provided long-duration capacity vs. 4 hour limit with battery storage

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SENSITIVITY: NPV COST OF PORTFOLIOS DISPATCHED IN ALTERNATIVE SCENARIOS

20-Year Net Present Value - Percentage of Reference Case

	Reference Case	Low Regulation	High Technology	80% Reduction of CO2 by 2050	High Regulation
Reference Case	100.0%	100.0%	100.0%	100.0%	100.0%
Business as Usual to 2039	119.7%	101.2%	120.7%	117.1%	112.5%
Business as Usual to 2029	108.0%	100.9%	108.5%	106.4%	104.8%
ABB1 Conversion + Small CCGT	112.6%	112.6%	111.5%	111.2%	107.4%
ABB1 Conversion	103.9%	104.5%	104.5%	103.9%	102.0%
ABB1 + ABB2 Conversions	110.0%	110.0%	110.1%	109.9%	105.5%
Diverse Small CCGT	105.3%	105.3%	104.2%	103.5%	102.7%
Renewables + Flexible Gas	98.4%	101.4%	98.2%	98.1%	97.7%
All Renewables by 2030	101.4%	108.2%	105.0%	100.5%	94.3%
Preferred Portfolio	102.3%	102.6%	101.3%	102.1%	102.2%

Alternative Scenario Changes vs. Ref Case

Scenario	Load	CO2 Prices	Gas Prices	Coal Prices	RE Cost
Low Reg	Higher	N/A	Higher	Ref	Ref
High Tech	Higher	Lower	Lower	Lower	Lower
80%	Lower	Ref	Ref	Lower	Lower
High Reg	Ref	Higher	Very High	Lower	Lower

STRUCTURED SCREENING PROCESS TO ADDRESS ISSUES EFFICIENTLY

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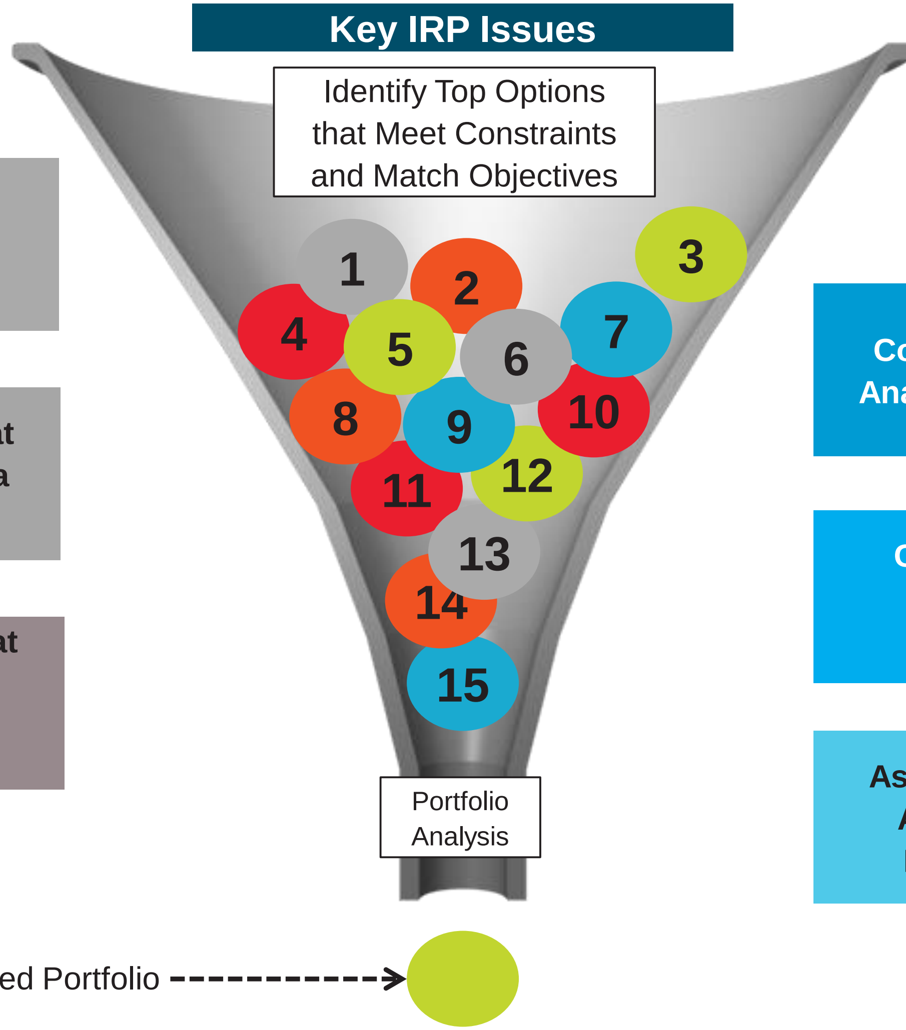
Task

Identify Portfolios (15)

Eliminate Portfolios that do not meet key criteria (10 remain)

Eliminate Portfolios that Exhibit Poorer Performance (4 remain)



Select Preferred Portfolio

Approach

Conduct Deterministic Analysis of 15 portfolios

Conduct Stochastic Analysis (200 iterations)

Assess Most Important Attributes to Select Preferred Portfolio

BALANCED SCORECARD RESULTS OF PROBABILISTIC ANALYSIS

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- Each portfolio was then dispatched 200 times under varying market conditions, with results populating a Balanced Scorecard (green=better scoring).

Balanced Scorecard	Stochastic Mean 20-Year NPVRR	95th Percentile Value of NPVRR	% Reduction of CO2e (2019-2039)	Energy Purchases as a % of Generation	Energy Sales as a % of Generation	Capacity Purchases as a % of Peak Demand	Capacity Sales as a % of Peak Demand
Reference Case	$2,536	$2,919	58.1%	16.8%	26.8%	9.7%	1.2%
Business as Usual to 2039	$2,912	$3,307	35.2%	12.0%	36.5%	0.1%	11.1%
Business as Usual to 2029	$2,689	$3,090	61.9%	15.2%	31.4%	7.1%	4.3%
ABB1 Conversion + Small CCGT	$2,872	$3,268	47.9%	6.6%	31.8%	1.3%	10.1%
ABB1 Conversion	$2,675	$3,045	61.5%	19.2%	26.4%	9.3%	1.2%
ABB1 + ABB2 Conversions	$2,834	$3,212	61.5%	18.5%	27.5%	4.0%	5.6%
Diverse Small CCGT	$2,680	$3,071	47.9%	6.4%	31.1%	1.7%	3.7%
Renewables + Flexible Gas	$2,526	$2,926	77.4%	21.5%	27.7%	9.4%	1.2%
All Renewables by 2030	$2,613	$3,002	79.3%	26.1%	31.9%	11.9%	1.7%
High Technology (Preferred Portfolio)	$2,590	$2,978	59.8%	16.7%	26.9%	0.4%	4.6%

- Several portfolios (marked in red) were not considered further due to high cost, high price risk, over-reliance on the market for sales and associated revenues, or over-exposure to market purchases and associated costs.

REMAINING OPTIONS A BETTER OPTION FOR CUSTOMERS THAN CONTINUING COAL OR CONVERSION

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Continuing use of the Brown units with Coal or Bridge options (Conversion) did not perform well in our analysis.

- Less Affordable – BAU and Conversion options cost customers more over the twenty year period than 4 remaining portfolios in all scenarios.
  - Higher O&M –requires more people to operate
  - Higher on-going capital expenditures to keep the units running
  - Less flexibility to capture benefits of the market
- Continuing to utilize coal has a higher initial capital investment than remaining options. Conversion has slightly less upfront capital investment. Due to On-going capital expenditures to keep these options running, the remaining book life of these assets do not fully depreciate
- Less Flexible – slow start time (8-24 hrs.) and slow ramp rate (2-3 MW/Min) do not position us well to support our customers in a future with high solar penetration
- Less Reliable – converted units continue to utilize old equipment that is prone to break down more than new equipment
- Less efficient – conversion is of units designed to burn coal has a worse heat rate (11,200) than modern combustion turbines. New CTs (9,900) have a better heat rate than existing Brown coal units (10,500) and existing peaking units (12,200)

OPTIMIZED PORTFOLIO BUILDOUTS & RETIREMENTS

Year	Reference Case	Renewables + Flexible Gas	Renewables 2030	High Technology
2021-23	1.25% Energy Efficiency	1.25% Energy Efficiency	1.25% Energy Efficiency	1.25% Energy Efficiency
2022	New Wind (300 MW)	New Wind (300 MW)	New Wind (300 MW)	New Wind (300 MW)
2023	New Solar (731 MW), New Storage (126 MW)	New Solar (731 MW) New Storage (126 MW)	New Solar (731 MW) New Storage (278 MW)	New Solar (731 MW) New Storage (126 MW)
2023	Retire ABB1, ABB2, FBC2, Exit Warrick (730 MW)	Retire ABB1, ABB2, FBC2, Exit Warrick (730 MW)	Retire ABB1, ABB2, FBC2, Exit Warrick (730 MW)	Retire ABB1, ABB2, FBC2, Exit Warrick (730 MW)
2024	New Combustion Turbine (236 MW)	New Combustion Turbine (236 MW)	-	New Combustion Turbine (236 MW)
2024	New Solar (415 MW) and Demand Response	New Solar (415 MW) and Demand Response	New Solar (415 MW) and Demand Response	New Solar (415 MW) and Demand Response
2024-26	0.75% Energy Efficiency	0.75% Energy Efficiency	1.00% Energy Efficiency	0.75% Energy Efficiency
2025		-	-	New Combustion Turbine (236 MW)
2027-39	0.75% Energy Efficiency	0.75% Energy Efficiency	1.00% Energy Efficiency	0.75% Energy Efficiency
2029-32	-	-	Retire FBC3, ABB3, ABB4 (427 MW), New Storage (360 MW), Solar (700 MW)	-
2033-39	New Solar (250 MW)	Retire FBC3 (270 MW), New Combustion Turbine (236 MW)	New Solar (450 MW)	New Storage (50 MW)
2024-39	Average Annual Capacity Market Purchases (137 MW)	Average Annual Capacity Market Purchases (135 MW)	Average Annual Capacity Market Purchases (170 MW)	Average Annual Capacity Market Purchases (4 MW)

BALANCED SCORECARD RESULTS OF PROBABILISTIC ANALYSIS

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The four remaining portfolios were evaluated under a range of factors including metrics and other factors.

Balanced Scorecard	Stochastic Mean 20-Year NPVRR	95th Percentile Value of NPVRR	% Reduction of CO2e (2019-2039)	Energy Purchases as a % of Generation	Energy Sales as a % of Generation	Capacity Purchases as a % of Peak Demand	Capacity Sales as a % of Peak Demand
Reference Case	$2,536	$2,919	58.1%	16.8%	26.8%	9.7%	1.2%
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All Renewables by 2030	$2,613	$3,002	79.3%	26.1%	31.9%	11.9%	1.7%
High Technology (Preferred Portfolio)	$2,590	$2,978	59.8%	16.7%	26.9%	0.4%	4.6%

The High Technology portfolio performed well across all factors in the balanced scorecard and was selected as the preferred portfolio. It hedges risk well against the energy and capacity markets relative to the remaining portfolios and maintains the flexibility.

- The reference case has a long term reliance on the capacity market, is less reliable (1 CT vs 2), less able to ramp in high renewables penetration environment, and provides less flexibility in the future
- The principal difference between the renewables + flexible gas portfolio and the preferred portfolio was a heavy reliance on market capacity purchases and the retirement date of Culley 3. Would lose $50M in construction efficiencies on building the 2nd CT (not reflected in NPVRR)
- The all renewables portfolio by 2030 would require an additional $20-30M in reliability upgrades (not reflected in NPVRR), relies heavily on emerging technology, and is very exposed to the capacity and energy markets

QUALITATIVE CONSIDERATIONS: THE PREFERRED PORTFOLIO IS A GOOD OPTION FOR CUSTOMERS

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The preferred portfolio offers a transition pathway away from coal while providing the optionality to adapt to future technology and market changes. This diverse set of resources offers customers the benefit of clean renewable energy, with the reliability required by our customers.

- Two highly dispatchable combustion turbines (460 MW) allow for a high penetration of renewables, ensuring reliability and hedges against the energy and capacity markets
  - Assurance of reliable service. Thermal resources are still needed to maintain reliable service in multiday periods of cloud cover and no wind
  - Two CTs provide better support than one. Better coverage should a unit go down to provide a hedge against high energy prices and provide system support when issues arise
  - Two CTs keeps existing interconnection rights, which shields customers from potential transmission upgrade costs in the future should Vectren have to re-enter the MISO Queue (a three year process)
  - Two CTs provide fast start (10 min) & more fast ramping capability (80 MW/minute vs 40 MW/minute) to support for intermittent solar and allows for a smooth transition into a renewables future locally and regionally as the MISO system adapts to higher levels of renewables across the system
  - Two CTs replace required capacity and shields customers from potential future high capacity prices in the MISO market
  - Two CTs built at the same time provide $50M in construction cost savings vs. a 10 year delay of the 2nd CT (Renewables + Flexible Gas Portfolio – not reflected in NPVRR)
  - Two CTs provide a high degree of flexibility in the future

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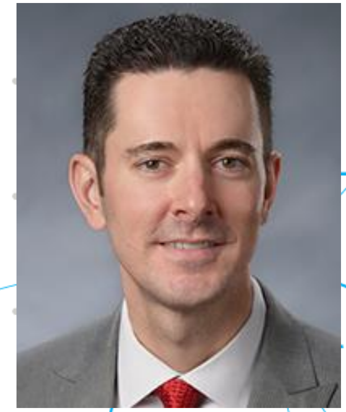
NEXT STEPS

JUSTIN JOINER

VECTREN DIRECTOR OF
POWER SUPPLY SERVICES



CONTINUE MONITORING EXTERNAL DEVELOPMENTS AND FACTORS

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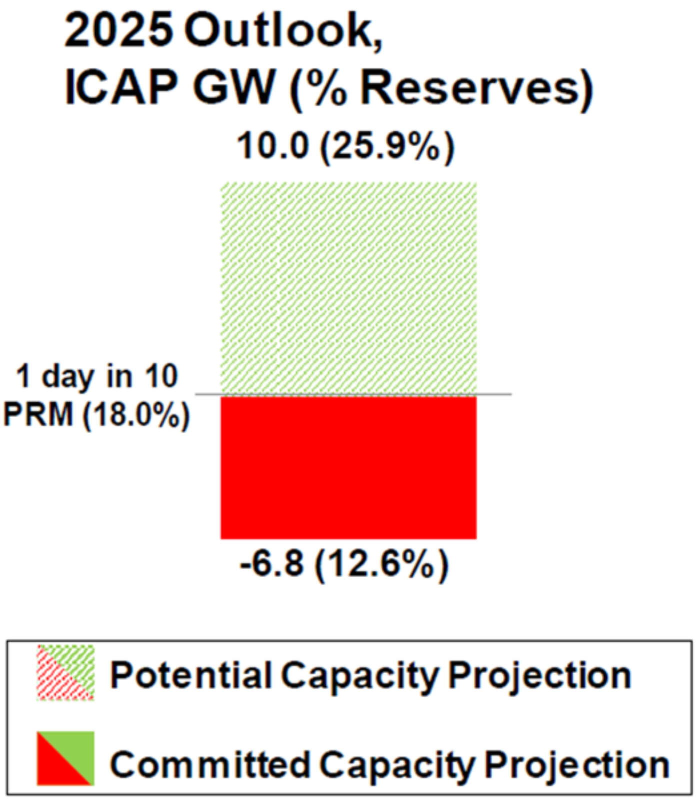
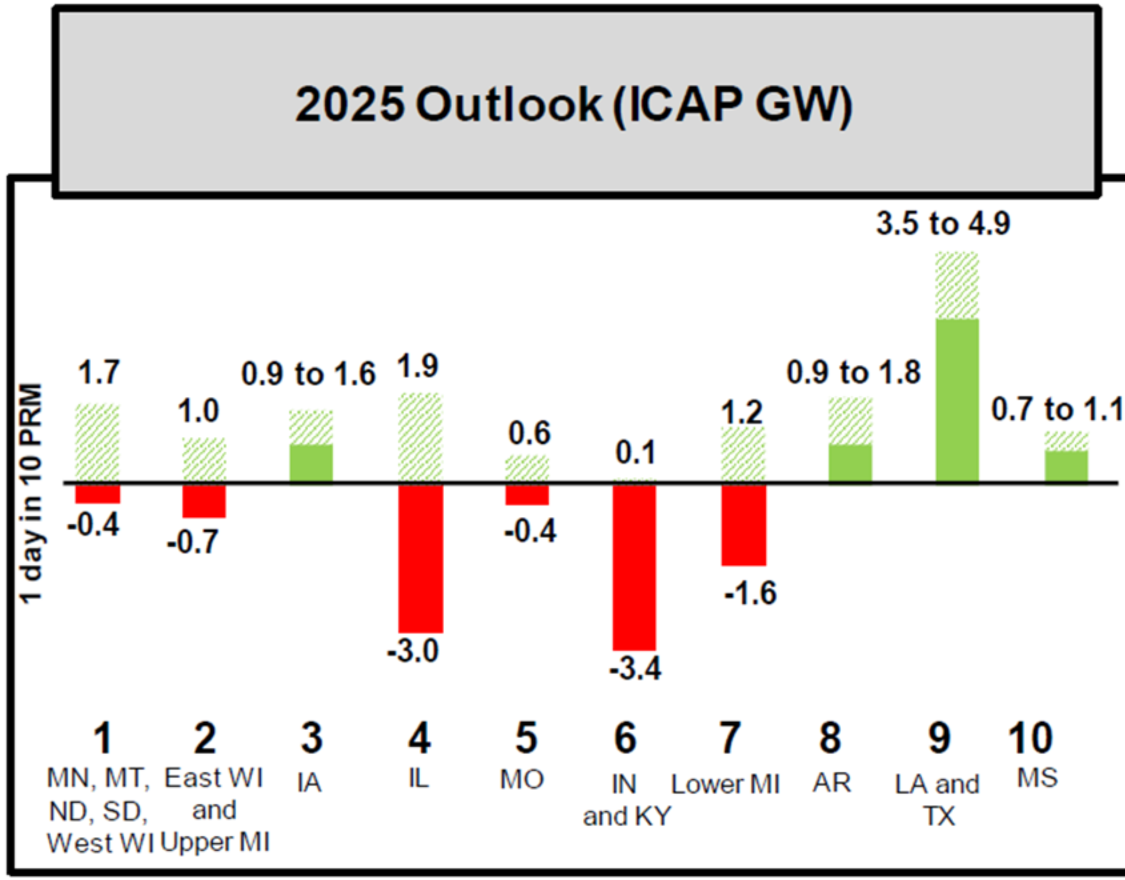
Will continue to evaluate the paradigm shift underway in the industry towards renewables, while the Preferred Portfolio provides needed flexibility, reliability, diversity and affordability that is needed to accommodate

- **Customer**
  - Demand for clean energy and emerging technology
  - ESG goals and requirements
- **State of Indiana**
  - Announced and recently completed generation retirements
  - Legislative taskforce
  - Economic development
- **MISO**
  - Resource adequacy now and in the future
  - Wholesale energy market construct now and in the future
  - Transmission system configuration ability to meet needs now and in the future

2020 OMS-MISO SURVEY RESULTS

Latest Resource Adequacy results demonstrate the generation shift underway MISO-wide and that is carried out through unit retirements and new generation builds, thus producing less certainty in future years around available capacity





*Per June MISO presentation of 2020 OMS-MISO Survey results

- Regional surpluses and potential resources will be critical for all zones to serve their deficits while meeting local requirements
- Positions include reported inter-zonal transfers, but do not reflect other possible transfers between zones
- Exports from Zones 8, 9, and 10 were limited by the Sub-regional Power Balance Constraint

NEXT STEPS

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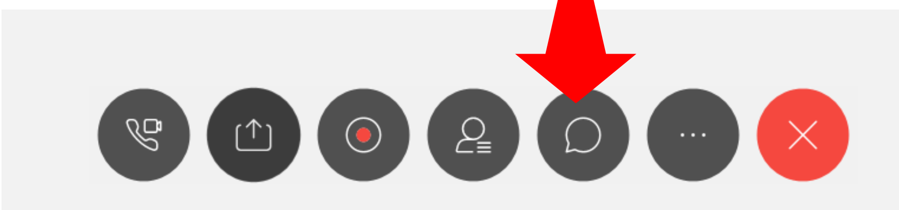
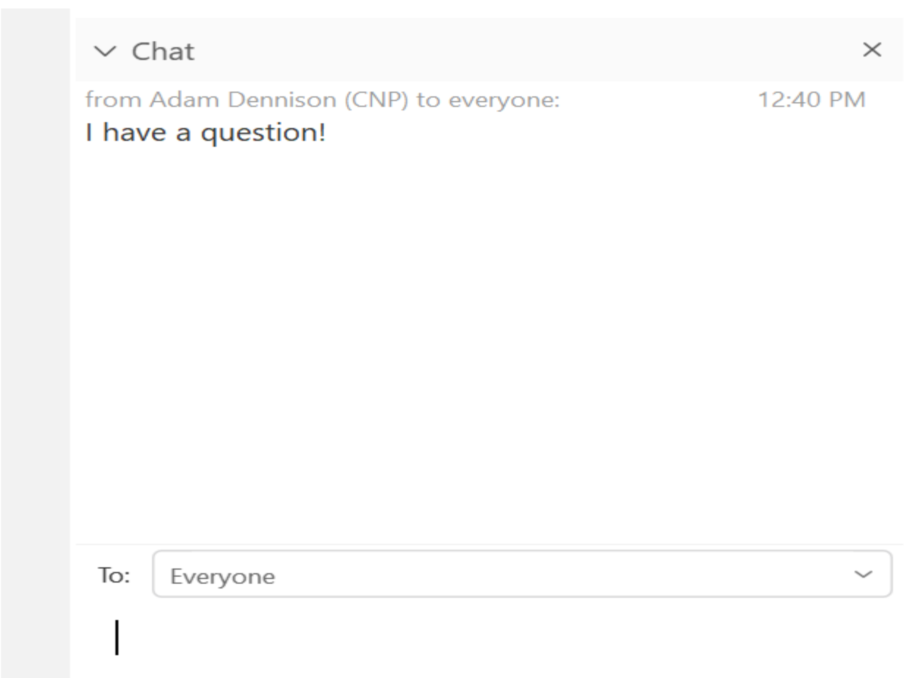
To maximize the $320M in customer savings that the Preferred Portfolio presents, an action plan is in place that is focused on two phases

- **Near-term: next 6 months**
  - Enter into agreements with the most attractive projects received from 2019 All-Source RFP
    - To maximize tax credits for our customers, projects must be under-construction/in-service soon
  - Conduct a second RFP in the Fall to address remaining renewable needs identified in IRP
  - Continue monitoring state developments; Statewide Resource Plan, Legislative Taskforce, COVID-19
- **Mid-term: next 12 months**
  - File Certificate of Public Convenience and Necessity (CPCN) in 2021
  - Begin permitting, civil engineering and preliminary site work for Combustion Turbines
    - Multi-year process
  - Continue advancement and refinement of renewable energy expertise
    - Work with developers to understand project attributes and ensure quality control and price certainty
    - Evaluate pricing of battery and determine appropriate timing install
    - Apply insights gained to future projects

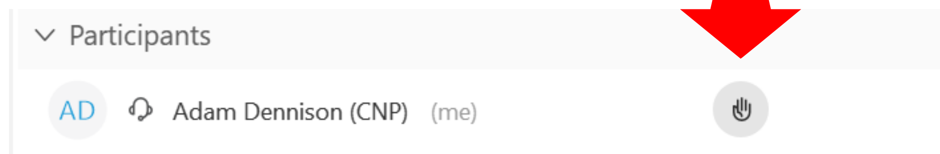
Q&A

Ask “everyone” in chat.

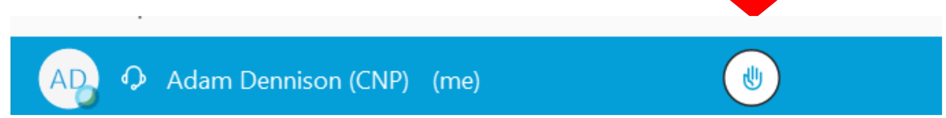




Raise Hand for a Follow-up



After question has been answered, lower hand



STAKEHOLDER COMMENT PERIOD

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Speakers who have signed up ahead of the meeting will be allotted time to verbally provide comments (consider designating a speaker for each organization). Please type, I would like to make a comment in chat if you did not sign up early. We will accommodate as many requests as possible. Please pay attention to the on-screen prompts in order to allow for as many comments as possible.

One Minute

Two Minutes

Next Speaker

APPENDIX

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OPTIMIZED PORTFOLIO BUILDOUTS & RETIREMENTS

Year	Reference Case	Business as Usual to 2039	Business as Usual to 2029	Gas Conversion ABB1	Gas Conversion ABB1 + ABB2
2021-23	1.25% Energy Efficiency	1.25% Energy Efficiency	1.25% Energy Efficiency	1.25% Energy Efficiency	1.25% Energy Efficiency
2022	New Wind (300 MW)	New Wind (300 MW)	New Wind (300 MW)	New Wind (300 MW)	New Wind (300 MW)
2023	New Solar (731 MW), New Storage (126 MW)	New Solar (731 MW), New Storage (126 MW)	New Solar (731 MW), New Storage (126 MW)	New Solar (731 MW), New Storage (126 MW)	New Solar (731 MW), New Storage (126 MW)
2023	Retire ABB1, ABB2, FBC2, Exit Warrick (730 MW)	Scrubber control on ABB1 and ABB2, Exit Warrick (150 MW)	Exit Warrick (150 MW)	Retire ABB2, FBC2, Exit Warrick (485 MW)	Retire FBC2, Exit Warrick (240 MW)
2024	New Combustion Turbine (236 MW)	-	-	ABB1 Conversion (245 MW)	ABB1+ABB2 Conversions (490 MW)
2024	New Solar (415 MW) and Demand Response	New Solar (415 MW) and Demand Response	New Solar (415 MW) and Demand Response	New Solar (415 MW) and Demand Response	New Solar (415 MW) and Demand Response
2024-26	0.75% Energy Efficiency	0.75% Energy Efficiency	0.75% Energy Efficiency	0.75% Energy Efficiency	0.75% Energy Efficiency
2027-39	0.75% Energy Efficiency	0.25% Energy Efficiency	0.50% Energy Efficiency	0.75% Energy Efficiency	0.50% Energy Efficiency
2029-30	-	-	Retire ABB1, ABB2, FBC2 (580 MW), New Combustion Turbine (236 MW)	-	-
2033-34	-	-	-	Retire ABB1, New Combustion Turbine (279 MW)	Retire ABB1+ABB2, New Combustion Turbine (279 MW)
2037-39	New Solar (250 MW)	-	-	-	-
2024-39	Avg Annual Capacity Mkt Purchases (137 MW)	No Capacity Market Purchases	Avg Annual Capacity Mkt Purchases (101 MW)	Avg Annual Capacity Mkt Purchases (133 MW)	Avg Annual Capacity Mkt Purchases (56 MW)

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OPTIMIZED PORTFOLIO BUILDOUTS & RETIREMENTS

Year	Gas Conversion ABB1 + CCGT	Diverse Small CCGT	Diverse Medium CCGT	Renewables + Flexible Gas	Renewables 2030
2021-23	1.25% Energy Efficiency	1.25% Energy Efficiency	1.25% Energy Efficiency	1.25% Energy Efficiency	1.25% Energy Efficiency
2022	New Wind (300 MW)	New Wind (300 MW)	New Wind (300 MW)	New Wind (300 MW)	New Wind (300 MW)
2023	New Solar (731 MW) New Storage (126 MW)	New Solar (731 MW) New Storage (126 MW)	New Solar (731 MW) New Storage (126 MW)	New Solar (731 MW) New Storage (126 MW)	New Solar (731 MW) New Storage (278 MW)
2023	Retire ABB2, FBC2, Exit Warrick (485 MW)	Retire ABB1, ABB2, FBC2, Exit Warrick (730 MW)	Retire ABB1, ABB2, FBC2, Exit Warrick (730 MW)	Retire ABB1, ABB2, FBC2, Exit Warrick (730 MW)	Retire ABB1, ABB2, FBC2, Exit Warrick (730 MW)
2024	ABB1 Conversion (245 MW)	-	-	New Combustion Turbine (236 MW)	-
2024	New Solar (415 MW) and Demand Response	New Solar (415 MW) and Demand Response	New Solar (415 MW) and Demand Response	New Solar (415 MW) and Demand Response	New Solar (415 MW) and Demand Response
2024-26	0.75% Energy Efficiency	0.75% Energy Efficiency	0.75% Energy Efficiency	1.00% Energy Efficiency	0.75% Energy Efficiency
2025	-	New Small CCGT (433 MW)	New Medium CCGT (497 MW)	-	-
2026	New Small CCGT (433 MW)	-	-	-	-
2024-26	0.50% Energy Efficiency	0.50% Energy Efficiency	0.25% Energy Efficiency	1.00% Energy Efficiency	0.75% Energy Efficiency
2029-32	-	-	-	-	Retire FBC3, ABB3, ABB4 (427 MW), New Storage (360 MW), Solar (700 MW)
2033-34	-	-	-	Retire FBC3 (270 MW), New Combustion Turbine (236 MW)	New Solar (450 MW)
2024-39	Avg Annual Capacity Mkt Purchases (16 MW)	Avg Annual Capacity Mkt Purchases (23 MW)	Avg Annual Capacity Mkt Purchases (18 MW)	Avg Annual Capacity Mkt Purchases (135 MW)	Avg Annual Capacity Mkt Purchases (170 MW)

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OPTIMIZED PORTFOLIO BUILDOUTS & RETIREMENTS

Year	HB 763	Low Regulatory	High Technology	80% Reduction of CO2 by 2050	High Regulatory
2021-23	1.25% Energy Efficiency	1.25% Energy Efficiency	1.25% Energy Efficiency	1.25% Energy Efficiency	1.25% Energy Efficiency
2022	New Wind (300 MW)	New Wind (300 MW)	New Wind (300 MW)	New Wind (300 MW)	New Wind (300 MW)
2023	New Solar (731 MW) New Storage (278 MW)	New Solar (731 MW) New Storage (278 MW)	New Solar (731 MW) New Storage (126 MW)	New Solar (731 MW) New Storage (202 MW)	New Solar (731 MW) New Storage (278 MW)
2023	Retire ABB1, ABB2, FBC2, Exit Warrick (730 MW)	Retire ABB1, ABB2, FBC2, Exit Warrick (730 MW)	Retire ABB1, ABB2, FBC2, Exit Warrick (730 MW)	Retire ABB1, ABB2, FBC2, Exit Warrick (730 MW)	Retire ABB1, ABB2, FBC2, Exit Warrick (730 MW)
2024	New Landfill Gas (27 MW)	New Combustion Turbine (279 MW)	New Combustion Turbine (236 MW)	-	-
2024	New Solar (415 MW) and Demand Response	New Solar (415 MW) and Demand Response	New Solar (415 MW) and Demand Response	New Solar (415 MW) and Demand Response	New Solar (415 MW) and Demand Response
2024-26	1.50% Energy Efficiency	1.25% Energy Efficiency	0.75% Energy Efficiency	0.75% Energy Efficiency	1.25% Energy Efficiency
2025	New Solar (550 MW) New Wind (650 MW) New Storage (50 MW)	-	New Combustion Turbine (236 MW)	-	New Solar (550 MW) New Wind (650 MW) New Storage (50 MW)
2026-39	New Solar (1,100 MW) New Wind (2,500 MW) New Storage (220 MW)	New Solar (1,000 MW) New Wind (2,400 MW)	-	-	New Solar (1,260 MW) New Wind (2,650 MW) New Storage (290 MW)
2027-39	1.25% Energy Efficiency	1.00% Energy Efficiency	0.75% Energy Efficiency	0.5% Energy Efficiency	0.50% Energy Efficiency
2033-39	-	-	New Storage (50 MW)	New Solar (800 MW) New Wind (2,750 MW) New Storage (190 MW)	-
2024-39	Avg Annual Capacity Mkt Purchases (10 MW)	Avg Annual Capacity Mkt Purchases (12 MW)	Avg Annual Capacity Mkt Purchases (4 MW)	Avg Annual Capacity Mkt Purchases (203 MW)	Avg Annual Capacity Mkt Purchases (11 MW)

STAKEHOLDER FEEDBACK

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Request	Response
Will you please provide documents that lead you to believe that MISO is moving to a seasonal (sub-annual) construct?	Below are two examples: one from 2019 and the most recent https://cdn.misoenergy.org/20191106%20RASC%20Item%204b%20RAN%20Capacity%20Accreditation397077.pdf https://cdn.misoenergy.org/20200601%20RAN%20Workshop%20Item%2002%20PDP%20and%20RAN%20Overview449826.pdf
Will you consider modeling a larger hydro resource?	We plan to model the option for 2 - 50 MW projects, consistent with the tech assessment and reasonable assumptions for nearby dams.
Will you please provide the user manual for Aurora?	It is included in the read only copy of the model. Provided a work-around pdfs for help function material and put interested parties in touch with Aurora for access to on-line help function.
RFP provides price certainty for projects. I'm concerned that you are varying capital costs within stochastic modeling	We did not vary capital costs in the near term for stochastic modeling. It should be noted the on-going discussions with several bidders indicate higher prices than initially provided within bids.

CANDIDATE PORTFOLIOS FOR PROBABILISTIC ANALYSIS

Selected as Candidate

Not Selected

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Portfolio	Group	Portfolio	Reason
1	Reference	Reference Case	Serves as a baseline for other portfolios
2	BAU	BAU to 2039	Evaluate continued coal operation, capacity value
3		BAU to 2029	Evaluate limited coal operations, capacity value
4	Bridge	ABB1	Evaluate limited bridge option (1 conversion)
5		ABB1+ABB2	Evaluate performance of 2 conversions
6		ABB1+CCGT	Evaluate interaction with market, capacity value
7	Diverse	Diverse Small CCGT	Evaluate diverse mix, capacity value
8		Diverse Medium CCGT	Higher cost than small CCGT; no additional value
9	Renewables	Renewables+ Flexible Gas	Evaluate a mix of options, heavy with renewables
10		Renewable 2030	Evaluate a storage- and renewables-heavy portfolio
11		HB 763	Overbuilt with 6.2 GW renewables, high LMPs
12	Scenario-Based	Low Regulatory	Overbuilt with 4.8 GW renewables
13		High Technology (Preferred Portfolio	Evaluate performance of portfolio with 2 CTs
14		80% Reduction	Overbuilt with 5 GW renewables
15		High Regulatory	Overbuilt with 6.6 GW renewables, high LMPs

UNECONOMIC ASSET MEASURE CONSIDERED, BUT REMOVED FROM SCORECARD

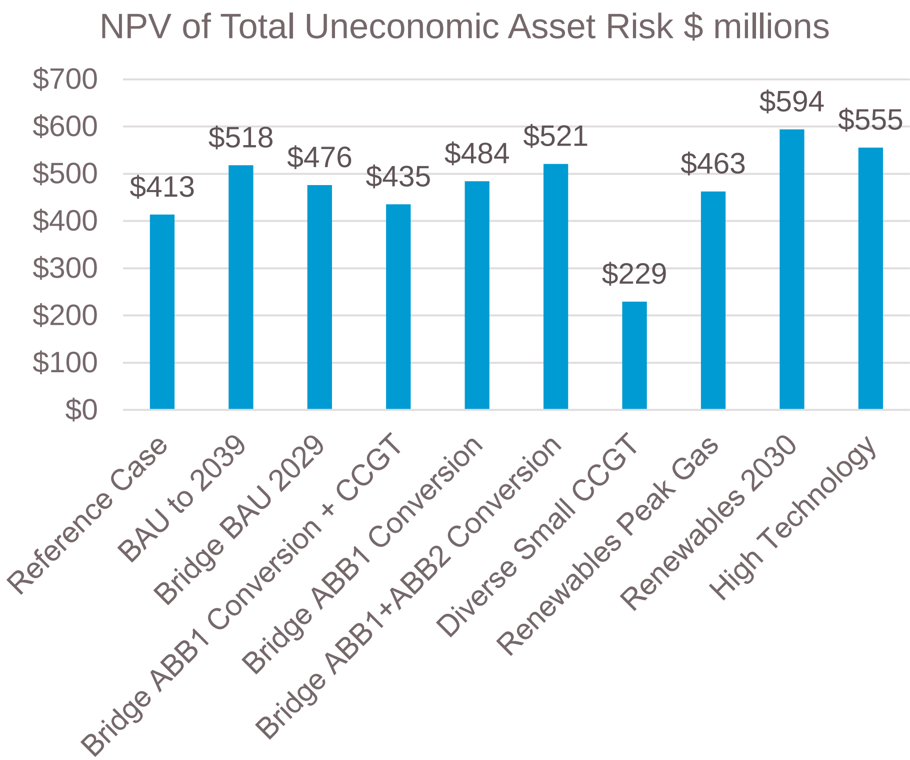
Following the recent order on the 2x1 CCGT, Vectren worked with Pace Global and the stakeholders, to develop the following approach to address the concern over recovering large capital investments:

- Determine in any iteration (scenario) when for three years in succession, revenues (capacity + energy) did not cover costs (fixed and variable).
- Then calculate remaining undepreciated costs plus future losses. This is the uneconomic cost for that iteration, which is multiplied by 1/200 to calculate the Expected Value of the uneconomic cost for the portfolio.

The results were not anticipated - Portfolios with plants with large energy revenues (coal and combined cycle) performed better than combustion turbines, even though they require a larger capital spend than CTs.

CTs were immediately considered potentially uneconomic assets. This occurred for 3 reasons:

1. CTs were a hedge against an illiquid capacity market – but capacity prices were not a stochastic variable
2. Capacity prices averaged about 50% of CONE. This is less than the cost to recover CT investment.
3. CTs have low CFs, which result in low energy revenues



Vectren 2019 IRP
4th Stakeholder Meeting Minutes Q&A
June 15, 2020, 1:00 p.m. – 3:30 p.m.

Lynnae Wilson (CenterPoint Energy Indiana Electric Chief Business Officer) – Welcome, Safety Message (Firework Safety Tips), and Vectren Introductions

> Subject Matter Experts in the Room: Matt Rice, Justin Joiner, Natalie Hedde, Bob Heidorn, Wayne Games, Angila Retherford, Jason Stephenson, Ryan Wilhelmus
>
> Subject Matter Experts Participating Via Webex: Ryan Abshier, Rina Harris, Shane Bradford, Angie Casbon-Scheller, Tom Bailey, Steve Rawlinson, Chris Leslie, Heather Watts, Cas Swiz, Matt Lind, and Gary Vicinus

Stakeholders: Approximately 180 stakeholders registered to participate in the Webex meeting. List of affiliations include the following:

ACES	First Solar	NextEra Energy Resources
Advanced Energy Economy	GE Gas Power	NIPSCO
AECOM	GSG Communications LLC	Origis Energy
AEP	Hallador Energy	Orion Renewable Energy Group
AES/IPL	Hoosier Energy	Ranger Power
Air Quality Services	I&M	Repower IN and Solarize Evansville
Alcoa Corp	IBEW Local 702	Shell Energy
Arevon Energy Management	Indeck Energy Services, Inc.	Sierra Club
AstraZeneca Pharmaceuticals	Indiana Coal Council	Solarize Indiana Inc
Boardwalk Pipelines	Indiana Office of Utility Consumer Counselor	Solarpack Development, Inc.
Bowen Engineering	Indiana DG	Southern Illinois Generation Company
Citizens Action Coalition of IN	Indivisible Evansville	Southwest Indiana Chamber of Commerce
City of Evansville	Inovateus Solar LLC	St. Joseph Phase II, LLC
Community Energy	Invenergy	State Utility Forecasting Group
CountryMark	IURC	Valley Watch
Earthjustice	juwi Inc.	Vectren Industrial Group
Economic Development Coalition of Southwest Indiana	MEEA	Vermillion Rise Mega Park
Energy Futures Group	Midwest Fertilizer	Vote Solar
Energy Ventures Analysis Inc	Morton Solar	Whole Sun Designs
ENGIE Solar	New Master Development LLC	[redacted]

Presentation Summary:

Lynnae Wilson (CenterPoint Energy Indiana Electric Chief Business Officer) **/ Matt Rice** (Vectren Manager of Resource Planning) Meeting Guidelines, Agenda, IRP Stakeholder Process, and the presenting of the Preferred Portfolio

Peter Hubbard (Manager of Energy Business Advisory, Pace Global) Risk Analysis Process and Results

Justin Joiner (Vectren Director of Power Supply Services) Future Considerations, MISO OMS Survey Results, and Next Steps

Lynnae Wilson (CenterPoint Energy Indiana Electric Chief Business Officer) Closing Comments

Stakeholder Q&A:

Question:
Wendy Bredhold: When do you plan to share the slides?
Jean Webb: I'd like to have it now to print out and mark up.
Suzanne Escudier: Will the PPT be available after the meeting?
Wendy Bredhold: Can you post slides now since we are done?
Answer:
The slides will be posted today at www.vectren.com\irp at 3:30 Central.

Question:
Wendy Bredhold: Are you building that wind in 2022?
Answer:
We will continue to evaluate this resource, and there could be a second RFP(timing is yet to be determined).

Question:
John Blair: Are you planning ownership or PPA for both wind and solar? If so, are you also prepared to use your power of eminent domain to secure the necessary sites for both? Last are you considering using useless, non-productive stripper pits as sites for your solar plants?
Answer:
Eminent domain would be a last resort.
Answer to Second Question:
We are looking at all of the above. We are looking at all of the land around us trying to determine the best plan forward.

Question:
Mike Mullett: Please define "universal solar" in relation to transmission-connected vs. distribution-connected solar and/or above/below 10 mw facilities.
Answer:
Universal solar is utility scale solar, which is the most cost-effective option for our customers. Customer owned solar connected to the distribution system was accounted for in our load forecast as a load reduction, reducing the resources needed to serve our customers. That forecast is included in a report at www.Vectren.com\irp, titled 2019 Long Term Electric Energy and Demand Forecast Report.
https://www.vectren.com/assets/downloads/planning/irp/IRP-2019-Vectren-Sales-and-Demand-Forecast-Documentation.pdf

Question:
Wendy Bredhold: What is the retirement date for Culley 3 in this plan?
Answer:
The preferred portfolio continues to run Culley 3 throughout the forecast, but that can be determined at a later date.

Question:
Laura Arnold: Are there any phone numbers available for someone to call who is experiencing Internet difficulties?
Answer:
Phone number: 1-415-655-0003, access code: 1332773493

Question:
Emily Medine: What is assumed about MISO dispatchability of wind and solar?
Answer:
For solar it was assumed capacity factor would be around 24% and 38% for wind.

Question:
Emily Medine: No. MISO's right to dispatch
Answer:
We use MISO's current practices and provide a forecast and then MISO dispatches our units based on that forecast.

Question:
Mike Mullett: Please comment on the Forum Energy - Great River Energy Agreement re very long duration storage -- see, e.g. , https://www.greentechmedia.com/articles/read/form-energys-first-project-pushes-long-duration-storage-to-new-heights-150-hour-duration
Answer:
We will review this after the meeting. We did model 8-hour flow batteries but they were not cost effective, thus not selected.

Question:
Mike Mullett: Please comment on the Vectren Electric capex requirements for the Preferred Portfolio, especially regarding BAU and other portfolios evaluated.
Answer:
There aren't any capital requirements for the preferred portfolio but all paths forward cost money, including BAU which would require a large investment. We don't know what capital spend will be at this point because we haven't determined how much solar and wind will be PPA vs. an ownership option.

Question:
Michael Smith: With renewables and DR increasing to 64% of portfolio, what percentage of that 64% renewables will be Vectren-owned resources or will the energy be procured through 3rd party PPAs?
Answer:
This is yet to be determined.

Question:
John Haselden: Will the gas pipeline to the CT's be sized for additional future resources?

Answer:
This is yet to be determined.

Question:
Suzanne Escudier: Can you type in the website where we can find the presentation after the meeting?
Answer:
www.vectren.com\irp. At this site you will also find all materials from past meetings. The deck will be posted today at 3:30 p.m.

Question:
Jean Webb: So, the reason for not selecting the renewables by 2030 portfolio is because of your limits on market sales/purchases? How much is now purchased from market as a reference.
Answer:
This portfolio had a heavy reliance on the market for both capacity and energy and we felt that the preferred portfolio performed better overall. This portfolio also relies heavily on battery storage which is an emerging technology. It also requires an additional $20-$30 million in transmission system upgrades. With renewables it is important to have dispatchable resources to back them up when not available. [In 2019, Vectren purchased approximately 9% of its need as a percentage of generation].

Question:
Jean Webb: Will the current wind contracts be renewed? Benton and Fowler Ridge.
Answer:
We will look at all resource available in the RFP. Also, these contracts don't expire for several more years (late 2020's).

Question:
John Blair: What are your current plans for Warrick 4?
Answer:
We currently plan to exit joint operation of Warrick 4 in 2023.

Question:
Mary Lyn Stoll: As noted in the presentation, technology and renewable energy markets are in a period of rapid growth and transition. Given how quickly these changes occur, does Vectren have a formal policy in place to continue to actively review the latest updates and changes to quickly determine whether and when a higher proportion of renewables would become the best option given Vectren's goals?
Answer:
This IRP is a first step in this process, and the analysis will be performed again in 2022.

Question:
Anna Sommer: Where do you stand with respect to negotiations with respondents to the RFP? Are you planning to acquire these planned new resources from those respondents and the question is whether those acquisitions are PPA or asset transfers? Or is there some other resource acquisition process anticipated?
Answer:
We've been in communication with respondents to gain more clarity on the status of the projects. We are still working to determine what projects will be PPA and which will be utility owned. A second RFP would be the other resource acquisition process at this point.

Question:
Crystal Young: Is there any plan for electric vehicle infrastructure buildout?
Answer:
We are actively investigating this enterprise wide to determine our best steps forward for both the Houston area, as well as southern Indiana. We did include an EV forecast as an addition to load so we've thought through what the need would be from a generation standpoint.

Question:
Mike Mullett: How is OVEC contract being modeled, and for how long in the Preferred Portfolio?
Answer:
OVEC was modeled as a PPA and is included as a resource in the preferred portfolio throughout the forecast.

Question:
Michael Smith: Assuming the 2 each, GTs (460MW) are simple cycle and not a 2 x 1 CCGT with HRSTG boiler and steam turbine for waste heat?
Answer:
Correct. These are 2 simple cycle gas turbines.

Question:
Sadie Holzmeyer: Since it is currently financially beneficial for business and homeowners to invest in their own solar panels to not only sustain their own energy needs by generating their own renewable energy independent from Vectren's energy production, but also save money into the future, could Vectren not consider something like incorporating rooftop solar to supplement their renewable energy demands?
Answer:
We modeled universal solar because it is the most cost-effective solution for our customers.

Question:
Jean Webb: I had asked about modeling expanding net-metering so that rooftop solar expanded, and therefore less capacity would need to be built. Was that done?
Answer:
We modeled about 84 MW's of installed capacity from rooftop solar as a reduction to our load. There was not a portfolio where we modeled leasing space on customer roofs to install solar. There is a lot of cost and legal issues with this approach. Large scale solar is more efficient; plus, we would not get capacity credit from MISO with rooftop solar.

Question:
Mike Mullett: When will next all-source RFP be conducted? Will there be stakeholder engagement on the terms and conditions of that RFP?
Answer:
The RFP in the fall would not be all-source. The next all-source would potentially be for the next IRP but we've found there are many difficulties with this process. The long time frame makes it difficult for developers to hold their projects and pricing plus many projects are picked up by other groups while the IRP analysis is being performed.

Question:
Niles Rosenquist: On an annual basis, how much of the power production did you show earlier is projected to be from the gas turbines?

Answer:
Matt Rice reviewed the generation graph on slide 19 showing a small amount of generation from combustion turbines.

Question:
Anna Sommer: When does Vectren anticipate coming in for regulatory approvals for these new resources? And what steps remain before that happens?
Answer:
We are working on evaluating the best time to make our submissions, but it will likely be done over a period of time. We will likely start with some of the renewable resources we need later this year and the gas CT's will likely be in 2021.

Question:
Jean Webb: What years will the gas plants open?
Answer:
We are projecting they will be in service in the 2024-2025 planning year.

Question:
Jean Webb: Where will they be built?
Answer:
This is yet to be determined, but the A.B. Brown site offers many benefits including close proximity to the 345 KV transmission line, existing equipment that can be utilized by the CT's, as well as existing interconnection rights.

Question:
Jean Webb: Update on coal ash ponds there?
Answer:
We have contracts in place to recycle the ash from the Brown ash pond for use in a concrete application. We would anticipate filing our application with IDEM for approval probably in 2021. The west pond at Culley is almost complete and should be complete later this year. We are currently evaluating the east pond at Culley to determine how we will close it.

Question:
Pam Locker: Can you remind me of the expected cost of the natural gas plant?
Answer:
Two CT's are around $300-$320 million. We will have a better idea after the equipment is sent out for bids.

Question:
Jean Webb: Does that cost include the gas lines our will that go on our bills as a rider?
Answer:
If a pipeline is needed then yes, it would be part of customer rates. We won't know exact cost until we determine where the CT's will be built. [Pipeline cost estimates were included in the modeling as a firm gas service.]

Question:
Wendy Bredhold: How do you justify to continue to run Culley 3 when it isn't a least cost option?
Answer:
When we looked at Culley 3 in 2016 there was a little bit of premium to run that unit but we received approval to upgrade the plant and plan to implement those upgrades for diversity of our fleet.

Stakeholder Feedback:

Mike Mullett: Thank you for a very informative and interactive presentation, especially given the virtual nature of the meeting. For me, at least, the internet quality was very high, both in terms of the slides and the audio. The use of the Chat for Q&A was also very helpful.

Pam Locker: Thank you for increasing the percentage of renewable resources.

Attachment 4.1 2019 Vectren Long-Term Electric Energy and Demand Forecast Report

CenterPoint Energy
Cause No. 45501
Petitioner's Exhibit 4
MAR WP1 (Public)

Itron
Knowledge to Shape Your Future

Electric | Gas | Water
information collection, analysis and application

2019 Long-Term Electric Energy and Demand Forecast Report

Vectren

Submitted to:

Vectren, a CenterPoint Energy Company
Evansville, Indiana

Submitted by:

Itron, Inc.
20 Park Plaza
Suite 428
Boston, Massachusetts 02116
(617) 423-7660

Itron

October 2019

Contents

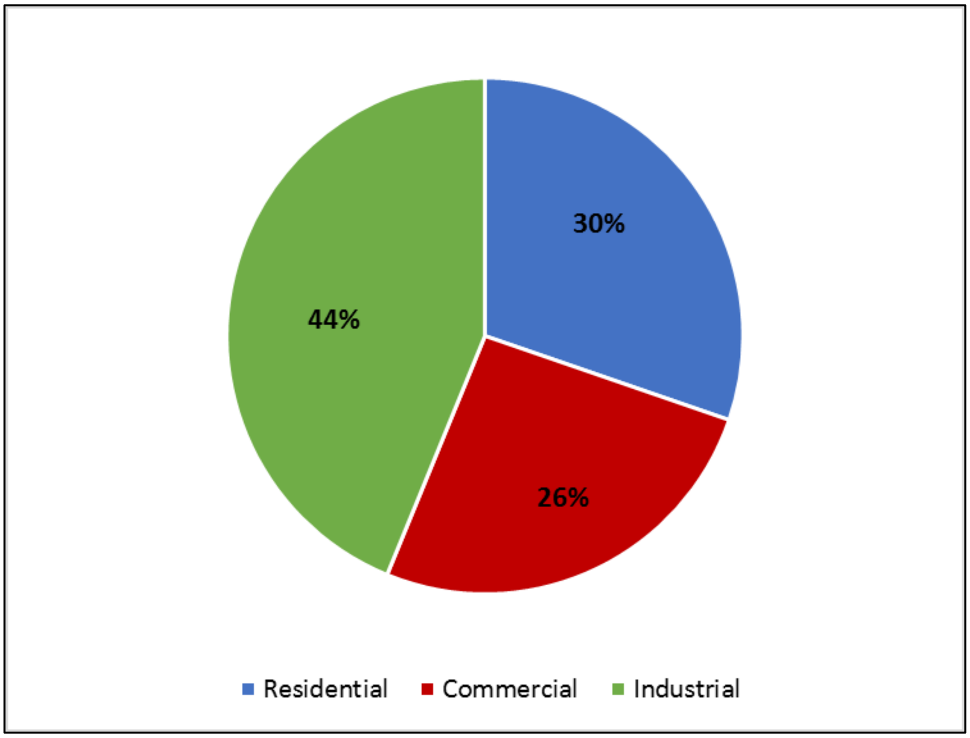
1 Overview

Itron, Inc. was contracted by Vectren to develop a long-term load forecast to support the 2019/20 Integrated Resource Plan. The energy and demand forecasts extend through 2039. It is based on a bottom-up approach that starts with residential, commercial, and industrial load forecasts that then drive system energy and peak demand. In addition, the forecast includes developing long-term behind-the-meter solar and electric vehicle load forecasts. This report presents the results, assumptions, and overview of the forecast methodology.

1.1 VECTREN Service Area

Vectren serves approximately 146,000 electric customers in Southwest Indiana; Evansville is the largest city within the service area. The service area includes a large industrial base with industrial customers accounting for approximately 44% of sales in 2018. The residential class accounts for 30% of sales with approximately 128,000 customers and the commercial class 26% of sales; there are approximately 18,000 nonresidential customers. System 2018 energy requirements are 5,308 GWh with non-weather normalized system peak reaching 1,039.2 MW. Figure 1 shows 2018 class-level sales distribution.

Figure 1: 2018 Annual Sales Breakdown



Despite relatively weak economic growth, since 2010, customer growth has been modest with residential customer growth averaging 0.5% and commercial customer growth 0.3%. GDP has averaged 1.2% growth until recently with 2018 GDP increasing to 3.9% and an expected 3.6% increase in 2019. GDP growth slows to expected 1.9% growth over the next twenty years with employment growth of 0.6%. Steady economic and employment growth contributes to continued moderate long-term customer growth.

Appliance efficiency standards coupled with DSM program activity has held sales growth in check. Since 2010 weather-normalized average use has declined on average 1.4% per year; this translates into 0.9% annual decline in residential sales. Commercial sales have also been falling; normalized sales have declined 0.6% per year. The industrial sector is the only sector showing positive growth with industrial sales averaging 1.8% average annual growth (excluding loss of a large customer account). When combined, total normalized sales have averaged 0.3% annual growth.

While DSM activity has had a significant impact on sales, for the IRP filing, the energy and demand forecasts do not include future DSM energy savings; DSM savings are treated as a resource in determining the most cost-effective options. Excluding future DSM, energy requirements and peak demand are expected to increase on average 0.6% over the next twenty years. Table 1-1 shows the VECTREN energy and demand forecasts. The forecast excludes future DSM savings, but includes the impact of customer-owned distributed generation (mostly behind-the-meter solar) and electric vehicles. Vectren utility scale solar and other distributed generation are not included in this report but are accounted for within the IRP and the forecast submitted to MISO.

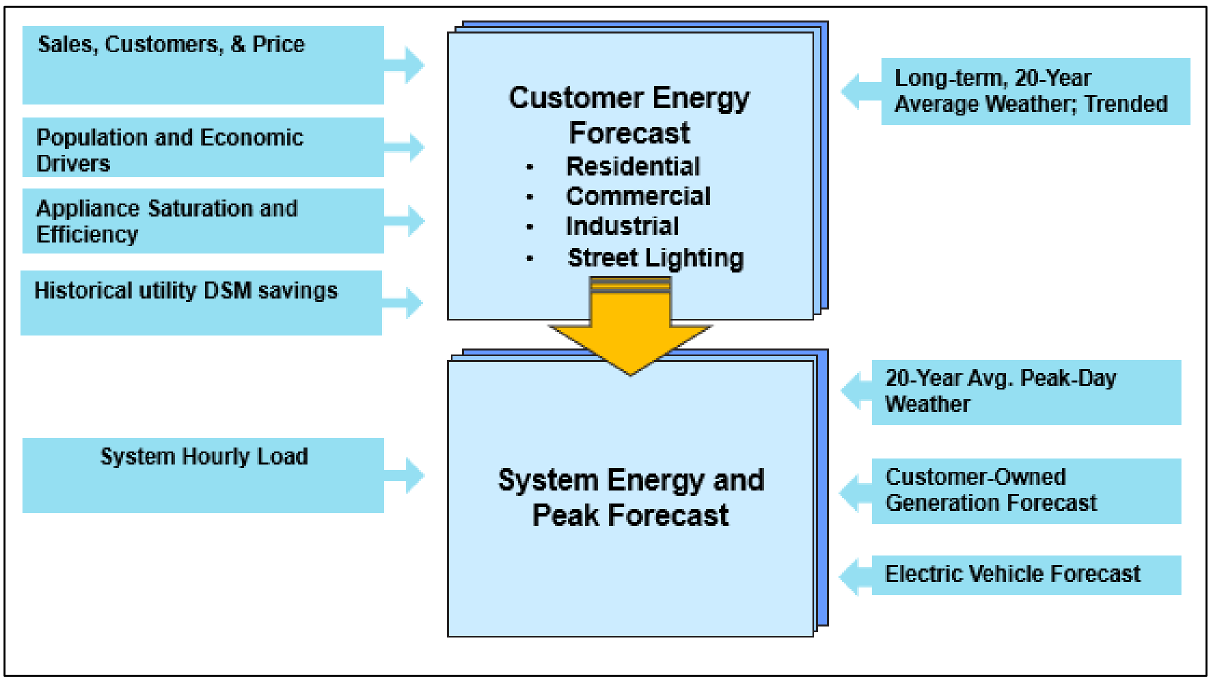
Table 1-1: Energy and Demand Forecast (Excluding DSM Program Savings)

Year	Energy (MWh)		Summer Peak (MW)		Winter Peak (MW)	
2019	5,169,366		1,075		786	
2020	5,395,568	4.4%	1,105	2.7%	834	6.1%
2021	5,402,326	0.1%	1,107	0.2%	831	-0.3%
2022	5,527,069	2.3%	1,131	2.1%	850	2.2%
2023	5,763,459	4.3%	1,173	3.7%	888	4.5%
2024	5,795,986	0.6%	1,178	0.5%	891	0.4%
2025	5,811,218	0.3%	1,181	0.3%	891	0.0%
2026	5,828,820	0.3%	1,184	0.3%	892	0.1%
2027	5,849,607	0.4%	1,188	0.3%	894	0.2%
2028	5,880,148	0.5%	1,194	0.5%	897	0.4%
2029	5,895,966	0.3%	1,197	0.3%	897	0.0%
2030	5,912,671	0.3%	1,201	0.3%	897	0.0%
2031	5,930,819	0.3%	1,205	0.3%	898	0.0%
2032	5,955,984	0.4%	1,210	0.4%	899	0.2%
2033	5,970,297	0.2%	1,214	0.3%	899	-0.1%
2034	5,991,229	0.4%	1,219	0.4%	900	0.1%
2035	6,013,551	0.4%	1,224	0.4%	901	0.1%
2036	6,040,644	0.5%	1,230	0.5%	903	0.3%
2037	6,055,140	0.2%	1,234	0.4%	902	-0.1%
2038	6,074,726	0.3%	1,239	0.4%	903	0.1%
2039	6,093,472	0.3%	1,244	0.4%	904	0.1%
CAGR 20-39		0.6%		0.6%		0.4%

2 Forecast Approach

The long-term energy and demand forecasts are based on a build-up approach. End-use sales derived from the customer class sales models (residential, commercial, industrial, and street lighting) drive system energy and peak demand. Energy requirements are calculated by adjusting sales forecast upwards for line losses. Peak demand is forecasted through a monthly peak-demand linear regression model that relates peak demand to peak-day weather conditions and end-use energy requirements (heating, cooling, and other use). System energy and peak are adjusted for residential and commercial PV adoption and EV charging impacts. Figure 2 shows the general framework and model inputs.

Figure 2: Class Build-up Model



In the long-term, both economic growth and structural changes drive energy and demand requirements. Structural changes include the impact of changing appliance owner-ship trends, end-use efficiency changes, increasing housing square footage, and thermal shell efficiency improvements. Changing structural components are captured in the residential and commercial sales forecast models through a specification that combines economic drivers with end-use energy intensity trends. This type of model is known as a Statistically Adjusted End-Use (SAE) model. The SAE model variables explicitly incorporate end-use saturation and efficiency projections, as well as changes in population, economic conditions, price, and weather. Both residential and commercial sales are forecasted using an SAE specification. Industrial sales are forecasted using a two-step approach, which includes a generalized econometric model that relates industrial sales to seasonal patterns and industrial economic activity. Streetlight sales are forecasted using a simple trend and seasonal model.

2.1 Residential Model

Residential average use and customers are modeled separately. The residential sales forecast is then generated as the product of the average use and customer forecasts.

Average Use. The residential average use model relates customer monthly average use to a customer's heating requirements (XHeat), cooling requirements (XCool), other use (XOther), and DSM activity per customer:

$$ResAvgUse_{ym} = (B_1 \times XHeat_{ym}) + (B_2 \times XCool_{ym}) + (B_3 \times XOther_{ym}) + (B_4 \times DSM_{ym}) + e_{ym}$$

Where:

y = year
m = month

The model coefficients (B_1, B_2, B_3, and B_4) are estimated using a linear regression model. Monthly average use data is derived from historical monthly billed sales and customer data from January 2010 to June 2019.

The model variables incorporate end-use saturation and efficiency projections, as well as changes in household size, household income, price, weather, and DSM activity. The model result is an estimate of monthly heating, cooling, and other use energy requirements on a kWh per household basis, which includes the impact of DSM. Incremental future DSM is then added back to the model results to arrive at an average use forecast that does not include the impact of future DSM.

Figure 3 to Figure 5 show the constructed monthly heating, cooling, and other end-use variables. The specific calculations of the end-use variables are presented in Appendix B.

Figure 3: Residential XHeat

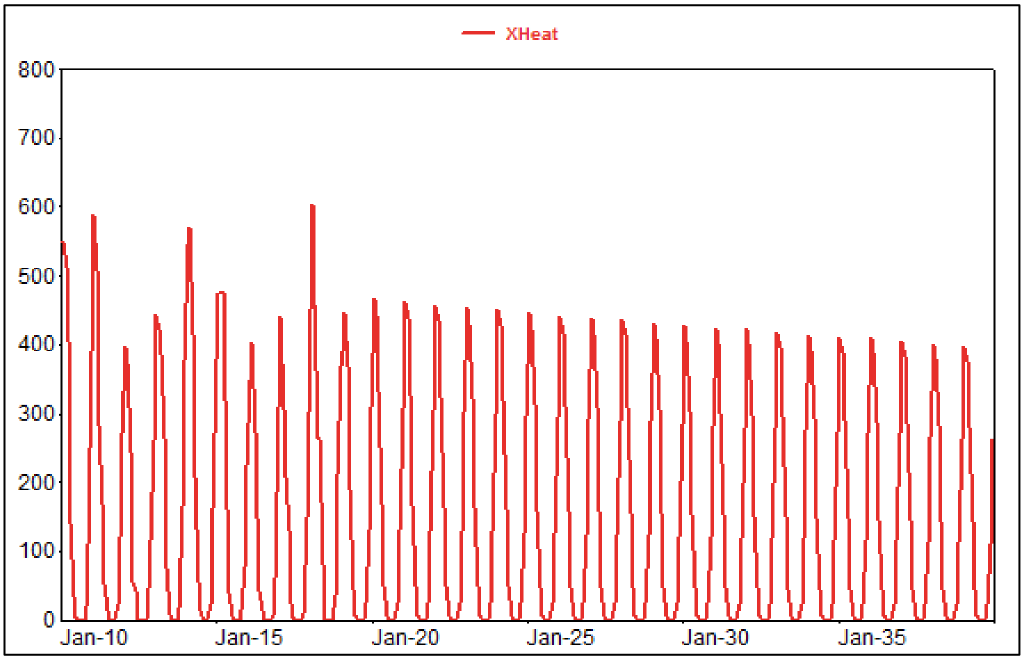


Figure 4: Residential XCool

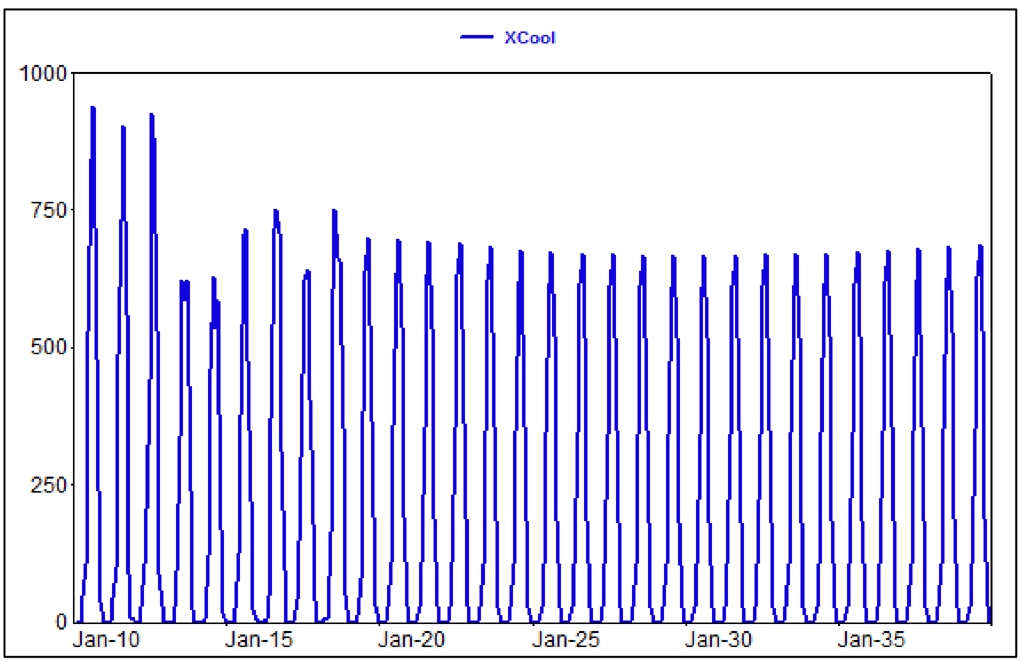
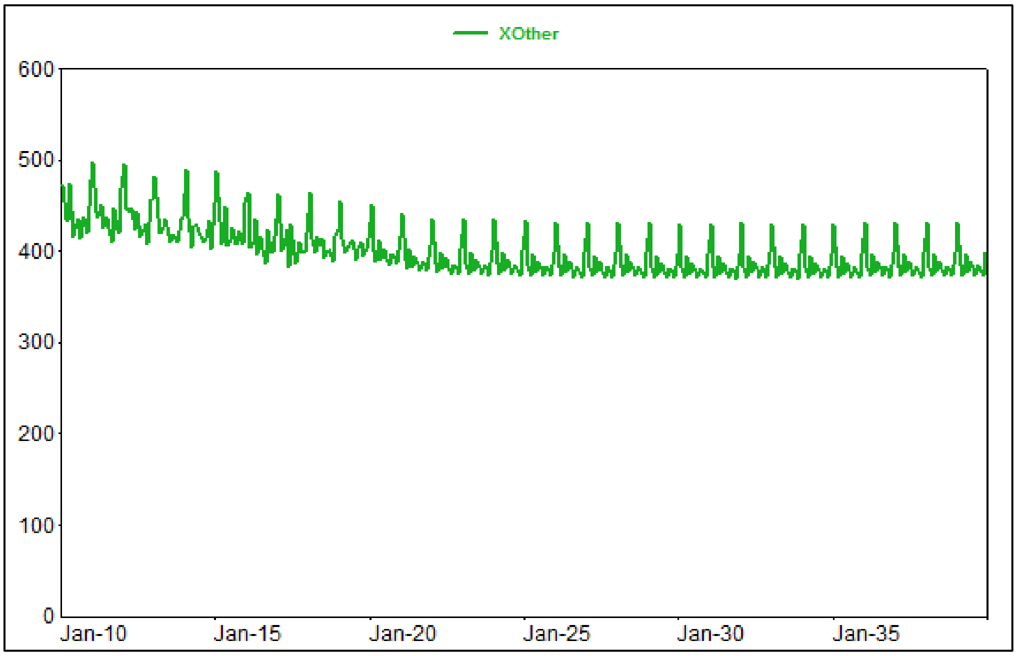


Figure 5: Residential XOther



The average use model is estimated over the period January 2010 through June 2019. The model explains historical average use well with an Adjusted R^2 of 0.98 and in-sample Mean Absolute Percent Error (MAPE) of 1.9%. Model coefficients are statistically significant at the 95% level of confidence and higher. Model coefficients and statistics are provided in Appendix A.

Customer Forecast

The customer forecast is based on a monthly regression model that relates the number of customers to Evansville MSA (Metropolitan Statistical Area) household projections. The model results in 0.4% long-term customer growth.

Sales Forecast

Excluding future DSM savings, average use through the forecast period is flat. With flat average use and 0.4% customer growth, residential sales averages 0.4% growth between 2020 and 2039. Table 2-1 summarizes the residential forecast.

Table 2-1: Residential Forecast (Excluding Future DSM)

Year	Sales (MWh)		Customers		AvgUse (kWh)	
2019	1,397,951		128,325		10,894	
2020	1,394,147	-0.3%	129,037	0.6%	10,804	-0.8%
2021	1,385,056	-0.7%	129,808	0.6%	10,670	-1.2%
2022	1,389,250	0.3%	130,762	0.7%	10,624	-0.4%
2023	1,393,879	0.3%	131,653	0.7%	10,588	-0.3%
2024	1,403,897	0.7%	132,458	0.6%	10,599	0.1%
2025	1,406,700	0.2%	133,214	0.6%	10,560	-0.4%
2026	1,412,868	0.4%	133,887	0.5%	10,553	-0.1%
2027	1,419,111	0.4%	134,474	0.4%	10,553	0.0%
2028	1,429,310	0.7%	135,002	0.4%	10,587	0.3%
2029	1,432,393	0.2%	135,503	0.4%	10,571	-0.2%
2030	1,439,085	0.5%	136,007	0.4%	10,581	0.1%
2031	1,446,125	0.5%	136,473	0.3%	10,596	0.1%
2032	1,456,783	0.7%	136,902	0.3%	10,641	0.4%
2033	1,460,392	0.2%	137,288	0.3%	10,637	0.0%
2034	1,467,666	0.5%	137,619	0.2%	10,665	0.3%
2035	1,475,665	0.5%	137,942	0.2%	10,698	0.3%
2036	1,487,624	0.8%	138,236	0.2%	10,761	0.6%
2037	1,492,228	0.3%	138,459	0.2%	10,777	0.1%
2038	1,499,727	0.5%	138,624	0.1%	10,819	0.4%
2039	1,506,655	0.5%	138,751	0.1%	10,859	0.4%
CAGR 20-39		0.4%		0.4%		0.0%

2.2 Commercial Model

The commercial sales model is also estimated using an SAE specification. The difference is that in the commercial sector, the sales forecast is based on a total sales model, rather than an average use and customer model. Commercial sales are expressed as a function of heating requirements, cooling requirements, other commercial use, and DSM activity:

$$ComSales_{ym} = (B_1 \times XHeat_{ym}) + (B_2 \times XCool_{ym}) + (B_3 \times XOther_{ym}) + (B_4 \times DSM_{ym}) + e_{ym}$$

Where:

y = year
m = month

The constructed model variables include Heating Degree Days (HDD), Cooling Degree Days (CDD), billing days, commercial economic activity variable, price, end-use intensity trends, and DSM activity. Figure 6 to Figure 8 show the constructed model variables. The specific variable construction is provided in Appendix B.

Figure 6: Commercial XHeat

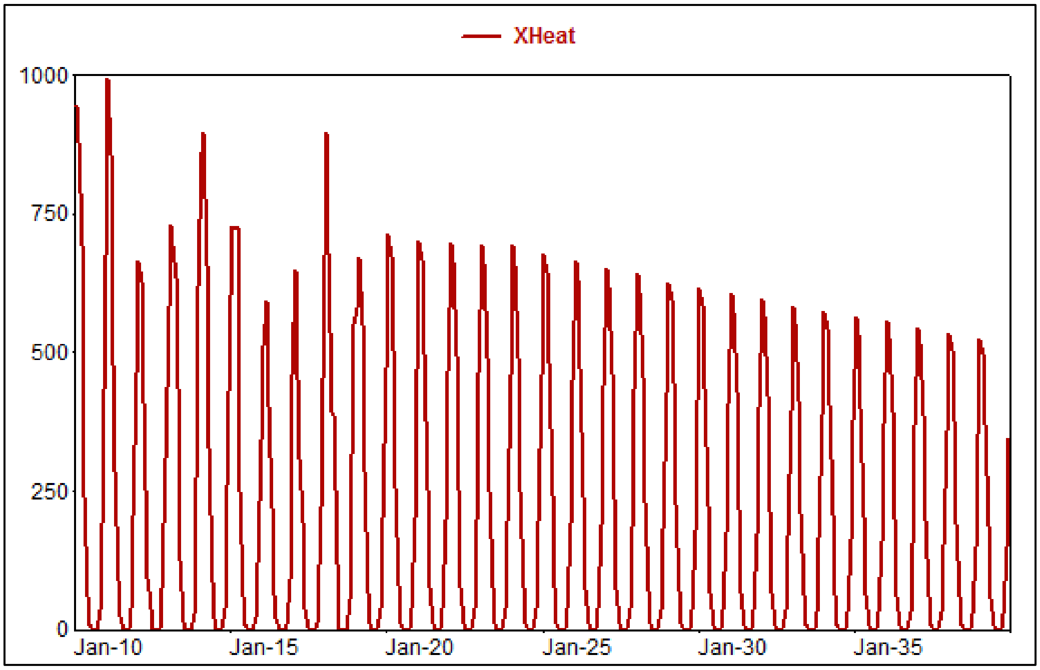


Figure 7: Commercial XCool

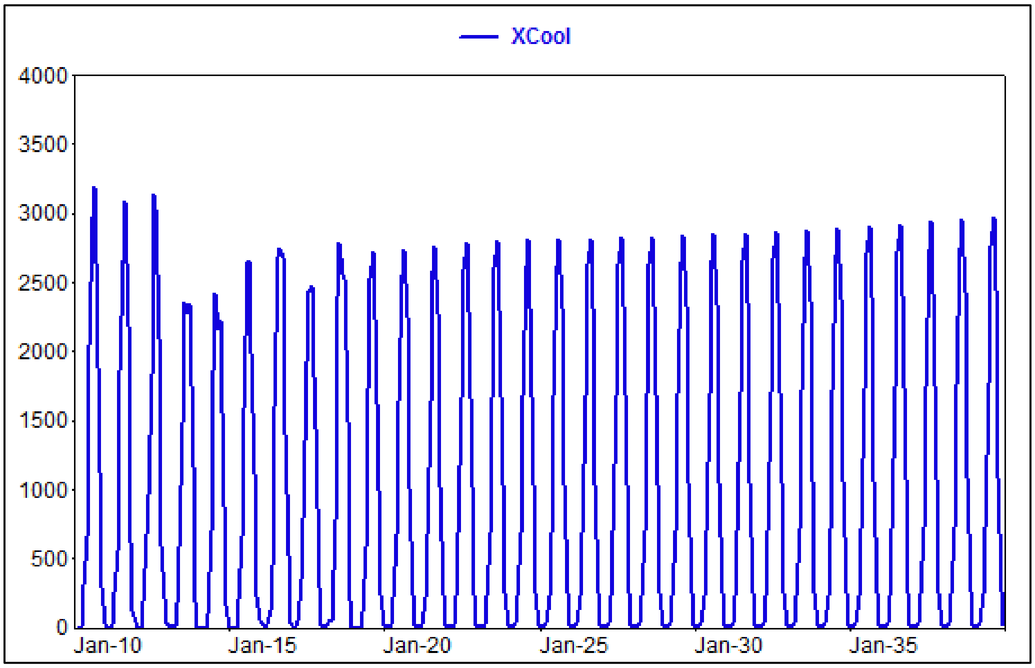
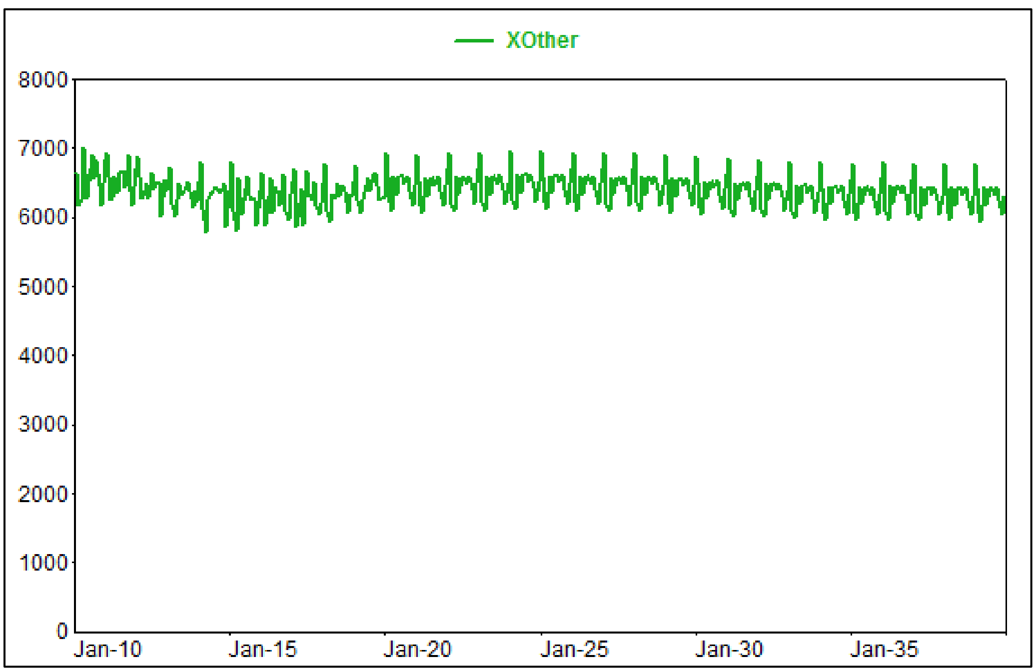


Figure 8: Commercial XOther



The estimated model coefficients (B_1, B_2, B_3, and B_4) calibrate the model to actual commercial sales data. The commercial sales model performs well with an Adjusted R^2 of 0.96 and an in-sample MAPE of 1.8%. The model is estimated with monthly billed sales data from January 2010 to June 2019. The model results include the impact of DSM. Incremental future DSM is then added back to the model results to arrive at a sales forecast that does not include the impact of future DSM.

Commercial sales average 0.2% annual growth through 2039, excluding the impact of future DSM savings. Commercial sales are driven by moderate residential customer and economic growth. Economic activity is captured by combining non-manufacturing output, non-manufacturing employment, and population through a weighted commercial economic variable called *ComVar*. *ComVar* is defined as:

$$ComVar_{ym} = \left(GDP_{ym}^{0.25}\right) \times \left(Employment_{ym}^{0.25}\right) \times \left(Population_{ym}^{0.5}\right)$$

Where:

y = year
m = month

The weights are determined by testing alternative sets of weights that generate the best in-sample and out-of-sample model statistics.

A separate model is estimated for commercial customers; customer projections are based on a monthly regression model that relates the number of customers to non-manufacturing employment in the Evansville MSA. The forecast excludes future DSM savings. Table 2-2 summarizes the commercial forecast.

Table 2-2: Commercial Forecast

Year	Sales (MWh)		Customers	
2019	1,268,993		18,731	
2020	1,281,221	1.0%	18,817	0.5%
2021	1,285,272	0.3%	18,870	0.3%
2022	1,292,595	0.6%	18,935	0.3%
2023	1,297,044	0.3%	18,999	0.3%
2024	1,303,746	0.5%	19,060	0.3%
2025	1,304,199	0.0%	19,122	0.3%
2026	1,305,034	0.1%	19,184	0.3%
2027	1,306,083	0.1%	19,247	0.3%
2028	1,310,084	0.3%	19,309	0.3%
2029	1,309,689	0.0%	19,371	0.3%
2030	1,308,851	-0.1%	19,434	0.3%
2031	1,308,792	0.0%	19,496	0.3%
2032	1,311,763	0.2%	19,560	0.3%
2033	1,310,653	-0.1%	19,624	0.3%
2034	1,312,270	0.1%	19,689	0.3%
2035	1,314,615	0.2%	19,754	0.3%
2036	1,319,551	0.4%	19,820	0.3%
2037	1,320,643	0.1%	19,887	0.3%
2038	1,324,172	0.3%	19,954	0.3%
2039	1,327,364	0.2%	20,021	0.3%
CAGR 20-39		0.2%		0.3%

2.3 Industrial Model

The industrial sales forecast is developed with a two-step approach. The first five years of the forecast is derived from Vectren's expectation of specific customer activity. The forecast after the first five years is based on the industrial forecast model. Vectren determines a baseline volume based on historical consumption use. The baseline use is then adjusted to reflect expected closures and expansions. Near-term sales are also adjusted for the addition of new industrial customers. After five years, the forecast is derived from the industrial sales model; forecasted growth is applied to the fifth-year industrial sales forecast.

The industrial sales model is a generalized linear regression model that relates monthly historical industrial billed to manufacturing employment, manufacturing output, CDD, and monthly binaries to capture seasonal load variation and shifts in sales data. The industrial economic driver is a weighted combination of manufacturing employment and manufacturing output. The industrial economic (*IndVar*) variable is defined as:

$$IndVar_{ym} = \left(ManufEmploy_{ym}^{0.5}\right) \times \left(ManufOutput_{ym}^{0.5}\right)$$

Where:

y = year
m = month

The imposed weights are determined by evaluating in-sample and out-of-sample statistics for alternative weighting schemes. The model Adjusted R^2 is 0.74 with a MAPE of 5.2%. The relatively low Adjusted R^2 and high MAPE are a result of the large month-to-month variations in industrial billing data. The industrial model excludes sales to one of VECTREN's largest customers, which is currently meeting most of its load through onsite cogeneration.

Excluding DSM, industrial sales average 1.0% annual growth with strong near-term growth. After 2023, industrial sales average 0.4% annual growth. Table 2-3 summarizes the industrial sales forecast.

Table 2-3: Industrial Forecast (Excluding Future DSM)

Year	Total Industrial	
2019	2,159,155	
2020	2,347,543	8.7%
2021	2,360,025	0.5%
2022	2,463,638	4.4%
2023	2,669,566	8.4%
2024	2,682,185	0.5%
2025	2,693,010	0.4%
2026	2,702,706	0.4%
2027	2,715,218	0.5%
2028	2,730,260	0.6%
2029	2,742,862	0.5%
2030	2,753,258	0.4%
2031	2,763,983	0.4%
2032	2,774,906	0.4%
2033	2,786,352	0.4%
2034	2,797,969	0.4%
2035	2,809,553	0.4%
2036	2,819,333	0.3%
2037	2,828,251	0.3%
2038	2,837,072	0.3%
2039	2,846,045	0.3%
CAGR 20-39		1.0%

2.4 Street Lighting Model

Streetlight sales are fitted with a simple exponential smoothing model with a trend and seasonal component. Street lighting sales are increasing at 0.2% annually throughout the forecast horizon. Table 2-4 shows the streetlight forecast.

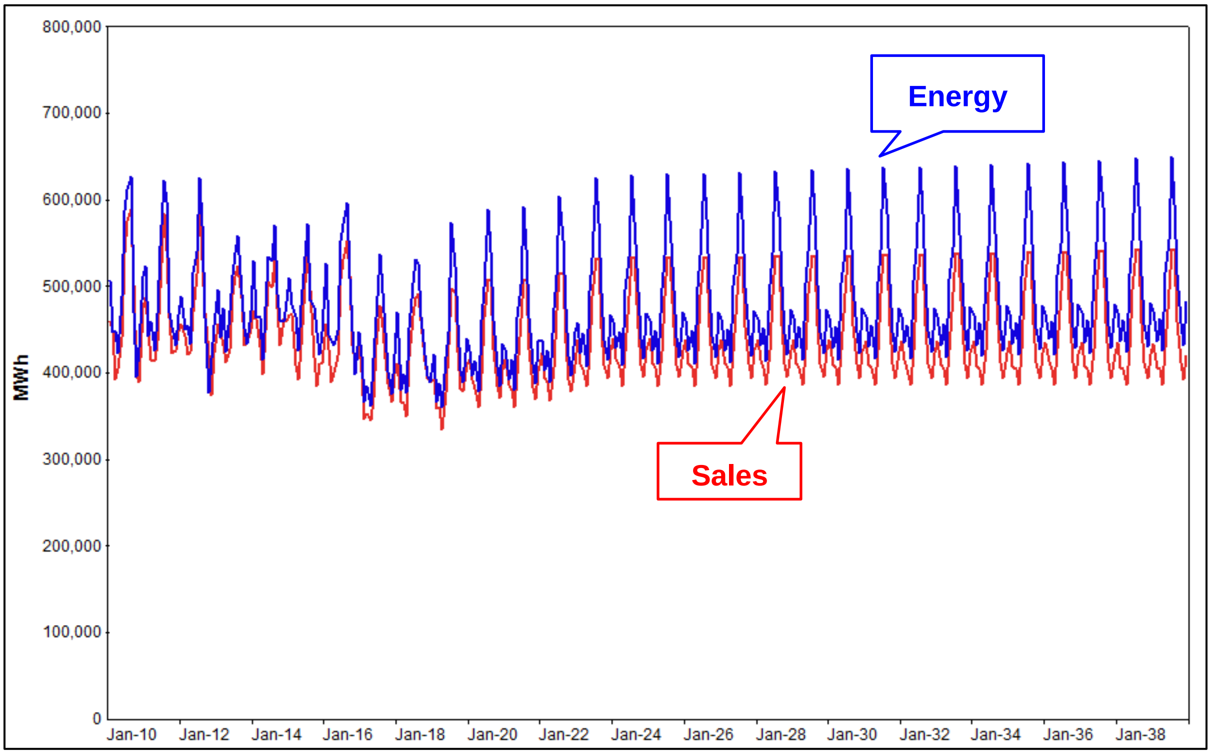
Table 2-4: Street Lighting Forecast

Year	Sales (MWh)	
2019	21,526	
2020	21,645	0.6%
2021	21,680	0.2%
2022	21,715	0.2%
2023	21,749	0.2%
2024	21,784	0.2%
2025	21,819	0.2%
2026	21,854	0.2%
2027	21,889	0.2%
2028	21,924	0.2%
2029	21,959	0.2%
2030	21,994	0.2%
2031	22,029	0.2%
2032	22,064	0.2%
2033	22,098	0.2%
2034	22,133	0.2%
2035	22,168	0.2%
2036	22,203	0.2%
2037	22,238	0.2%
2038	22,273	0.2%
2039	22,308	0.2%
CAGR 20-39		0.2%

2.5 Energy Forecast Model

The energy forecast is derived directly from the sales forecast by applying a monthly energy adjustment factor to the sales forecast. The energy adjustment factor includes line losses and any differences in timing between monthly sales estimates and delivered energy (*unaccounted for energy*). Monthly adjustment factors are calculated based on the historical relationship between energy and sales. The energy forecast is adjusted for rooftop solar generation and electric vehicles. Figure 9 shows the monthly sales and energy forecast, excluding the impact of future DSM.

Figure 9: Energy and Sales Forecast (Excluding DSM)



2.6 Peak Forecast Model

The long-term system peak forecast is derived through a monthly peak regression model that relates peak demand to heating, cooling, and base load requirements:

$$Peak_{ym} = B_0 + B_1 HeatVar_{ym} + B_2 CoolVar_{ym} + B_3 BaseVar_{ym} + e_{ym}$$

Where:

y = year
m = month

End-use energy requirements are estimated from class sales forecast models.

<u>Heating and Cooling Model Variables</u>

The residential and commercial SAE model coefficients are used to isolate historical and projected weather-normal heating and cooling requirements. Heating requirements are interacted with peak-day HDD and cooling requirements with peak-day CDD; this interaction allows peak-day weather impacts to change over time with changes in heating and cooling requirements. The peak model heating and cooling variables are calculated as:

- $HeatVar_{ym} = HeatLoadIdx_{ym} \times PkHDD_{ym}$
- $CoolVar_{ym} = CoolLoadIdx_{ym} \times PkCDD_{ym}$

  Where $HeatLoadIdx_{ym}$ is an index of total system heating requirements in year *y* and month *m* and $CoolLoadIdx_{ym}$ is an index of total system cooling requirements in year *y* and month *m*. $PkHDD_{ym}$ is the peak-day HDD in year *y* and month *m* and $PkCDD_{ym}$ is the peak-day CDD in year y and month *m*.

Figure 10 and Figure 11 show *HeatVar* and *CoolVar*. The variation in the historical period is a result of variation in peak-day HDD and CDD.

Figure 10: Peak-Day Heating Variable

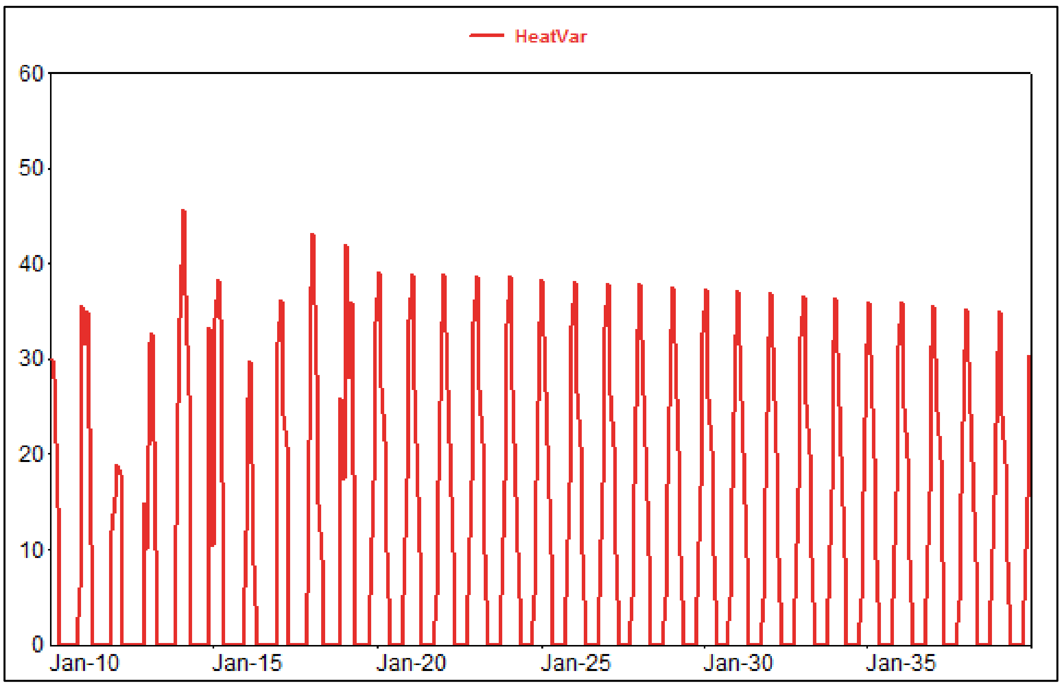
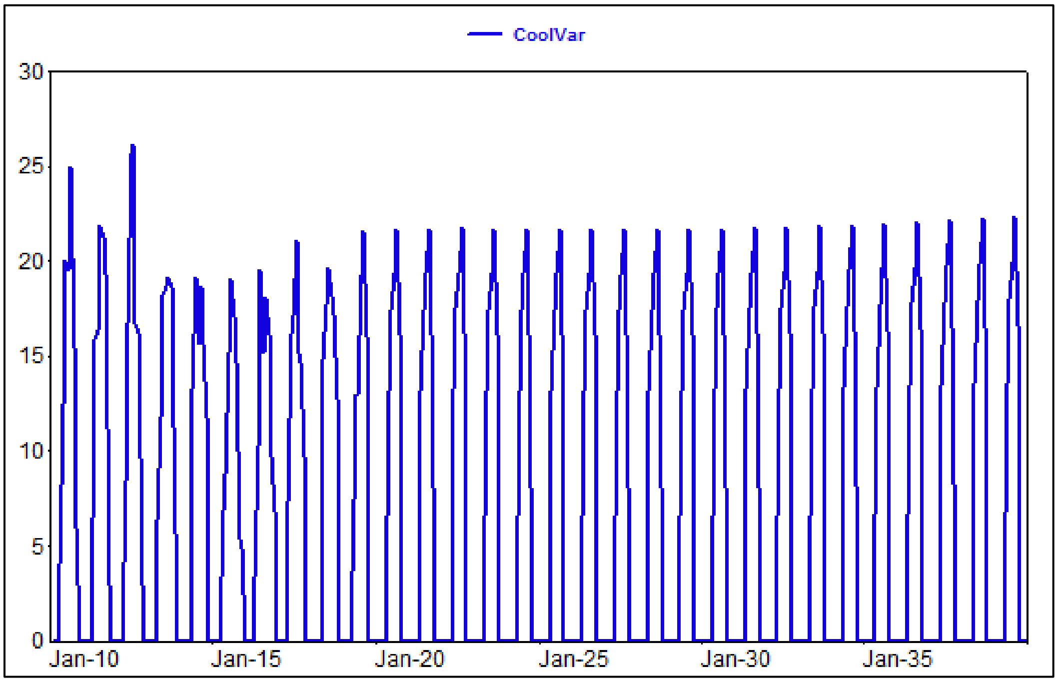


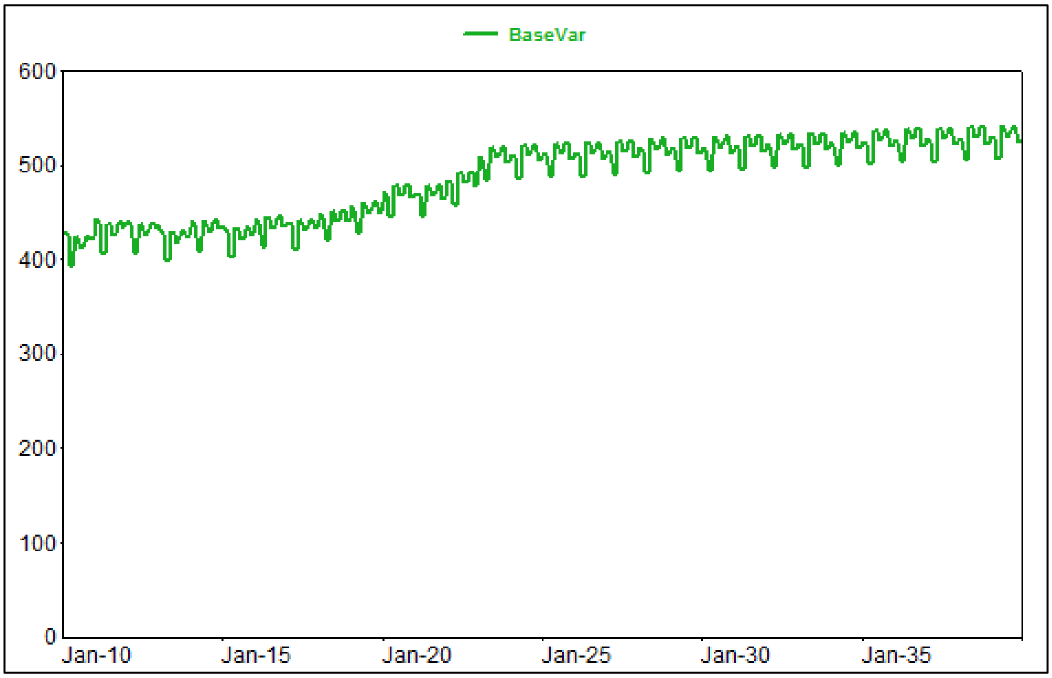
Figure 11: Peak-Day Cooling Variable



Base Load Variable

The base-load variable (*BaseVar*$_{ym}$) captures non-weather sensitive load at the time of the monthly peak. Monthly base-load estimates are calculated by allocating non-weather sensitive energy requirements to end-use estimates at the time of peak. End-use allocation factors are based on a set of end-use profiles developed by Itron. Figure 12 shows the non-weather sensitive peak-model variable.

Figure 12: Peak-Day Base-Use Variable



Model Results

The peak model is estimated over the period January 2010 to June 2019. The model explains monthly peak variation well with an adjusted R^2 of 0.95 and an in-sample MAPE of 2.81%. The end-use variables – *HeatVar*, *CoolVar*, and *BaseVar* are all highly statistically significant. Model statistics and parameters are included in Appendix A.

The peak demand forecast is adjusted for solar load and electric vehicle impacts, but excludes the impact of future DSM savings. Table 2-5 shows total energy and peak demand.

Table 2-5: Energy and Peak Forecast[1]

Year	Energy (MWh)		Summer Peak (MW)		Winter Peak (MW)	
2019	5,169,366		1,075		786	
2020	5,395,568	4.4%	1,105	2.7%	834	6.1%
2021	5,402,326	0.1%	1,107	0.2%	831	-0.3%
2022	5,527,069	2.3%	1,131	2.1%	850	2.2%
2023	5,763,459	4.3%	1,173	3.7%	888	4.5%
2024	5,795,986	0.6%	1,178	0.5%	891	0.4%
2025	5,811,218	0.3%	1,181	0.3%	891	0.0%
2026	5,828,820	0.3%	1,184	0.3%	892	0.1%
2027	5,849,607	0.4%	1,188	0.3%	894	0.2%
2028	5,880,148	0.5%	1,194	0.5%	897	0.4%
2029	5,895,966	0.3%	1,197	0.3%	897	0.0%
2030	5,912,671	0.3%	1,201	0.3%	897	0.0%
2031	5,930,819	0.3%	1,205	0.3%	898	0.0%
2032	5,955,984	0.4%	1,210	0.4%	899	0.2%
2033	5,970,297	0.2%	1,214	0.3%	899	-0.1%
2034	5,991,229	0.4%	1,219	0.4%	900	0.1%
2035	6,013,551	0.4%	1,224	0.4%	901	0.1%
2036	6,040,644	0.5%	1,230	0.5%	903	0.3%
2037	6,055,140	0.2%	1,234	0.4%	902	-0.1%
2038	6,074,726	0.3%	1,239	0.4%	903	0.1%
2039	6,093,472	0.3%	1,244	0.4%	904	0.1%
CAGR 20-39		0.6%		0.6%		0.4%

[1] Does not include Vectren owned distributed generation or projected DSM

3 Customer Owned Distributed Generation

The energy and peak forecasts incorporate the impact of customer-owned photovoltaic systems. System adoption is expected to increase as solar system costs decline, which is partially offset by changes in net metering laws that will credit excess generation at a rate lower than retail rates in the future. As of June 2019, VECTREN had 421 residential solar customers and 65 commercial solar customers, with an approximate installed capacity of 8.9 MW.

3.1 Monthly Adoption Model

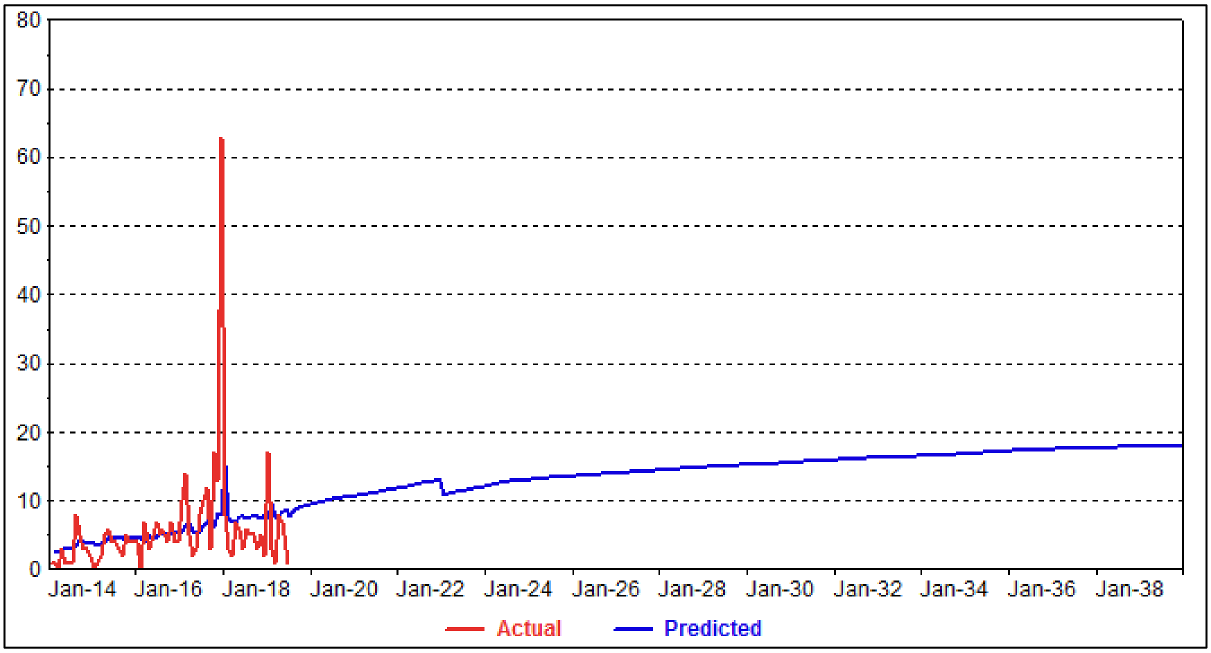
The primary factor driving system adoption is a customer's return-on-investment. A simple payback model is used as proxy. Simple payback reflects the length of time needed to recover the cost of installing a solar system - the shorter the payback, the higher the system adoption rate. From the customer's perspective, this is the number of years until electricity is "free." Simple payback also works well to explain leased system adoption as return on investment drives the leasing company's decision to offer leasing programs. Solar investment payback is calculated as a function of system costs, federal and state tax credits and incentive payments, retail electric rates, and treatment of excess generation (solar generation returned to the grid). Currently, excess generation is credited at the customer's retail rate. In the next few years excess solar generation will be credited at the wholesale cost plus 25%.

One of the most significant factors driving adoption is declining system costs; costs have been declining rapidly over the last five years. In 2010, residential solar system cost was approximately $7.00 per watt. By 2017 costs had dropped to $3.70 per watt. For the forecast period, we assume system costs continue to decline 10% annually through 2024 and an additional 3% annually after 2024. Cost projections are consistent with the U.S. Dept. of Energy's Sun Shot Solar goals and the Energy Information Administration's (EIA), most recent cost projections.[2]

The solar adoption model relates monthly residential solar adoptions to simple payback. Figure 13 shows the resulting residential solar adoption forecast.

[2] "Tracking the Sun". Lawrence Berkeley National Laboratory. September 2018.

Figure 13: Residential Solar Share Forecast



In the commercial sector, there have been too few adoptions to estimate a robust model; commercial system adoption has been low across the country. Limited commercial adoption reflects higher investment hurdle rates, building ownership issues (i.e., the entity that owns the building often does not pay the electric bill), and physical constraints as to the placement of the system. For this forecast, we assume there continues to be some commercial rooftop adoption by allowing commercial adoption to increase over time, based on the current relationship between commercial and residential adoptions rates.

Declining solar costs continue to drive solar adoption through 2022. Adoptions drop after 2023 with the change in the net metering law, but then continue to increase with declining system costs. Table 3-1 shows projected solar adoption.

Table 3-1: Solar Customer Forecast

Year	Residential Systems	Commercial Systems	Total Systems
2019	431	67	498
2020	541	84	624
2021	671	104	775
2022	814	126	939
2023	957	148	1,105
2024	1,104	170	1,274
2025	1,260	194	1,454
2026	1,424	220	1,644
2027	1,592	246	1,838
2028	1,766	273	2,038
2029	1,946	300	2,246
2030	2,126	328	2,454
2031	2,313	357	2,670
2032	2,505	387	2,892
2033	2,697	416	3,113
2034	2,897	447	3,344
2035	3,101	479	3,579
2036	3,305	510	3,815
2037	3,515	543	4,058
2038	3,731	576	4,307
2039	3,947	609	4,556
CAGR 20-39	11.0%	11.0%	11.0%

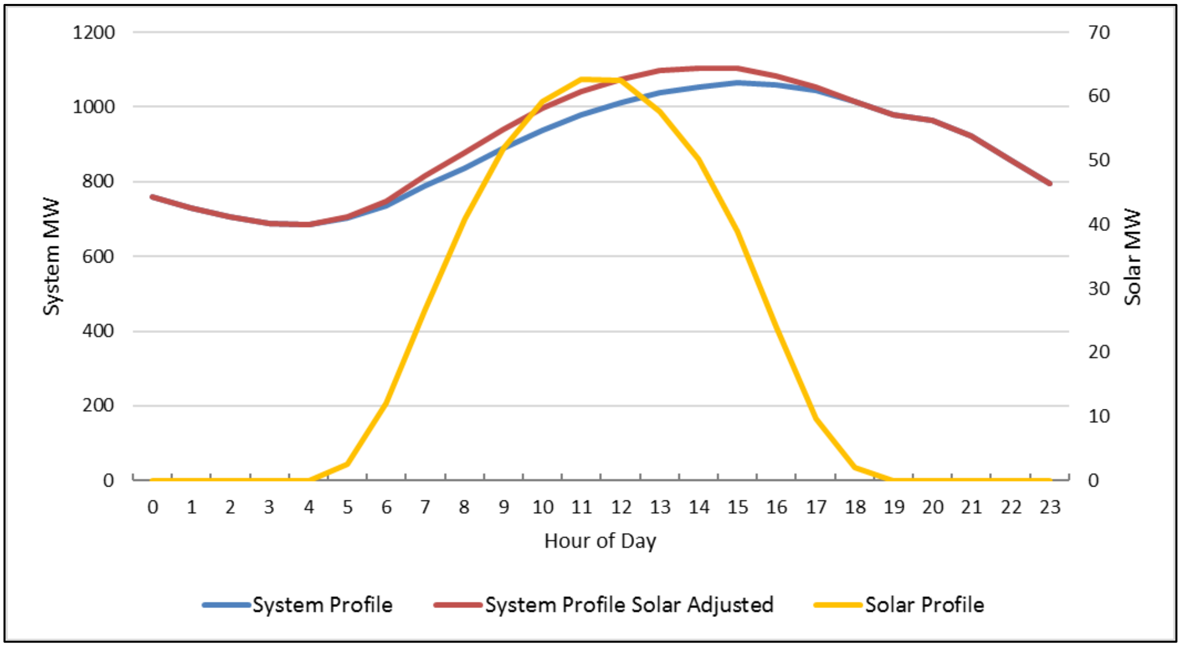
3.2 Solar Capacity and Generation

Installed solar capacity forecast is the product of the solar customer forecast and average system size (measured in kW). Based on recent solar installation data, the residential average size is 10.47 KW, and commercial average system size is 69.5 KW.

The capacity forecast (MW) is translated into system generation (MWh) forecast by applying monthly solar load factors to the capacity forecast. Monthly load factors are derived from a typical PV load profile for Evansville, IN. The PV shape is from the National Renewable Energy Laboratory (NREL) and represents a typical meteorological year (TMY).

The impact of solar generation on system peak demand is a function of the timing between solar load generation and system hourly demand. Solar output peaks during the mid-day while system peaks later in the afternoon. Figure 14 shows the system profile, solar adjusted system profile, and solar profile for a peak producing summer day.

Figure 14: Solar Hourly Load Impact



Based on system and solar load profiles, 1.0 MW of solar capacity reduces summer peak demand by approximately 0.29 MW. This adjustment factor is applied to the solar capacity forecast to yield the summer peak demand impact. Solar capacity has no impact on the winter peak demand as the winter peak is late in the evening when there is no solar generation.

Table 3-2 shows the PV capacity forecast, expected annual generation, and demand at time of peak.

Table 3-2: Solar Capacity and Generation

Year	Total Generation MWh	Installed Capacity MW (Aug)	Demand Impact MW
2019	12,084	9.3	2.7
2020	15,241	11.8	3.5
2021	18,877	14.6	4.3
2022	22,895	17.6	5.2
2023	26,943	20.7	6.1
2024	31,139	23.8	7.0
2025	35,469	27.1	8.0
2026	40,099	30.6	9.0
2027	44,835	34.2	10.1
2028	49,831	37.9	11.2
2029	54,796	41.7	12.3
2030	59,872	45.6	13.4
2031	65,153	49.6	14.6
2032	70,721	53.6	15.8
2033	75,979	57.7	17.0
2034	81,598	62.0	18.3
2035	87,349	66.3	19.5
2036	93,306	70.6	20.8
2037	99,030	75.1	22.1
2038	105,119	79.7	23.5
2039	111,208	84.3	24.8
CAGR 20-39	11.0%	10.9%	10.9%

4 Electric Vehicle Forecast

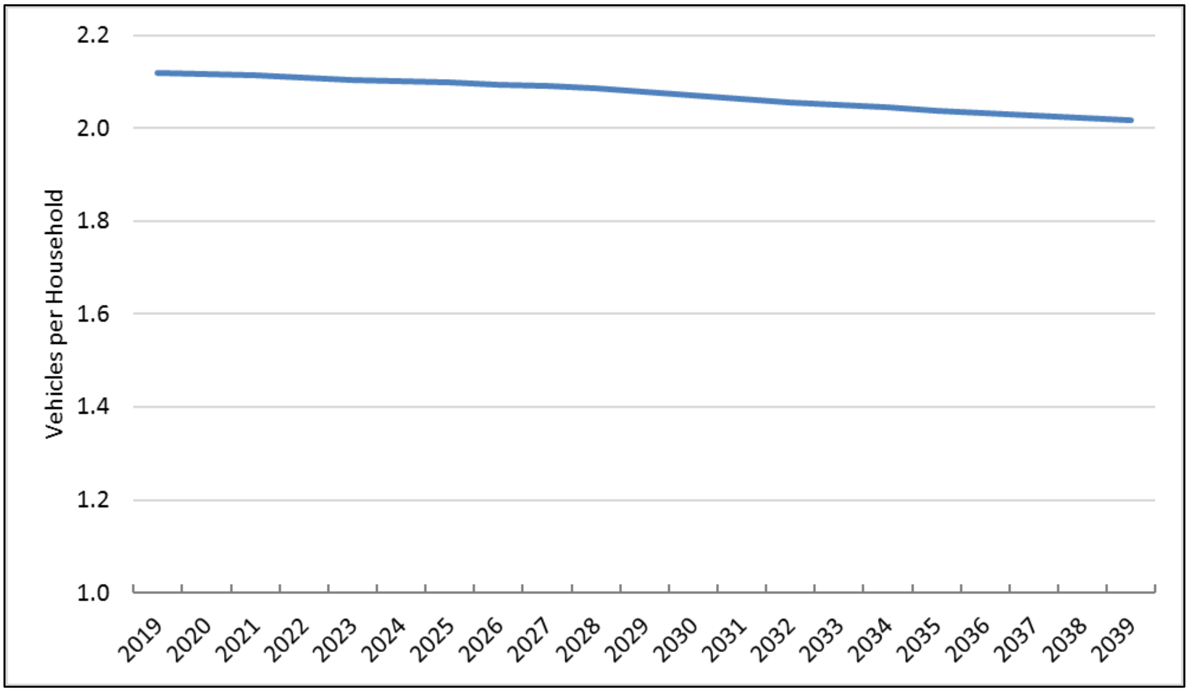
The 2019 Long-Term forecast also includes the impact of electric vehicle adoption. Currently Vectren has relatively few electric vehicles, but this is expected to increase significantly over the next twenty years with improvements in EV technology and declines in battery and vehicle costs. At the time of the forecast Vectren had 238 registered electric vehicles in the counties that Vectren serves: this included full electric (i.e., battery electric vehicles - BEV) as well as plug-in hybrid electric (PHEV) vehicles. The 238 vehicles were comprised of 105 BEVs and 133 PHEVs, with a total of 23 different make/model vehicles represented.

4.1 Methodology

The Energy Information Administration (EIA) produces a transportation forecast as part of their Annual Energy Outlook. One component of this forecast is a vehicle stock forecast by technology type, including electric vehicles. Using these data, we are able to calculate the average number of cars per household and projected electric vehicle share - BEV and PHEV.

Figure 15 shows projected number of vehicles per household. The number of vehicles declines over time as the number of persons per household declines and demand for car services such as Uber and Lyft increases.

Figure 15: EIA Vehicle Per Household

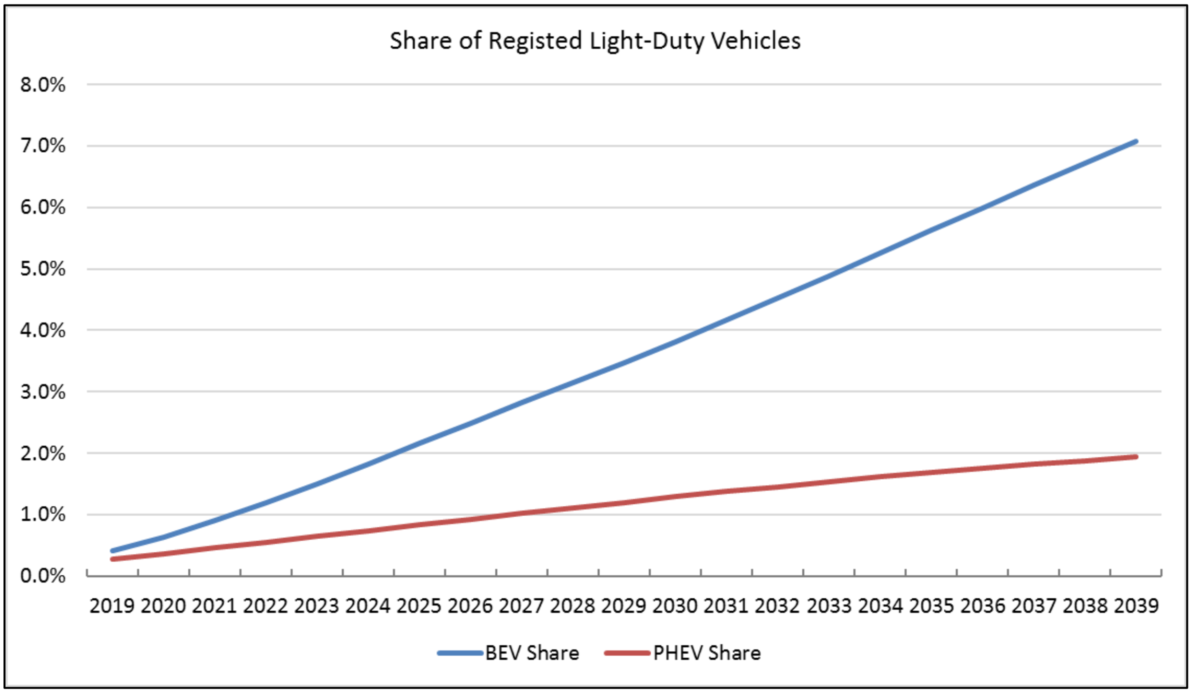


Total service area vehicles are calculated as the product of forecasted customers times EIA projected vehicles per household:

$$Ttl\,Vehicles = \; Custs_{yr} \times EIA\,Vehicle\;Per\;HH_{yr}$$

The number of BEV and PHEV are calculated by applying EIA's projected BEV and PHEV saturation to the service area total vehicle forecast. The share of electric vehicles are projected to increase from 0.5% to 7.1% BEV and 1.9% PHEV by 2039. The BEV and PHEV saturation forecast is shown in Figure 16.

Figure 16: EV & PHEV Market Share



The resulting electric vehicle forecast is summarized in Table 4-1:

Table 4-1: Electric Vehicle Forecast

Year	BEV Count	PHEV Count
2019	115	140
2020	283	266
2021	711	509
2022	1,783	974
2023	3,936	1,712
2024	5,112	2,065
2025	6,069	2,342
2026	7,015	2,613
2027	7,953	2,878
2028	8,884	3,136
2029	9,827	3,390
2030	10,785	3,639
2031	11,771	3,878
2032	12,772	4,109
2033	13,789	4,329
2034	14,816	4,538
2035	15,848	4,736
2036	16,875	4,926
2037	17,887	5,108
2038	18,887	5,279
2039	19,885	5,445

4.2 Electric Vehicle Energy & Load Forecast

Electric vehicles' impact on VECTREN's load forecast depends on the amount of energy a vehicle consumes annually and the timing of vehicle charging. BEVs consume more electricity than PHEVs and accounting for this distinction is important. An EV weighted annual kWh use is calculated based on the current mix of EV models. EV usage is derived from manufacturers' reported fuel efficiency to the federal government (www.fueleconomy.gov). The average annual kWh for the current mix of EVs registered in Vectren's service territory is 3,752kWh for BEV and 2,180 kWh for PHEV based on annual mileage of 12,000 miles.

Electric vehicles' impact on peak demand depends on when and where EVs are charged. Since Vectren does not have incentivized BEV/PHEV off-peak charging rates, it is assumed that the majority of charging will occur at home in the evening hours; this has a minimal impact on summer peak demand. Table 4-2 shows the electric vehicle forecast.

Table 4-2: Electric Vehicle Load Forecast

Year	BEV MWh	PHEV MWh	Total EV MWh	Demand Impact MW (Aug)
2019	432	305	737	0.1
2020	1,063	580	1,643	0.2
2021	2,667	1,110	3,777	0.4
2022	6,691	2,124	8,815	1.0
2023	14,769	3,732	18,501	2.1
2024	19,178	4,503	23,681	2.5
2025	22,770	5,106	27,876	2.9
2026	26,320	5,697	32,017	3.3
2027	29,838	6,275	36,113	3.8
2028	33,334	6,837	40,171	4.2
2029	36,869	7,392	44,261	4.6
2030	40,467	7,933	48,400	5.0
2031	44,164	8,455	52,619	5.5
2032	47,920	8,959	56,878	5.9
2033	51,735	9,438	61,173	6.3
2034	55,591	9,895	65,486	6.8
2035	59,461	10,327	69,788	7.2
2036	63,315	10,741	74,056	7.7
2037	67,111	11,137	78,248	8.1
2038	70,863	11,510	82,373	8.5
2039	74,607	11,872	86,479	8.9

5 Forecast Assumptions

5.1 Weather Data

Historical and normal HDD and CDD are derived from daily temperature data for the Evansville airport. Normal degree-days are calculated by averaging the historical daily HDD and CDD over the last twenty years. In past forecasts, we assumed normal HDD and CDD will occur in each of the forecast years. Recent analysis suggests an alternative approach. In reviewing historical weather data, we found a statistically significant positive, but slow, increase in average temperature. This translates into fewer HDD and more CDD over time. Our analysis showed HDD are decreasing 0.2% per year while CDD are increasing 0.5% per year. These trends are incorporated into the forecast. Starting normal HDD are allowed to decrease 0.2% over the forecast period while CDD increase 0.5% per year through 2039. Figure 17 and Figure 18 show historical and forecasted monthly HDD and CDD.

Figure 17: Heating Degree Days

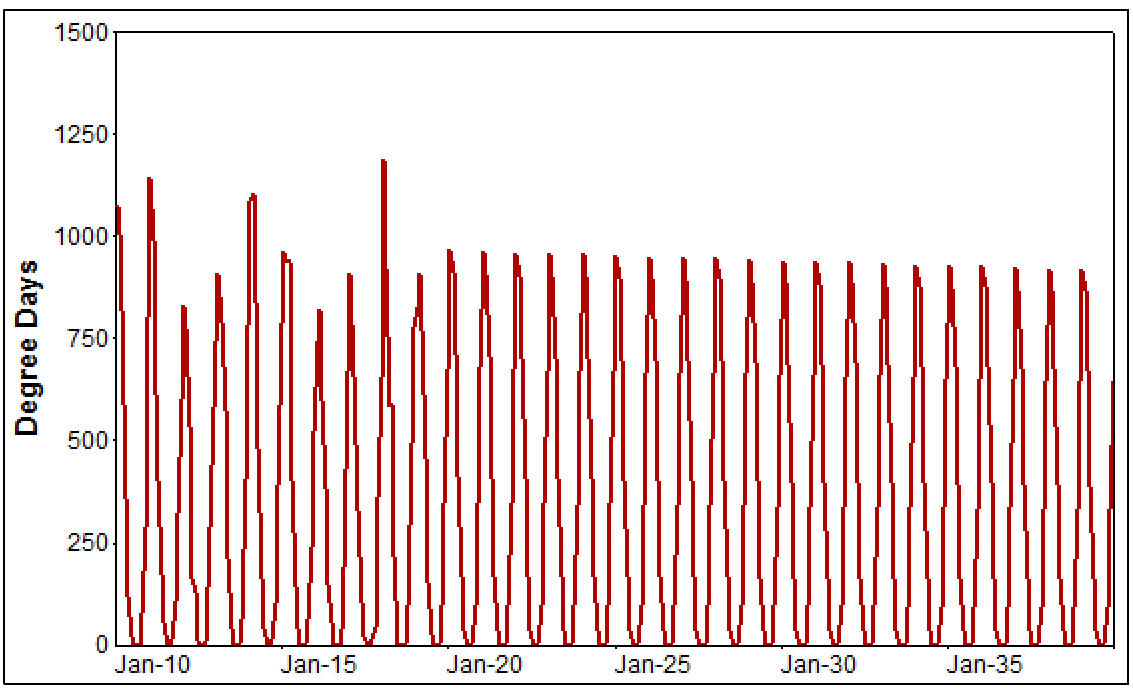
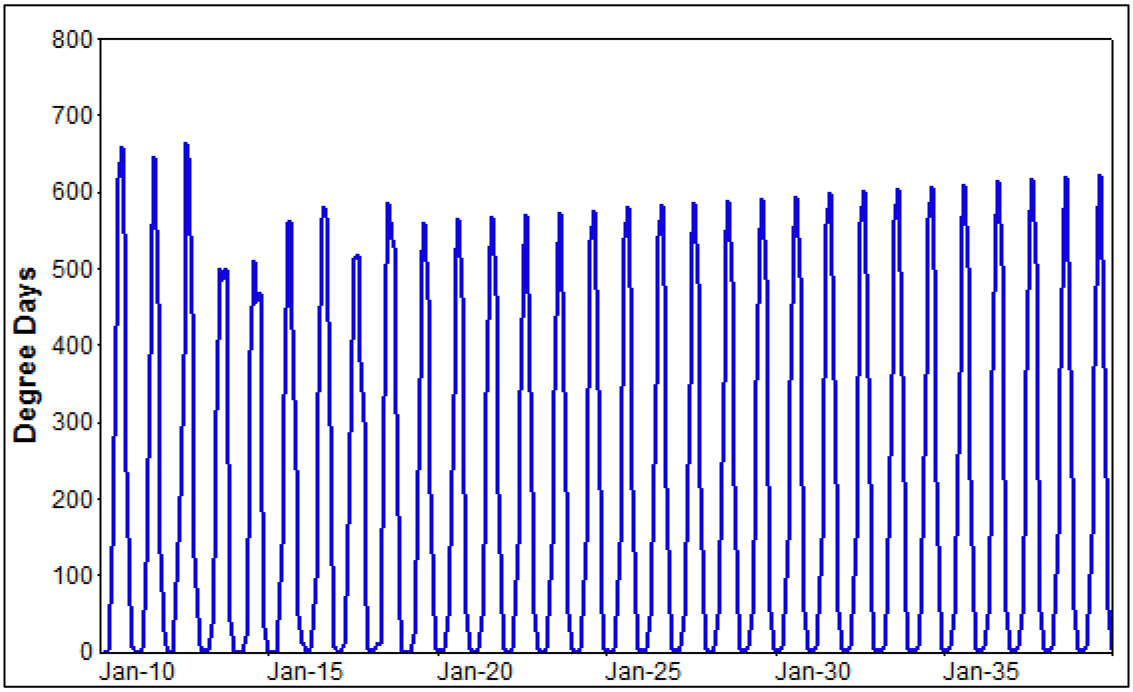


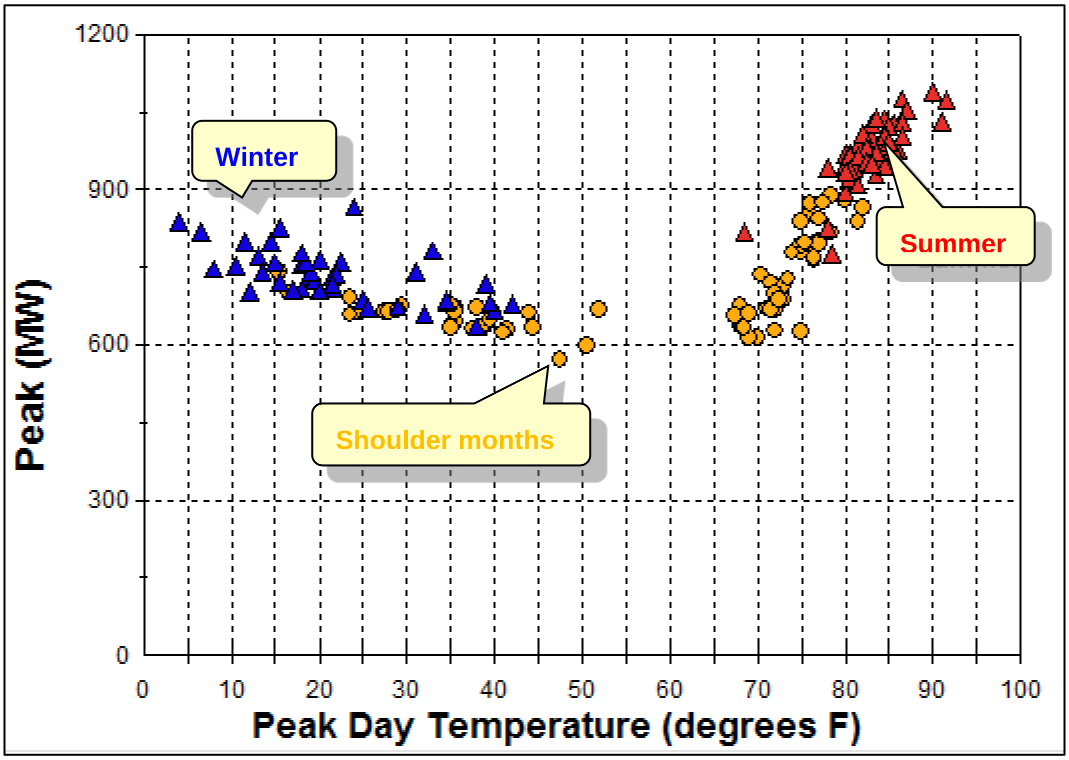
Figure 18: Cooling Degree Days



Peak-Day Weather Variables

Peak-day CDD and HDD are used in forecasting system peak demand. Peak-day HDD and CDD are derived by finding the daily HDD and CDD that occurred on the peak day in each month. The appropriate breakpoints for defining peak-day HDD and CDD are determined by evaluating the relationship between monthly peak and the peak-day average temperature, as shown in Figure 19.

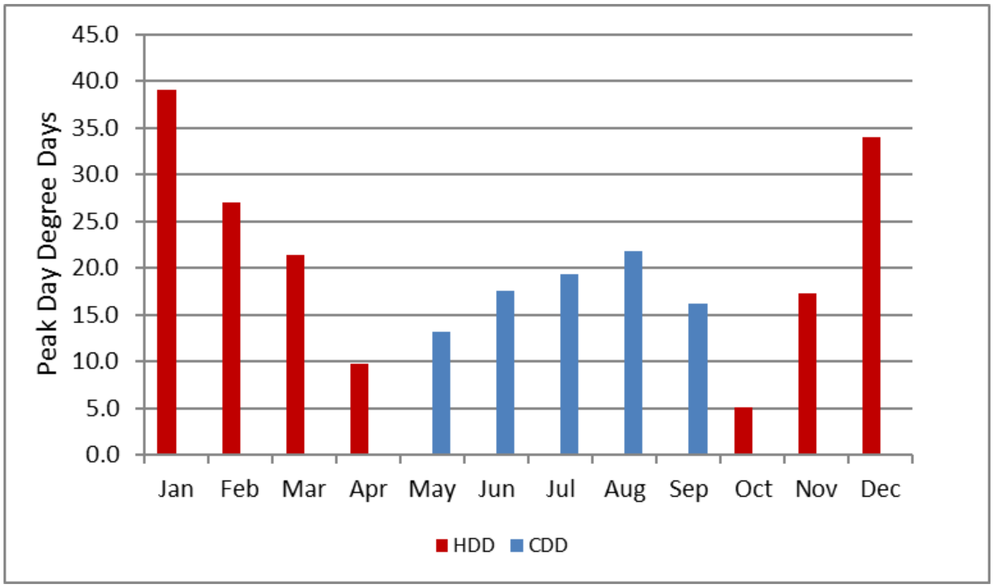
Figure 19: Monthly Peak Demand /Temperature Relationship



Peak-day cooling occurs when temperatures are above 65 degrees and peak-day heating occurs when temperatures are below 55 degrees.

Normal peak-day HDD and CDD are calculated using 20 years of historical weather data, based on a rank and average approach, these are not trended. The underlying rate class sales models incorporate trended normal weather; derived heating and cooling sales from these models are an input into the peak model. Using a trended peak weather would double count the impact of increasing temperatures. Normal peak-day HDD and CDD are based on the hottest and coldest days that occurred in each month over the historical time period. Figure 20 shows the normal peak-day HDD and CDD values used in the forecast.

Figure 20: Normal Peak-Day HDD & CDD



5.2 Economic Data

The class sales forecasts are based on *Moody's Economy.com* May 2019 economic forecast for the Evansville Metropolitan Statistical Area (MSA). The primary economic drivers in the residential sector are household income and the number of new households. Household formation is stable and increasing consistently though the forecast period with 0.4% average annual growth. Real household income growth is modest, averaging 1.6% over the forecast period.

Commercial sales are driven by nonmanufacturing output, nonmanufacturing employment, and population. Non-manufacturing output is forecasted to grow at 1.7% per year through the forecast period with non-manufacturing employment is growing 0.6% per year and population a little over 0.1% per year.

The industrial model relates sales to manufacturing output and employment. Manufacturing output is projected to increase more rapidly over the next 5 years, with output increasing 2.3% per year, over the long-term manufacturing output averages 1.8% annual growth. While output increases, associated manufacturing employment is projected to decline at a 0.5% annual rate.

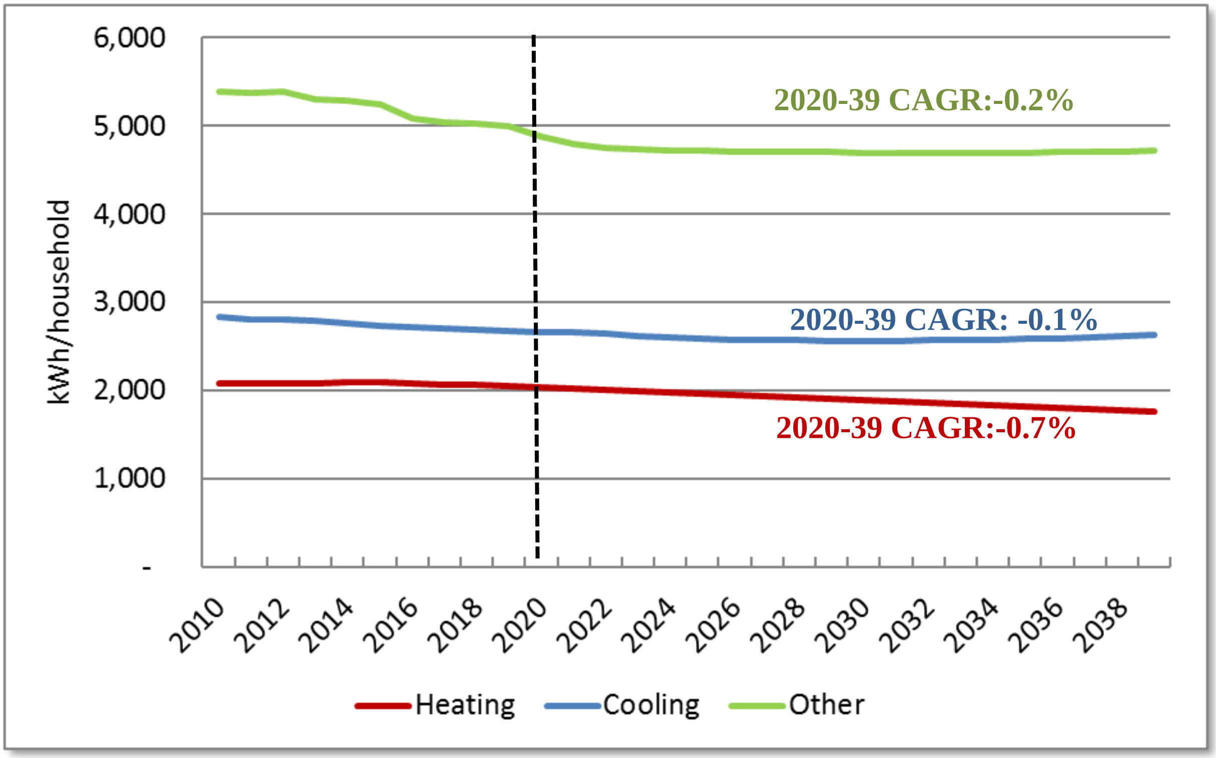
Historical electric prices (in real dollars) are derived from billed sales and revenue data. Historical prices are calculated as a 12-month moving average of the average rate (revenues divided by sales); prices are expressed in real dollars. Prices impact residential and commercial sales through imposed short-term price elasticities. Short-term price elasticities are small; residential and commercial price elasticities are set at -0.10. Price is not an input to the industrial sales model. Price projections are based on the Energy Information Administration's (EIA) long-term real growth rates. Over the forecast period, prices increase 1.5% annually.

5.3 Appliance Saturation and Efficiency Trends

Over the long-term, changes in end-use saturation and stock efficiency impact class sales, system energy, and peak demand. End-use energy intensities, expressed in kWh per household for the residential sector and kWh per square foot for the commercial sectors, are incorporated into the constructed forecast model variables. Energy intensities reflect both change in ownership (saturation) and average stock efficiency. In general, efficiency is improving faster than end-use saturation resulting in declining end-use energy use. Energy intensities are derived from Energy Information Administration's (EIA) 2019 Annual Energy Outlook and Vectren's appliance saturation surveys. The residential sector incorporates saturation and efficiency trends for seventeen end-uses. The commercial sector captures end-use intensity projections for ten end-use classifications across ten building types.

Residential end-use intensities are used in constructing the model end-use variables. Figure 21 shows the resulting aggregated end-use intensity projections.

Figure 21: Residential End-Use Energy Intensities

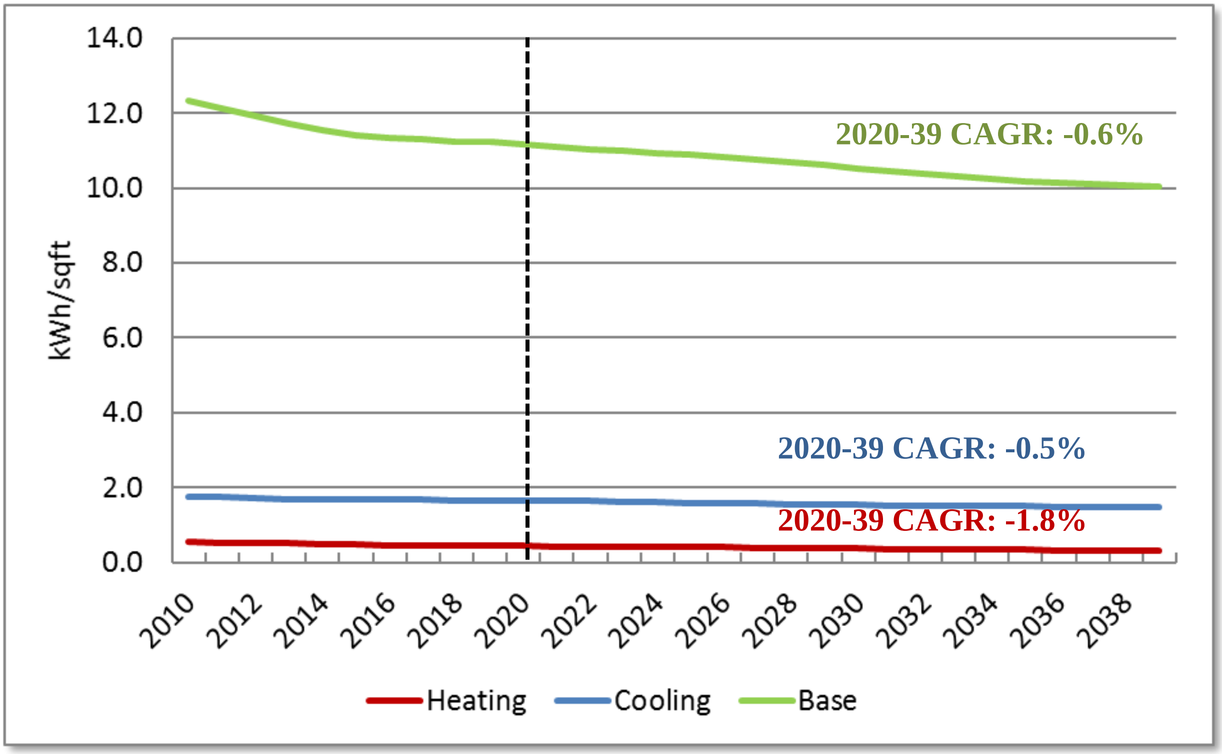


*CAGR=Compound Average Growth Rate

Heating intensity declines 0.7% annually through the forecast period, reflecting declining share in electric heat saturation. Cooling intensity declines 0.1% annually through the forecast period as overall air conditioning efficiency improvements outweigh increase in saturation. Total non-weather sensitive end-use intensity declines 0.2% annually.

Commercial end-use intensities (expressed in kWh per sqft) are based on the EIA's East South Central Census Division forecast; the starting intensity estimates are calibrated to Vectren commercial sales. As in the residential sector, end-use energy use has been declining as a result of new codes and standards and utility DSM programs. Figure 22 shows commercial end-use energy intensity forecasts for total heating, cooling, and non-weather sensitive loads.

Figure 22: Commercial End-Use Energy Intensity



Commercial usage is dominated by non-weather sensitive (Base) end-uses, which over the forecast period are projected to decline 0.6% per year. Cooling intensity declines 0.5% annually through the forecast period. Heating intensity declines even stronger at 1.8% annual rate though commercial electric heating is relatively small.

Appendix A: Model Statistics

Residential Average Use Model

Variable	Coefficient	StdErr	T-Stat	P-Value
mStructRev.XHeat	1.131	0.024	47.002	0.00%
mStructRev.XCool	1.102	0.015	72.536	0.00%
mStructRev.XOther	1.247	0.019	64.464	0.00%
mBin.Jan	41.217	10.23	4.029	0.01%
mBin.Aug	42.865	11.411	3.756	0.03%
mBin.Sep	34.721	10.421	3.332	0.12%
mBin.Oct	30.013	9.805	3.061	0.28%
mDSMF.DSM	-0.628	0.098	-6.44	0.00%

Model Statistics	
Iterations	1
Adjusted Observations	111
Deg. of Freedom for Error	103
R-Squared	0.989
Adjusted R-Squared	0.988
Model Sum of Squares	6,162,873.25
Sum of Squared Errors	70,284.55
Mean Squared Error	682.37
Std. Error of Regression	26.12
Mean Abs. Dev. (MAD)	19.03
Mean Abs. % Err. (MAPE)	1.93%
Durbin-Watson Statistic	1.81

Residential Customer Model

Variable	Coefficient	StdErr	T-Stat	P-Value
Economics.PopEV	960.574	2.859	335.981	0.00%
AR(1)	0.958	0.02	47.011	0.00%
MA(1)	0.438	0.086	5.101	0.00%

Model Statistics	
Iterations	8
Adjusted Observations	113
Deg. of Freedom for Error	110
R-Squared	0.996
Adjusted R-Squared	0.996
Model Sum of Squares	322,162,685.79
Sum of Squared Errors	1,295,103.33
Mean Squared Error	11,773.67
Std. Error of Regression	108.51
Mean Abs. Dev. (MAD)	87.12
Mean Abs. % Err. (MAPE)	0.07%
Durbin-Watson Statistic	1.91

VECTREN

Commercial Sales Model

Variable	Coefficient	StdErr	T-Stat	P-Value
mStructRev.XOther	9.238	1.188	7.776	0.00%
mStructRev.XCool	15.486	0.442	35.027	0.00%
mStructRev.XHeat	20.148	1.804	11.165	0.00%
mBin.Yr14	2763.076	860.831	3.21	0.18%
mBin.Feb	2174.958	1122.048	1.938	5.54%
mBin.Jun	-4324.45	995.223	-4.345	0.00%
mBin.Oct	3652.067	1025.239	3.562	0.06%
mBin.Nov	2720.101	1042.823	2.608	1.05%
mBin.Aug09Plus	29960.933	7537.599	3.975	0.01%
mDSM.DSM	-0.498	0.13	-3.826	0.02%

Model Statistics	
Iterations	1
Adjusted Observations	110
Deg. of Freedom for Error	100
R-Squared	0.964
Adjusted R-Squared	0.961
Model Sum of Squares	18,976,689,674.96
Sum of Squared Errors	712,451,460.27
Mean Squared Error	7,124,514.60
Std. Error of Regression	2,669.18
Mean Abs. Dev. (MAD)	1,974.42
Mean Abs. % Err. (MAPE)	1.82%
Durbin-Watson Statistic	1.586

Industrial Sales Model

Variable	Coefficient	StdErr	T-Stat	P-Value
mEcon.IndVar	118487.802	2254.45	52.557	0.00%
mWthrRev.CDD65	57.963	6.069	9.551	0.00%
mBin.Jul09Plus	29846.553	2190.612	13.625	0.00%
mBin.Feb	11020.029	3029.515	3.638	0.04%
mBin.Apr	7543.537	3000.036	2.514	1.32%
mBin.Sep	19778.485	3582.861	5.52	0.00%
mBin.Nov	17466.878	3505.353	4.983	0.00%
mBin.Yr09	-16514.547	3068.532	-5.382	0.00%
mBin.Yr16Plus	11358.694	1919.002	5.919	0.00%

Model Statistics	
Iterations	1
Adjusted Observations	137
Deg. of Freedom for Error	128
R-Squared	0.757
Adjusted R-Squared	0.742
Model Sum of Squares	37,889,478,247.99
Sum of Squared Errors	12,146,223,745.81
Mean Squared Error	94,892,373.01
Std. Error of Regression	9,741.27
Mean Abs. Dev. (MAD)	7,706.07
Mean Abs. % Err. (MAPE)	5.24%
Durbin-Watson Statistic	1.714

Residential Solar Adoption Model

Variable	Coefficient	StdErr	T-Stat	P-Value
CONST	23.491	11.774	1.995	5.04%
Payback.ResPayback	-1.31	0.866	-1.512	13.55%
AR(1)	0.144	0.126	1.143	25.75%

Model Statistics	
Iterations	6
Adjusted Observations	65
Deg. of Freedom for Error	62
R-Squared	0.068
Adjusted R-Squared	0.038
Model Sum of Squares	286.23
Sum of Squared Errors	3,925.31
Mean Squared Error	63.31
Std. Error of Regression	7.96
Mean Abs. Dev. (MAD)	3.71
Mean Abs. % Err. (MAPE)	91.11%
Durbin-Watson Statistic	2.009

Peak Model

Variable	Coefficient	StdErr	T-Stat	P-Value
mCPkEndUses.HeatVar	3.147	0.335	9.405	0.00%
mCPkEndUses.CoolVar	18.522	0.542	34.196	0.00%
mCPkEndUses.BaseVar	1.519	0.024	62.389	0.00%
mBin.Jan16	148.429	30.989	4.79	0.00%
mBin.Nov16	-86.871	31.195	-2.785	0.64%
mBin.Yr15	47.869	10.315	4.641	0.00%
mBin.May	-49.483	10.624	-4.658	0.00%
mBin.Oct	-48.783	11.583	-4.212	0.01%
mBin.Yr12Plus	-35.439	7.391	-4.795	0.00%

Model Statistics	
Iterations	1
Adjusted Observations	111
Deg. of Freedom for Error	102
R-Squared	0.952
Adjusted R-Squared	0.949
Model Sum of Squares	1,908,789.28
Sum of Squared Errors	95,539.47
Mean Squared Error	936.66
Std. Error of Regression	30.6
Mean Abs. Dev. (MAD)	22
Mean Abs. % Err. (MAPE)	2.81%
Durbin-Watson Statistic	1.855

Appendix B: Residential SAE Modeling Framework

The traditional approach to forecasting monthly sales for a customer class is to develop an econometric model that relates monthly sales to weather, seasonal variables, and economic conditions. From a forecasting perspective, econometric models are well suited to identify historical trends and to project these trends into the future. In contrast, the strength of the end-use modeling approach is the ability to identify the end-use factors that are drive energy use. By incorporating end-use structure into an econometric model, the statistically adjusted end-use (SAE) modeling framework exploits the strengths of both approaches.

There are several advantages to this approach.

- The equipment efficiency and saturation trends, dwelling square footage, and thermal shell integrity changes embodied in the long-run end-use forecasts are introduced explicitly into the short-term monthly sales forecast. This provides a strong bridge between the two forecasts.
- By explicitly introducing trends in equipment saturations, equipment efficiency, dwelling square footage, and thermal integrity levels, it is easier to explain changes in usage levels and changes in weather-sensitivity over time.
- Data for short-term models are often not sufficiently robust to support estimation of a full set of price, economic, and demographic effects. By bundling these factors with equipment-oriented drivers, a rich set of elasticities can be incorporated into the final model.

This section describes the SAE approach, the associated supporting SAE spreadsheets, and the *MetrixND* project files that are used in the implementation. The source for the SAE spreadsheets is the 2019 Annual Energy Outlook (AEO) database provided by the Energy Information Administration (EIA).

Residential Statistically Adjusted End-Use Modeling Framework

The statistically adjusted end-use modeling framework begins by defining energy use ($USE_{y,m}$) in year (y) and month (m) as the sum of energy used by heating equipment ($Heat_{y,m}$), cooling equipment ($Cool_{y,m}$), and other equipment ($Other_{y,m}$). Formally,

$$USE_{y,m} = Heat_{y,m} + Cool_{y,m} + Other_{y,m} \quad (1)$$

Although monthly sales are measured for individual customers, the end-use components are not. Substituting estimates for the end-use elements gives the following econometric equation.

$$USE_m = a + b_1 \times XHeat_m + b_2 \times XCool_m + b_3 \times XOther_m + \varepsilon_m \qquad (2)$$

$XHeat_m$, $XCool_m$, and $XOther_m$ are explanatory variables constructed from end-use information, dwelling data, weather data, and market data. As will be shown below, the equations used to construct these X-variables are simplified end-use models, and the X-variables are the estimated usage levels for each of the major end uses based on these models. The estimated model can then be thought of as a statistically adjusted end-use model, where the estimated slopes are the adjustment factors.

Constructing XHeat

As represented in the SAE spreadsheets, energy use by space heating systems depends on the following types of variables.

- Heating degree days
- Heating equipment saturation levels
- Heating equipment operating efficiencies
- Thermal integrity and footage of homes
- Average household size, household income, and energy prices

The heating variable is represented as the product of an annual equipment index and a monthly usage multiplier. That is,

$$XHeat_{y,m} = HeatIndex_{y,m} \times HeatUse_{y,m} \qquad (3)$$

Where:

- $XHeat_{y,m}$ is estimated heating energy use in year (y) and month (m)
- $HeatIndex_{y,m}$ is the monthly index of heating equipment
- $HeatUse_{y,m}$ is the monthly usage multiplier

The heating equipment index is defined as a weighted average across equipment types of equipment saturation levels normalized by operating efficiency levels. Given a set of fixed weights, the index will change over time with changes in equipment saturations (*Sat*), operating efficiencies (*Eff*), building structural index (*StructuralIndex*), and energy prices. Formally, the equipment index is defined as:

$$HeatIndex_y = StructuralIndex_y \times \sum_{Type} Weight^{Type} \times \frac{\left(Sat_y^{Type} \big/ Eff_y^{Type} \right)}{\left(Sat_{2015}^{Type} \big/ Eff_{2015}^{Type} \right)} \qquad (4)$$

The *StructuralIndex* is constructed by combining the EIA's building shell efficiency index trends with surface area estimates, and then it is indexed to the 2015 value:

$$StructuralIndex_y = \frac{BuildingShellEfficiencyIndex_y \times SurfaceArea_y}{BuildingShellEfficiencyIndex_{2015} \times SurfaceArea_{2015}} \qquad (5)$$

The *StructuralIndex* is defined on the *StructuralVars* tab of the SAE spreadsheets. Surface area is derived to account for roof and wall area of a standard dwelling based on the regional average square footage data obtained from EIA. The relationship between the square footage and surface area is constructed assuming an aspect ratio of 0.75 and an average of 25% two-story and 75% single-story. Given these assumptions, the approximate linear relationship for surface area is:

$$SurfaceArea_y = 892 + 1.44 \times Footage_y \qquad (6)$$

For electric heating equipment, the SAE spreadsheets contain two equipment types: electric resistance furnaces/room units and electric space heating heat pumps. Examples of weights for these two equipment types for the U.S. are given in Table 1.

Table 1: Electric Space Heating Equipment Weights

Equipment Type	Weight (kWh)
Electric Resistance Furnace/Room units	767
Electric Space Heating Heat Pump	127

Data for the equipment saturation and efficiency trends are presented on the *Shares* and *Efficiencies* tabs of the SAE spreadsheets. The efficiency for electric space heating heat pumps are given in terms of Heating Seasonal Performance Factor [BTU/Wh], and the efficiencies for electric furnaces and room units are estimated as 100%, which is equivalent to 3.41 BTU/Wh.

Heating system usage levels are impacted on a monthly basis by several factors, including weather, household size, income levels, prices, and billing days. The estimates for space heating equipment usage levels are computed as follows:

$$HeatUse_{y,m} = \left(\frac{HDD_{y,m}}{HDD_{05}}\right) \times \left(\frac{HHSize_y}{HHSize_{05,7}}\right)^{0.25} \times \left(\frac{Income_y}{Income_{05,7}}\right)^{0.10} \times \left(\frac{Elec\,Price_{y,m}}{Elec\,Price_{05,7}}\right)^{-0.10} \tag{7}$$

Where:

- *HDD* is the number of heating degree days in year (*y*) and month (*m*).
- *HHSize* is average household size in a year (*y*)
- *Income* is average real income per household in year (*y*)
- *ElecPrice* is the average real price of electricity in month (*m*) and year (*y*)

By construction, the $HeatUse_{y,m}$ variable has an annual sum that is close to 1.0 in the base year (2005). The first term, which involves heating degree days, serve to allocate annual values to months of the year. The remaining terms average to 1.0 in the base year. In other years, the values will reflect changes in the economic drivers, as transformed through the end-use elasticity parameters. The price impacts captured by the Usage equation represent short-term price response.

Constructing XCool

The explanatory variable for cooling loads is constructed in a similar manner. The amount of energy used by cooling systems depends on the following types of variables.

- Cooling degree days
- Cooling equipment saturation levels
- Cooling equipment operating efficiencies
- Thermal integrity and footage of homes
- Average household size, household income, and energy prices

The cooling variable is represented as the product of an equipment-based index and monthly usage multiplier. That is,

$$XCool_{y,m} = CoolIndex_y \times CoolUse_{y,m} \tag{8}$$

Where

- $XCool_{y,m}$ is estimated cooling energy use in year (*y*) and month (*m*)

- $CoolIndex_y$ is an index of cooling equipment
- $CoolUse_{y,m}$ is the monthly usage multiplier

As with heating, the cooling equipment index is defined as a weighted average across equipment types of equipment saturation levels normalized by operating efficiency levels. Formally, the cooling equipment index is defined as:

$$CoolIndex_y = StructuralIndex_y \times \sum_{Type} Weight^{Type} \times \frac{\left(Sat_y^{Type} \middle/ Eff_y^{Type} \right)}{\left(Sat_{2015}^{Type} \middle/ Eff_{2015}^{Type} \right)} \qquad (9)$$

For cooling equipment, the SAE spreadsheets contain three equipment types: central air conditioning, space cooling heat pump, and room air conditioning. Examples of weights for these three equipment types for the U.S. are given in Table 2.

Table 2: Space Cooling Equipment Weights

Equipment Type	Weight (kWh)
Central Air Conditioning	1,219
Space Cooling Heat Pump	240
Room Air Conditioning	177

The equipment saturation and efficiency trends data are presented on the *Shares* and *Efficiencies* tabs of the SAE spreadsheets. The efficiency for space cooling heat pumps and central air conditioning (A/C) units are given in terms of Seasonal Energy Efficiency Ratio [BTU/Wh], and room A/C units efficiencies are given in terms of Energy Efficiency Ratio [BTU/Wh].

Cooling system usage levels are impacted on a monthly basis by several factors, including weather, household size, income levels, and prices. The estimates of cooling equipment usage levels are computed as follows:

$$CoolUse_{y,m} = \left(\frac{CDD_{y,m}}{CDD_{05}}\right) \times \left(\frac{HHSize_y}{HHSize_{05,7}}\right)^{0.25} \times \left(\frac{Income_y}{Income_{05,7}}\right)^{0.10} \times \left(\frac{Elec\,Price_{y,m}}{Elec\,Price_{05,7}}\right)^{-0.10} \qquad (10)$$

Where:

- *CDD* is the number of cooling degree days in year (*y*) and month (*m*).

- *HHSize* is average household size in a year (*y*)
- *Income* is average real income per household in year (*y*)
- *ElecPrice* is the average real price of electricity in month (*m*) and year (*y*)

By construction, the *CoolUse* variable has an annual sum that is close to 1.0 in the base year (2005). The first term, which involves cooling degree days, serve to allocate annual values to months of the year. The remaining terms average to 1.0 in the base year. In other years, the values will change to reflect changes in the economic driver changes.

Constructing XOther

Monthly estimates of non-weather sensitive sales can be derived in a similar fashion to space heating and cooling. Based on end-use concepts, other sales are driven by:

- Appliance and equipment saturation levels
- Appliance efficiency levels
- Average number of days in the billing cycle for each month
- Average household size, real income, and real prices

The explanatory variable for other uses is defined as follows:

$$XOther_{y,m} = OtherEqpIndex_{y,m} \times OtherUse_{y,m} \tag{11}$$

The first term on the right-hand side of this expression ($OtherEqpIndex_y$) embodies information about appliance saturation and efficiency levels and monthly usage multipliers. The second term (*OtherUse*) captures the impact of changes in prices, income, household size, and number of billing-days on appliance utilization.

End-use indices are constructed in the SAE models. A separate end-use index is constructed for each end-use equipment type using the following function form.

$$ApplianceIndex_{y,m} = Weight^{Type} \times \frac{\left(Sat_y^{Type} \Big/ \frac{1}{UEC_y^{Type}} \right)}{\left(Sat_{2015}^{Type} \Big/ \frac{1}{UEC_{2015}^{Type}} \right)} \times MoMult_m^{Type} \times \tag{12}$$

Where:

- *Weight* is the weight for each appliance type
- *Sat* represents the fraction of households, who own an appliance type
- $MoMult_m$ is a monthly multiplier for the appliance type in month (*m*)
- *Eff* is the average operating efficiency the appliance
- *UEC* is the unit energy consumption for appliances

This index combines information about trends in saturation levels and efficiency levels for the main appliance categories with monthly multipliers for lighting, water heating, and refrigeration.

The appliance saturation and efficiency trends data are presented on the *Shares* and *Efficiencies* tabs of the SAE spreadsheets.

Further monthly variation is introduced by multiplying by usage factors that cut across all end uses, constructed as follows:

$$ApplianceUse_{y,m} = \left(\frac{BDays_{y,m}}{30.5}\right) \times \left(\frac{HHSize_y}{HHSize_{05,7}}\right)^{0.25} \times \left(\frac{Income_y}{Income_{05,7}}\right)^{0.10} \times \left(\frac{ElecPrice_{y,m}}{ElecPrice_{05,7}}\right)^{-0.10} \tag{13}$$

The index for other uses is derived then by summing across the appliances:

$$OtherEqpIndex_{y,m} = \sum_k ApplianceIndex_{y,m} \times ApplianceUse_{y,m} \tag{14}$$

Appendix C: Commercial SAE Modeling Framework

The traditional approach to forecasting monthly sales for a customer class is to develop an econometric model that relates monthly sales to weather, seasonal variables, and economic conditions. From a forecasting perspective, the strength of econometric models is that they are well suited to identifying historical trends and to projecting these trends into the future. In contrast, the strength of the end-use modeling approach is the ability to identify the end-use factors that are driving energy use. By incorporating end-use structure into an econometric model, the statistically adjusted end-use (SAE) modeling framework exploits the strengths of both approaches.

There are several advantages to this approach.

- The equipment efficiency trends and saturation changes embodied in the long-run end-use forecasts are introduced explicitly into the short-term monthly sales forecast. This provides a strong bridge between the two forecasts.
- By explicitly introducing trends in equipment saturations and equipment efficiency levels, it is easier to explain changes in usage levels and changes in weather-sensitivity over time.
- Data for short-term models are often not sufficiently robust to support estimation of a full set of price, economic, and demographic effects. By bundling these factors with equipment-oriented drivers, a rich set of elasticities can be built into the final model.

This document describes this approach, the associated supporting Commercial SAE spreadsheets, and *MetrixND* project files that are used in the implementation. The source for the commercial SAE spreadsheets is the 2019 Annual Energy Outlook (AEO) database provided by the Energy Information Administration (EIA).

Commercial Statistically Adjusted End-Use Model Framework

The commercial statistically adjusted end-use model framework begins by defining energy use ($USE_{y,m}$) in year (y) and month (m) as the sum of energy used by heating equipment ($Heat_{y,m}$), cooling equipment ($Cool_{y,m}$) and other equipment ($Other_{y,m}$). Formally,

$$USE_{y,m} = Heat_{y,m} + Cool_{y,m} + Other_{y,m} \quad (1)$$

Although monthly sales are measured for individual customers, the end-use components are not. Substituting estimates for the end-use elements gives the following econometric equation.

$$USE_m = a + b_1 \times XHeat_m + b_2 \times XCool_m + b_3 \times XOther_m + \varepsilon_m \tag{2}$$

Here, $XHeat_m$, $XCool_m$, and $XOther_m$ are explanatory variables constructed from end-use information, weather data, and market data. As will be shown below, the equations used to construct these X-variables are simplified end-use models, and the X-variables are the estimated usage levels for each of the major end uses based on these models. The estimated model can then be thought of as a statistically adjusted end-use model, where the estimated slopes are the adjustment factors.

Constructing XHeat

As represented in the Commercial SAE spreadsheets, energy use by space heating systems depends on the following types of variables.

- Heating degree days,
- Heating equipment saturation levels,
- Heating equipment operating efficiencies,
- Commercial output, employment, population, and energy price.

The heating variable is represented as the product of an annual equipment index and a monthly usage multiplier. That is,

$$XHeat_{y,m} = HeatIndex_y \times HeatUse_{y,m} \tag{3}$$

Where:

- *$XHeat_{y,m}$ is estimated heating energy use in year (y) and month (m),*
- *$HeatIndex_y$ is the annual index of heating equipment, and*
- *$HeatUse_{y,m}$ is the monthly usage multiplier.*

The heating equipment index is composed of electric space heating equipment saturation levels normalized by operating efficiency levels. The index will change over time with changes in heating equipment saturations (*HeatShare*) and operating efficiencies (*Eff*). Formally, the equipment index is defined as:

$$HeatIndex_y = HeatSales_{2013} \times \frac{\left(HeatShare_y / Eff_y\right)}{\left(HeatShare_{2013} / Eff_{2013}\right)} \tag{4}$$

In this expression, 2013 is used as a base year for normalizing the index. The ratio on the right is equal to 1.0 in 2004. In other years, it will be greater than one if equipment saturation levels are above their 201

level. This will be counteracted by higher efficiency levels, which will drive the index downward. Base year space heating sales are defined as follows.

$$HeatSales_{2013} = \left(\frac{kWh}{Sqft}\right)_{Heating} \times \left(\frac{CommercialSales_{2013}}{\sum_e {kWh}/{Sqft_e}}\right) \tag{5}$$

Here, base-year sales for space heating is the product of the average space heating intensity value and the ratio of total commercial sales in the base year over the sum of the end-use intensity values. In the Commercial SAE Spreadsheets, the space heating sales value is defined on the *BaseYrInput* tab. The resulting $HeatIndex_y$ value in 2013 will be equal to the estimated annual heating sales in that year. Variations from this value in other years will be proportional to saturation and efficiency variations around their base values.

Heating system usage levels are impacted on a monthly basis by several factors, including weather, commercial level economic activity, prices and billing days. Using the COMMEND default elasticity parameters, the estimates for space heating equipment usage levels are computed as follows:

$$HeatUse_{y,m} = \left(\frac{HDD_{y,m}}{HDD_{05}}\right) \times \left(\frac{EconVar_{y,m}}{EconVar_{05,7}}\right) \times \left(\frac{Price_{y,m}}{Price_{05,7}}\right)^{-0.10} \tag{6}$$

Where:

- *HDD* is the number of heating degree days in month (m) and year (y).
- *EconVar* is the weighted commercial economic variable that blends Output, Employment, and Population in month (m), and year (y).
- *Price* is the average real price of electricity in month (m) and year (y).

By construction, the $HeatUse_{y,m}$ variable has an annual sum that is close to one in the base year (2004). The first term, which involves heating degree days, serve to allocate annual values to months of the year. The remaining terms average to one in the base year. In other years, the values will reflect changes in commercial output and prices, as transformed through the end-use elasticity parameters. For example, if the real price of electricity goes up

10% relative to the base year value, the price term will contribute a multiplier of about .98 (computed as 1.10 to the -0.18 power).

Constructing XCool

The explanatory variable for cooling loads is constructed in a similar manner. The amount of energy used by cooling systems depends on the following types of variables.

- Cooling degree days,
- Cooling equipment saturation levels,
- Cooling equipment operating efficiencies,
- Commercial output, employment, population and energy price.

The cooling variable is represented as the product of an equipment-based index and monthly usage multiplier. That is,

$$\mathrm{XCool}_{y,m} = \mathrm{CoolIndex}_{y} \times \mathrm{CoolUse}_{y,m} \tag{7}$$

Where:

- $XCool_{y,m}$ is estimated cooling energy use in year (y) and month (m),
- $CoolIndex_y$ is an index of cooling equipment, and
- $CoolUse_{y,m}$ is the monthly usage multiplier.

As with heating, the cooling equipment index depends on equipment saturation levels (*CoolShare*) normalized by operating efficiency levels (*Eff*). Formally, the cooling equipment index is defined as:

$$CoolIndex_y = CoolSales_{2013} \times \frac{\left(CoolShare_y / Eff_y\right)}{\left(CoolShare_{2013} / Eff_{2013}\right)} \tag{8}$$

Data values in 2013 are used as a base year for normalizing the index, and the ratio on the right is equal to 1.0 in 2013. In other years, it will be greater than one if equipment saturation levels are above their 2013 level. This will be counteracted by higher efficiency levels, which will drive the index downward. Estimates of base year cooling sales are defined as follows.

$$CoolSales_{2013} = \left(\frac{kWh}{Sqft}\right)_{Cooling} \times \left(\frac{CommercialSales_{2013}}{\sum_e {}^{kWh}/_{Sqft_e}}\right) \tag{9}$$

Here, base-year sales for space cooling is the product of the average space cooling intensity value and the ratio of total commercial sales in the base year over the sum of the end-use intensity values. In the Commercial SAE Spreadsheets, the space cooling sales value is defined on the *BaseYrInput* tab. The resulting *CoolIndex* value in 2013 will be equal to the estimated annual cooling sales in that year. Variations from this value in other years will be proportional to saturation and efficiency variations around their base values.

Cooling system usage levels are impacted on a monthly basis by several factors, including weather, economic activity levels and prices. Using the COMMEND default parameters, the estimates of cooling equipment usage levels are computed as follows:

$$CoolUse_{y,m} = \left(\frac{CDD_{y,m}}{CDD_{05}}\right) \times \left(\frac{EconVar_{y,m}}{EconVar_{05,7}}\right) \times \left(\frac{Price_{y,m}}{Price_{05,7}}\right)^{-0.10} \quad (10)$$

Where:

- *HDD* is the number of heating degree days in month (m) and year (y).
- *EconVar* is the weighted commercial economic variable that blends Output, Employment, and Population in month (m), and year (y).
- *Price* is the average real price of electricity in month (m) and year (y).

By construction, the *CoolUse* variable has an annual sum that is close to one in the base year (2004). The first term, which involves cooling degree days, serve to allocate annual values to months of the year. The remaining terms average to one in the base year. In other years, the values will change to reflect changes in commercial output and prices.

Constructing XOther

Monthly estimates of non-weather sensitive sales can be derived in a similar fashion to space heating and cooling. Based on end-use concepts, other sales are driven by:

- Equipment saturation levels,
- Equipment efficiency levels,
- Average number of days in the billing cycle for each month, and
- Real commercial output and real prices.

The explanatory variable for other uses is defined as follows:

$$XOther_{y,m} = OtherIndex_{y,m} \times OtherUse_{y,m} \quad (11)$$

The second term on the right-hand side of this expression embodies information about equipment saturation levels and efficiency levels. The equipment index for other uses is defined as follows:

$$OtherIndex_{y,m} = \sum_{Type} Weight_{2013}^{Type} \times \left(\frac{Share_{y}^{Type} / Eff_{y}^{Type}}{Share_{2013}^{Type} / Eff_{2013}^{Type}} \right) \qquad (12)$$

Where:

- *Weight* is the weight for each equipment type,
- *Share* represents the fraction of floor stock with an equipment type, and
- *Eff* is the average operating efficiency.

This index combines information about trends in saturation levels and efficiency levels for the main equipment categories. The weights are defined as follows:

$$Weight_{2013}^{Type} = \left(\frac{kWh}{Sqft}\right)_{Type} \times \left(\frac{CommercialSales_{04}}{\sum_e kWh / Sqft_e}\right) \qquad (13)$$

Further monthly variation is introduced by multiplying by usage factors that cut across all end uses, constructed as follows:

$$OtherUse_{y,m} = \left(\frac{BDays_{y,m}}{30.5}\right) \times \left(\frac{EconVar_{y,m}}{EconVar_{05,7}}\right) \times \left(\frac{Price_{y.m}}{Price_{05,7}}\right)^{-0.10} \qquad (14)$$

Attachment 4.2 Vectren Hourly System Load Data

Dt	Hour1	Hour2	Hour3	Hour4	Hour5	Hour6	Hour7	Hour8	Hour9	Hour10	Hour11	Hour12	Hour13	Hour14	Hour15	Hour16	Hour17	Hour18	Hour19	Hour20	Hour21	Hour22	Hour23	Hour24
1/1/2018	664	641	649	632	642	650	652	667	662	669	665	658	658	644	637	630	632	671	712	722	718	718	703	684
1/2/2018	673	665	667	675	680	703	772	779	790	787	770	759	724	715	695	688	695	718	749	763	770	767	744	723
1/3/2018	700	684	691	679	676	684	709	742	759	739	748	717	695	681	682	690	694	705	694	720	719	734	711	684
1/4/2018	676	676	671	682	685	710	740	789	798	795	770	747	735	728	721	703	711	725	772	754	767	750	728	706
1/5/2018	677	671	668	658	666	671	706	740	748	752	748	752	726	719	707	698	697	706	741	738	743	739	728	719
1/6/2018	698	693	697	688	703	693	718	733	742	730	717	699	679	653	631	631	620	653	688	695	685	691	683	663
1/7/2018	640	635	624	619	611	616	606	626	631	633	640	614	604	587	587	578	588	603	628	625	621	595	578	556
1/8/2018	532	525	518	512	523	540	589	706	723	716	723	716	718	713	707	705	708	711	732	728	724	714	683	657
1/9/2018	634	619	609	610	607	627	656	692	723	716	723	719	707	708	699	694	693	699	717	716	633	612	594	556
1/10/2018	528	513	509	499	504	503	539	570	585	576	583	585	577	573	567	566	572	576	586	589	576	569	553	518
1/11/2018	490	480	470	459	468	467	500	541	563	566	570	576	566	566	570	564	573	563	589	581	575	567	538	528
1/12/2018	511	508	513	532	540	568	593	631	663	672	693	702	701	694	696	681	671	680	699	687	680	660	636	606
1/13/2018	589	575	563	567	568	579	589	606	602	618	622	659	659	650	633	627	631	659	706	706	710	705	701	679
1/14/2018	673	666	667	670	673	685	691	714	719	712	694	686	666	658	651	651	662	684	718	707	701	700	679	658
1/15/2018	646	638	637	640	639	657	679	708	725	742	741	752	743	731	739	726	742	738	777	769	772	753	739	729
1/16/2018	709	715	714	718	726	743	772	809	823	825	818	808	808	799	752	746	754	772	800	797	791	780	756	730
1/17/2018	708	701	696	700	702	706	734	770	769	779	761	740	724	719	707	690	693	714	750	767	761	755	741	720
1/18/2018	698	688	690	683	683	694	729	762	767	749	730	719	686	678	673	662	658	668	710	713	719	706	691	651
1/19/2018	638	618	614	617	617	632	660	689	696	687	670	651	639	631	607	609	598	604	644	642	632	627	602	587
1/20/2018	557	552	540	538	536	545	543	550	558	555	550	538	525	526	520	516	521	531	551	552	545	535	515	496
1/21/2018	467	458	447	446	444	440	456	464	477	486	499	501	496	501	498	496	497	507	540	536	536	515	495	469
1/22/2018	439	440	431	424	429	448	489	547	563	582	582	581	596	590	582	569	564	562	589	595	597	583	571	537
1/23/2018	510	495	503	491	509	514	556	600	624	627	623	628	619	623	630	629	638	647	668	663	657	646	621	590
1/24/2018	560	549	549	540	545	554	594	629	638	645	640	624	616	603	599	586	579	600	635	648	652	645	629	600
1/25/2018	589	587	582	577	588	603	627	682	679	659	646	624	615	602	594	581	574	580	607	621	616	615	590	566
1/26/2018	539	537	528	530	530	540	572	618	632	612	606	595	579	585	568	562	556	553	577	586	583	572	562	537
1/27/2018	508	493	479	481	477	484	486	502	519	530	545	554	555	553	546	540	546	541	556	567	551	562	546	526
1/28/2018	506	494	491	492	499	505	507	525	531	531	524	510	504	496	488	478	485	495	542	552	558	549	534	509
1/29/2018	494	483	475	478	495	506	561	614	634	639	653	654	653	652	657	654	663	663	684	675	682	669	642	615
1/30/2018	589	570	568	566	576	600	631	682	686	682	666	652	633	629	610	612	606	612	658	667	671	658	643	615
1/31/2018	591	578	573	569	567	583	617	661	671	649	650	640	617	608	597	592	579	583	619	616	618	612	586	560
2/1/2018	526	513	513	507	503	524	546	583	607	612	617	616	613	628	635	652	655	664	674	692	692	695	668	636
2/2/2018	625	610	617	614	623	632	673	718	721	710	694	687	663	655	641	632	615	629	667	677	684	687	661	631
2/3/2018	615	596	599	587	595	591	589	599	604	609	619	621	598	585	567	556	561	572	596	593	591	576	550	519
2/4/2018	512	485	487	472	478	481	488	499	510	511	520	512	509	517	523	545	559	584	604	615	611	617	606	594
2/5/2018	585	568	568	563	579	601	645	709	722	704	682	683	663	650	635	629	622	647	681	686	688	672	644	598
2/6/2018	580	562	571	558	564	580	613	650	665	669	667	670	643	630	613	616	610	621	646	656	653	646	620	595
2/7/2018	571	549	555	548	559	575	614	645	663	672	682	694	676	658	656	653	649	642	671	639	657	664	638	611
2/8/2018	596	593	592	593	602	619	656	695	706	684	673	651	621	624	605	594	598	593	626	645	642	642	624	589
2/9/2018	571	559	555	550	549	560	582	623	635	623	614	605	592	576	577	560	552	554	568	576	562	564	543	525
2/10/2018	501	497	490	484	484	478	485	494	508	524	546	555	546	544	542	535	532	540	566	562	559	548	530	516
2/11/2018	495	477	476	464	471	480	486	513	524	546	559	571	578	583	591	589	598	604	625	633	626	614	598	568
2/12/2018	548	548	545	546	556	575	628	681	694	685	672	661	646	629	627	611	610	613	637	660	665	656	633	608
2/13/2018	580	578	574	578	580	590	624	673	679	679	671	657	638	626	615	599	586	584	614	622	622	605	582	558
2/14/2018	529	524	516	507	507	512	540	581	594	599	599	594	589	590	585	575	578	577	581	583	576	571	550	523
2/15/2018	497	484	474	468	469	475	501	545	557	565	574	570	570	569	575	575	568	557	577	591	586	574	555	519
2/16/2018	495	480	463	462	461	456	482	530	551	573	581	589	588	585	589	595	583	589	593	597	587	585	563	543
2/17/2018	519	508	501	507	501	512	511	519	526	540	564	580	575	578	561	561	553	560	565	570	558	544	534	520
2/18/2018	498	497	494	495	495	503	512	527	526	532	518	499	495	490	477	473	477	483	518	540	532	527	501	473
2/19/2018	459	448	441	432	435	461	488	536	543	546	560	569	559	566	566	559	551	560	567	577	582	567	537	510
2/20/2018	488	474	463	457	457	462	496	528	539	554	559	573	571	578	578	589	573	569	580	595	593	580	556	526
2/21/2018	496	475	460	447	442	454	480	530	554	563	574	581	585	590	595	586	593	599	613	618	606	599	575	548
2/22/2018	522	515	513	511	510	518	542	583	591	596	593	594	582	578	587	580	565	571	582	584	584	579	555	532
2/23/2018	506	492	492	478	482	493	519	554	561	573	569	570	571	568	567	564	565	553	558	566	561	561	544	519
2/24/2018	491	479	468	464	463	466	476	490	506	525	547	546	547	547	541	537	534	545	566	564	561	544	525	502
2/25/2018	481	457	452	452	446	446	454	452	464	484	489	495	487	483	471	476	476	493	511	546	536	535	510	486
2/26/2018	474	468	464	470	465	499	535	586	590	578	574	569	559	560	557	548	545	544	551	578	579	579	560	529
2/27/2018	515	504	504	497	506	524	556	591	595	580	564	568	551	558	551	549	539	543	557	577	566	568	539	514
2/28/2018	485	471	463	462	467	477	497	542	550	554	560	562	556	557	560	559	561	552	567	578	569	558	532	505
3/1/2018	471	465	458	449	440	445	475	522	532	542	553	555	542	553	549	551	552	542	565	574	569	571	542	527
3/2/2018	497	488	491	490	491	506	544	575	578	562	559	550	538	537	534	524	517	514	524	535	547	547	539	517
3/3/2018	499	483	479	481	483	488	507	502	508	498	493	490	479	464	460	455	445	449	464	484	490	486	478	456
3/4/2018	433	428	424	425	427	436	445	459	466	471	475	464	459	454	451	444	448	455	481	506	504	501	487	461
3/5/2018	449	445	443	442	446	466	502	547	559	572	579	572	581	577	572	577	576	579	584	591	588	563	550	523
3/6/2018	495	495	487	483	484	509	545	573	575	564	564	548	551	552	542	546	547	559	561	593	590	583	565	534

Dt	Hour1	Hour2	Hour3	Hour4	Hour5	Hour6	Hour7	Hour8	Hour9	Hour10	Hour11	Hour12	Hour13	Hour14	Hour15	Hour16	Hour17	Hour18	Hour19	Hour20	Hour21	Hour22	Hour23	Hour24
3/7/2018	515	510	500	509	517	519	550	592	608	596	598	608	605	598	591	595	593	594	603	626	614	607	593	566
3/8/2018	544	533	532	525	529	545	585	624	629	613	618	612	603	594	589	577	571	577	598	609	625	627	608	585
3/9/2018	560	558	557	561	562	580	607	643	646	636	624	611	588	576	562	570	554	556	566	583	577	574	564	539
3/10/2018	507	504	486	491	484	492	498	502	515	520	520	507	498	478	482	472	469	477	488	519	513	509	497	472
3/11/2018	447	440	429	432	430	446	460	466	482	486	490	499	503	506	517	530	547	554	569	587	575	559	518	498
3/12/2018	493	479	489	495	512	551	591	614	618	616	609	608	621	634	627	622	619	608	610	632	629	606	573	553
3/13/2018	538	542	533	538	553	587	641	655	635	623	613	596	614	595	588	577	588	585	599	624	619	607	573	554
3/14/2018	543	543	544	554	567	608	654	681	652	642	612	606	589	582	580	571	559	558	570	604	617	593	564	538
3/15/2018	538	515	512	518	526	552	599	611	596	585	577	573	564	561	545	558	544	533	542	566	562	548	521	498
3/16/2018	488	483	475	480	486	518	569	587	596	600	608	593	587	572	579	561	554	547	560	575	573	560	538	505
3/17/2018	485	474	477	477	480	491	514	514	533	547	540	529	528	519	511	498	495	505	516	529	529	522	504	489
3/18/2018	467	466	453	455	456	453	468	477	482	486	498	485	482	475	468	471	467	478	483	517	514	500	470	453
3/19/2018	446	441	445	450	473	512	564	585	585	582	577	570	571	569	578	566	580	567	585	597	588	565	528	500
3/20/2018	480	481	480	484	506	535	576	613	613	620	631	623	626	625	625	625	622	622	632	641	638	615	582	557
3/21/2018	543	538	540	532	543	573	613	633	625	630	614	616	600	595	575	567	557	552	563	594	600	578	550	527
3/22/2018	515	519	516	519	542	575	623	632	618	600	587	571	564	556	546	542	536	526	538	566	574	554	529	492
3/23/2018	488	478	471	475	492	508	572	576	591	589	583	582	571	569	549	545	533	535	547	563	555	549	527	508
3/24/2018	484	490	478	480	481	489	508	514	545	559	567	566	564	554	562	560	557	559	553	575	561	546	523	510
3/25/2018	487	473	471	471	463	484	489	505	524	536	531	520	507	497	500	495	504	510	514	534	530	522	498	471
3/26/2018	468	456	456	460	494	519	565	577	578	575	582	581	574	569	569	567	571	575	573	586	581	559	524	503
3/27/2018	486	476	478	467	478	493	532	547	557	567	572	569	573	567	570	565	570	555	563	564	570	546	519	487
3/28/2018	472	463	462	454	467	487	518	543	571	569	572	573	565	569	564	555	554	541	551	565	565	549	519	493
3/29/2018	474	472	465	455	470	491	529	542	553	565	569	576	569	561	566	556	552	545	559	570	570	549	517	482
3/30/2018	465	465	446	455	460	483	509	530	538	545	525	518	517	510	502	502	488	492	490	507	522	514	488	471
3/31/2018	459	458	452	461	468	466	470	472	481	480	478	472	467	457	459	457	465	464	476	476	478	464	454	425
4/1/2018	408	403	398	398	401	410	431	445	464	463	469	454	450	431	435	441	459	476	499	521	525	511	503	488
4/2/2018	564	560	556	554	583	623	677	692	707	710	700	700	693	691	682	679	680	672	681	702	700	665	628	607
4/3/2018	575	565	570	559	571	589	630	637	639	640	646	647	655	655	655	644	646	648	656	650	639	615	589	575
4/4/2018	556	563	570	571	593	626	677	691	697	703	692	688	684	675	664	654	653	660	663	657	664	680	652	631
4/5/2018	629	622	622	639	645	680	719	725	709	687	675	657	656	647	639	628	548	533	538	568	583	560	525	518
4/6/2018	504	486	489	480	495	523	560	564	568	551	554	544	546	538	530	536	527	521	531	558	561	558	544	515
4/7/2018	508	509	508	509	509	520	540	537	554	561	560	534	528	508	503	490	489	488	494	516	527	526	505	488
4/8/2018	481	479	475	481	481	495	507	514	524	514	506	503	497	492	484	484	504	505	526	537	539	517	496	464
4/9/2018	469	470	471	473	495	528	585	597	596	587	572	561	554	545	529	539	529	525	546	571	569	553	522	491
4/10/2018	484	478	476	479	498	536	574	587	587	580	580	573	567	572	560	561	561	552	564	579	595	579	550	521
4/11/2018	518	518	516	510	528	541	587	586	575	570	563	562	554	550	550	535	533	525	522	557	562	541	516	478
4/12/2018	468	459	453	452	461	490	528	541	546	547	556	556	558	566	564	561	555	556	545	569	569	542	509	483
4/13/2018	458	446	444	438	449	475	511	526	548	562	567	567	577	573	564	565	570	559	560	571	572	567	527	493
4/14/2018	477	462	456	445	438	442	450	462	474	492	499	503	492	494	495	492	488	492	494	499	501	476	460	438
4/15/2018	410	405	396	394	390	403	405	434	449	459	470	474	478	472	473	474	484	498	505	521	518	508	487	467
4/16/2018	462	458	459	465	486	527	582	606	622	662	674	623	632	622	620	618	616	615	610	614	620	605	571	540
4/17/2018	532	530	544	535	557	587	624	612	601	586	580	565	563	556	549	541	532	534	530	546	563	538	507	481
4/18/2018	473	462	463	469	480	513	538	555	554	558	550	561	524	567	584	572	572	548	543	550	555	525	494	466
4/19/2018	457	455	454	456	474	513	545	576	577	584	580	577	537	552	549	535	536	514	521	538	559	541	511	489
4/20/2018	484	478	475	474	492	524	557	561	561	551	545	540	532	531	523	519	512	507	497	496	518	514	479	457
4/21/2018	447	437	431	441	445	454	462	481	483	491	492	485	487	487	480	478	478	476	475	499	508	489	469	432
4/22/2018	413	414	397	393	391	385	390	405	425	427	435	442	438	448	447	447	450	469	465	480	476	467	438	415
4/23/2018	411	390	396	397	426	446	503	526	535	558	557	550	551	550	548	540	546	537	544	553	555	531	505	474
4/24/2018	454	447	437	440	446	473	502	525	532	538	541	543	547	542	539	543	539	541	544	555	543	533	494	471
4/25/2018	453	452	443	441	458	476	517	528	519	538	538	543	547	545	559	554	542	531	538	539	555	533	491	469
4/26/2018	452	437	436	432	432	467	540	511	530	532	534	533	541	540	545	541	533	531	524	530	541	520	487	445
4/27/2018	448	423	424	429	437	469	499	522	515	525	530	530	535	542	530	524	523	508	509	509	525	509	476	443
4/28/2018	429	415	407	408	407	409	419	422	435	448	447	437	444	446	435	444	443	446	442	451	464	442	427	407
4/29/2018	392	382	380	384	387	398	408	414	431	434	439	434	435	436	434	430	438	452	451	464	467	462	427	413
4/30/2018	398	402	402	407	427	458	513	518	567	612	617	611	619	622	621	630	578	547	538	541	556	538	490	457
5/1/2018	441	429	428	426	433	452	494	520	525	545	554	562	573	578	589	605	595	601	595	597	606	581	538	501
5/2/2018	471	459	452	449	449	473	516	530	561	576	602	612	637	661	662	674	677	668	659	664	676	650	597	557
5/3/2018	534	513	501	498	491	519	552	581	599	606	620	621	628	628	620	608	598	596	587	599	596	569	539	502
5/4/2018	484	477	470	464	471	497	527	556	589	603	616	633	631	639	636	639	608	595	585	591	585	564	524	490
5/5/2018	463	453	442	436	426	436	431	441	459	476	479	478	485	477	480	476	479	470	470	476	484	474	445	418
5/6/2018	399	389	378	378	370	381	373	398	421	443	454	473	495	508	516	527	540	552	541	542	546	514	477	434
5/7/2018	409	397	392	400	406	438	467	506	538	542	565	569	589	598	607	616	614	605	600	586	597	556	516	477
5/8/2018	453	438	424	426	425	453	475	502	521	537	560	563	583	593	609	620	616	619	611	596	610	568	520	476
5/9/2018	457	442	431	425	436	451	478	510	533	562	587	611	639	643	639	655	677	661	659	651	668	627	588	542
5/10/2018	516	496	476	472	461	487	515	554	581	620	645	672	702	726	758	766	775	719	684	673	665	620	582	536

Dt	Hour1	Hour2	Hour3	Hour4	Hour5	Hour6	Hour7	Hour8	Hour9	Hour10	Hour11	Hour12	Hour13	Hour14	Hour15	Hour16	Hour17	Hour18	Hour19	Hour20	Hour21	Hour22	Hour23	Hour24
5/11/2018	506	476	476	469	470	491	519	561	593	625	650	678	703	741	759	784	766	760	713	685	686	646	609	549
5/12/2018	522	496	478	470	466	454	440	480	512	557	601	629	660	652	675	693	710	692	676	658	652	617	567	526
5/13/2018	486	461	449	419	423	429	419	452	497	550	602	638	660	685	711	728	734	741	718	706	685	647	597	548
5/14/2018	517	495	479	465	480	506	553	607	651	701	747	789	822	856	882	898	900	886	860	829	813	764	697	624
5/15/2018	586	554	541	519	509	534	569	613	643	687	711	752	778	814	846	856	856	827	811	794	779	737	666	609
5/16/2018	574	547	530	524	521	548	583	604	611	628	640	644	677	717	746	762	783	787	771	748	735	699	631	582
5/17/2018	551	527	512	504	509	539	570	615	642	677	697	719	752	774	788	803	809	788	761	743	724	680	628	580
5/18/2018	539	534	519	513	510	530	564	592	611	623	630	628	629	641	651	671	661	661	646	643	637	618	576	530
5/19/2018	496	478	468	457	453	456	448	476	507	520	548	576	602	629	647	679	690	687	658	632	636	607	572	522
5/20/2018	489	456	439	428	419	415	423	458	497	548	572	602	643	679	708	732	734	718	694	665	644	618	566	525
5/21/2018	498	481	464	462	476	508	550	593	625	652	674	712	748	793	785	769	739	713	708	703	702	713	621	577
5/22/2018	546	521	514	506	508	529	568	615	647	689	722	757	794	820	843	860	861	851	821	787	766	722	662	596
5/23/2018	567	534	515	508	506	523	556	595	624	665	701	731	778	789	820	836	839	834	814	775	759	711	652	595
5/24/2018	558	532	515	501	499	514	542	584	625	664	702	738	759	796	822	835	828	830	798	769	746	698	640	591
5/25/2018	545	520	496	491	494	500	531	577	624	667	714	745	789	820	844	830	793	763	729	699	698	668	617	567
5/26/2018	537	513	497	493	483	476	477	505	529	587	619	656	689	722	745	767	773	776	758	728	710	676	629	594
5/27/2018	548	523	497	478	474	463	466	504	549	615	673	720	749	779	800	810	803	779	757	729	712	680	629	566
5/28/2018	534	500	478	463	461	466	462	494	536	604	656	701	741	762	779	799	809	779	730	688	681	645	596	558
5/29/2018	529	513	506	501	518	533	573	618	654	669	709	755	794	836	844	814	783	756	732	763	728	710	663	617
5/30/2018	591	566	559	562	559	569	610	635	664	676	711	730	748	735	795	820	827	822	809	782	775	749	686	635
5/31/2018	597	577	562	555	547	574	601	646	705	734	790	756	694	672	678	684	697	712	697	700	698	669	626	586
6/1/2018	554	534	515	507	520	576	629	671	712	768	798	847	886	920	948	959	934	902	780	742	730	703	661	604
6/2/2018	570	548	528	522	512	504	508	540	603	659	715	753	793	819	817	823	814	811	797	773	749	716	669	618
6/3/2018	582	542	512	502	492	487	490	521	559	590	608	623	643	655	660	682	692	694	673	650	633	608	552	512
6/4/2018	480	463	443	439	450	467	501	550	585	612	640	654	670	690	703	709	712	694	679	655	665	626	586	544
6/5/2018	510	496	484	476	479	493	520	565	606	634	666	686	713	748	771	794	801	802	784	753	733	692	630	573
6/6/2018	544	520	501	493	491	502	530	580	614	649	693	732	764	797	827	857	857	847	828	795	774	733	668	614
6/7/2018	575	548	528	522	516	523	561	615	657	713	766	813	857	882	914	924	927	904	891	861	838	789	734	680
6/8/2018	634	601	580	556	557	560	597	647	700	750	808	853	884	918	944	936	937	909	887	851	838	799	740	683
6/9/2018	640	605	585	557	544	528	535	569	633	683	738	787	809	825	809	751	694	659	647	628	618	603	575	538
6/10/2018	504	482	471	452	455	450	460	484	529	570	581	608	641	676	730	776	795	795	761	684	654	615	581	541
6/11/2018	501	494	485	480	495	514	552	589	635	679	704	734	758	781	818	854	875	883	867	822	794	756	690	619
6/12/2018	577	551	541	527	528	549	578	612	634	649	654	686	731	792	844	859	798	739	706	695	687	663	619	580
6/13/2018	555	533	524	518	521	531	560	611	637	671	723	761	806	840	879	890	906	900	874	841	830	788	722	661
6/14/2018	623	587	569	544	547	555	582	631	676	725	765	813	837	862	882	899	895	886	855	809	791	748	685	634
6/15/2018	596	575	555	550	551	559	580	628	654	702	770	820	863	908	933	941	937	921	903	865	839	808	749	688
6/16/2018	647	610	588	565	553	530	534	583	641	705	767	814	839	868	880	890	875	859	843	823	804	761	721	673
6/17/2018	619	587	553	532	522	512	522	564	626	691	756	804	828	864	879	885	894	891	868	849	825	801	744	692
6/18/2018	656	619	603	586	594	606	645	704	755	817	875	898	931	951	967	978	975	965	946	912	893	856	796	737
6/19/2018	687	658	632	610	610	611	650	708	762	802	855	890	914	943	962	967	967	951	930	896	876	839	787	728
6/20/2018	680	641	618	600	603	609	644	704	748	800	843	880	905	930	929	891	909	895	873	832	820	791	738	685
6/21/2018	655	625	609	589	594	599	628	649	661	685	695	722	721	751	788	799	795	773	755	734	719	697	648	603
6/22/2018	568	549	529	522	528	536	563	589	615	635	672	695	721	736	743	739	733	719	700	683	671	662	618	577
6/23/2018	544	519	509	498	486	476	473	505	549	581	619	637	656	670	674	694	720	728	724	693	675	654	610	569
6/24/2018	540	515	490	480	472	468	472	510	569	618	668	700	749	775	780	762	771	748	736	725	711	668	610	576
6/25/2018	544	531	519	512	519	555	583	617	641	665	666	659	696	735	759	785	806	797	792	774	758	729	676	633
6/26/2018	603	580	563	554	552	568	600	655	714	765	746	688	667	702	751	785	803	812	807	784	748	711	615	565
6/27/2018	550	528	519	506	517	520	553	584	615	636	683	709	754	819	859	878	921	919	913	888	867	831	784	734
6/28/2018	696	656	640	636	628	647	677	724	771	824	852	897	926	956	977	983	976	972	943	918	904	824	769	703
6/29/2018	667	633	623	607	594	609	631	689	733	788	828	878	909	955	974	988	976	979	942	924	902	857	796	741
6/30/2018	690	658	630	610	589	571	575	618	671	743	785	825	855	879	891	904	909	895	881	853	832	795	751	699
7/1/2018	659	624	591	577	564	551	562	614	678	730	788	834	855	889	895	913	915	924	909	883	856	830	767	730
7/2/2018	691	660	632	617	627	647	687	729	792	834	897	935	979	989	996	946	880	856	843	820	812	795	738	695
7/3/2018	660	643	623	618	614	622	657	710	765	814	868	904	928	905	913	919	924	877	829	799	788	759	721	676
7/4/2018	649	621	608	592	577	566	566	593	659	724	804	851	881	899	911	928	931	926	907	870	849	808	774	727
7/5/2018	688	644	626	604	604	618	659	733	796	873	925	968	1009	1029	1039	1023	1030	1025	1006	963	935	894	829	763
7/6/2018	715	685	658	639	634	640	656	699	743	792	839	880	909	927	938	936	912	888	863	824	788	752	706	644
7/7/2018	605	570	546	516	517	496	488	520	551	593	619	653	684	703	729	745	758	754	734	700	668	640	605	561
7/8/2018	525	500	489	478	480	470	473	515	553	613	672	718	761	800	827	850	865	888	861	837	803	785	730	672
7/9/2018	640	610	595	582	595	611	648	704	759	815	862	903	946	970	967	936	925	917	898	867	833	808	742	690
7/10/2018	643	612	593	581	574	582	613	669	732	798	846	876	915	937	954	972	972	967	948	922	897	854	793	733
7/11/2018	686	658	626	615	604	601	625	674	716	774	831	870	913	939	938	952	956	941	917	889	854	808	744	675
7/12/2018	626	592	560	540	540	542	569	626	664	707	750	790	829	863	884	905	920	906	884	842	818	782	716	658
7/13/2018	617	589	566	548	548	547	579	629	675	713	769	808	853	887	908	930	924	923	893	849	828	780	731	668
7/14/2018	622	586	560	540	524	517	521	551	603	669	749	794	851	891	910	922	902	852	789	762	726	700	655	604

Dt	Hour1	Hour2	Hour3	Hour4	Hour5	Hour6	Hour7	Hour8	Hour9	Hour10	Hour11	Hour12	Hour13	Hour14	Hour15	Hour16	Hour17	Hour18	Hour19	Hour20	Hour21	Hour22	Hour23	Hour24
7/15/2018	578	552	534	531	522	526	520	543	562	596	630	642	663	688	715	743	771	767	750	733	723	700	651	613
7/16/2018	571	558	543	538	537	564	595	633	659	706	758	813	851	885	918	938	941	939	914	876	849	818	746	686
7/17/2018	651	617	589	586	575	585	620	670	730	784	828	869	893	924	935	939	939	916	887	839	812	768	709	652
7/18/2018	612	586	547	549	538	547	570	611	645	685	727	763	798	835	858	869	876	865	832	793	760	717	649	596
7/19/2018	562	531	513	496	502	511	539	583	627	665	720	771	816	837	872	880	884	876	864	825	809	773	718	666
7/20/2018	625	603	571	571	558	577	608	657	709	759	821	854	886	911	945	960	966	955	927	893	864	819	747	676
7/21/2018	625	588	559	535	518	517	521	556	604	647	692	713	721	740	746	744	737	722	708	696	672	654	615	577
7/22/2018	542	523	505	491	486	491	489	509	530	548	579	587	608	630	656	669	668	674	658	631	630	616	579	549
7/23/2018	525	508	501	501	506	533	551	600	636	678	705	733	768	785	790	786	801	813	789	764	761	725	678	605
7/24/2018	595	574	561	542	545	556	581	623	677	716	775	810	841	875	887	900	903	890	864	831	807	753	690	638
7/25/2018	591	569	547	536	539	553	580	621	676	727	774	808	834	865	877	896	888	874	852	801	777	734	679	625
7/26/2018	584	558	533	524	519	531	556	608	677	737	780	807	856	890	922	927	920	881	855	824	799	764	713	654
7/27/2018	619	586	562	545	547	556	571	614	659	695	712	753	773	802	814	836	831	823	794	755	739	695	651	594
7/28/2018	554	529	505	497	482	479	473	495	531	573	614	649	671	699	724	735	741	741	724	693	676	638	595	555
7/29/2018	528	497	495	470	468	462	468	493	537	592	634	665	698	729	736	746	730	728	694	662	650	621	576	548
7/30/2018	516	505	501	496	511	538	569	609	636	663	686	694	705	709	703	698	689	679	677	672	680	666	622	585
7/31/2018	559	547	544	531	535	555	582	609	637	652	673	696	731	761	792	801	795	779	751	740	728	704	651	601
8/1/2018	564	545	534	527	523	538	566	601	635	664	714	744	770	796	821	832	839	825	809	775	765	724	664	602
8/2/2018	578	555	538	527	522	536	564	603	653	703	745	783	821	848	877	887	895	880	851	762	800	748	699	641
8/3/2018	602	565	552	537	533	543	576	615	668	716	762	798	831	877	914	934	934	924	899	856	850	799	745	688
8/4/2018	636	603	583	562	549	542	531	558	621	666	739	778	824	849	872	885	896	883	860	819	797	755	715	655
8/5/2018	610	582	557	538	528	520	520	549	599	652	719	780	827	862	884	899	895	872	823	783	781	737	686	629
8/6/2018	596	568	554	545	558	583	613	680	734	793	853	897	943	988	1004	1003	1000	976	949	927	906	869	793	736
8/7/2018	696	668	643	631	625	641	671	709	735	776	811	853	869	879	902	924	914	872	838	826	815	770	725	669
8/8/2018	638	613	598	594	584	614	648	669	702	732	754	790	832	866	884	901	917	900	887	864	853	800	745	688
8/9/2018	654	628	593	587	581	597	629	664	708	751	799	813	826	834	842	846	840	819	814	795	792	749	691	633
8/10/2018	609	587	567	562	561	584	614	647	685	727	750	771	786	809	820	835	859	859	843	807	779	745	692	645
8/11/2018	603	576	558	546	535	542	532	545	586	642	697	747	772	803	827	843	838	839	800	755	729	689	644	595
8/12/2018	554	528	512	498	488	484	481	505	556	613	658	696	737	782	801	820	833	837	809	778	746	702	640	578
8/13/2018	549	514	511	505	512	546	579	624	657	719	757	814	854	882	900	907	913	895	867	840	822	771	707	644
8/14/2018	607	577	563	539	541	559	597	625	667	721	773	814	860	887	916	930	910	877	856	836	827	774	720	662
8/15/2018	623	605	574	572	568	593	635	655	668	689	710	728	719	719	755	794	773	740	712	708	712	679	645	597
8/16/2018	580	563	559	556	557	586	625	660	679	682	737	748	763	776	793	835	857	862	853	839	825	784	730	677
8/17/2018	639	627	611	617	613	615	636	660	683	723	759	800	821	851	844	859	862	854	825	796	777	747	696	642
8/18/2018	615	600	575	570	553	556	544	570	595	631	679	725	744	756	760	789	797	788	761	730	717	673	634	589
8/19/2018	553	528	504	502	489	489	489	505	557	613	653	707	744	767	801	809	822	817	799	777	761	715	665	622
8/20/2018	595	579	553	553	568	596	645	685	706	737	772	803	814	828	839	847	860	855	835	815	808	759	707	632
8/21/2018	600	572	557	544	548	571	601	637	648	672	688	707	727	751	774	806	810	787	766	741	735	702	657	611
8/22/2018	575	549	536	531	537	554	594	614	630	650	671	679	696	716	743	757	761	734	711	686	681	638	588	538
8/23/2018	516	497	495	485	485	510	530	485	594	621	645	678	702	718	742	767	763	754	736	713	698	652	604	556
8/24/2018	518	506	496	487	490	517	535	563	578	588	608	619	622	625	620	613	605	598	603	606	611	606	576	549
8/25/2018	524	517	504	507	492	502	503	523	553	592	633	684	733	768	811	838	842	846	817	805	766	731	688	636
8/26/2018	597	570	544	534	522	521	515	543	591	652	697	753	806	841	864	892	892	889	872	831	808	754	704	656
8/27/2018	625	590	570	567	577	607	652	685	732	792	843	891	936	973	982	996	986	997	944	906	885	820	765	693
8/28/2018	661	632	609	581	595	599	651	678	725	790	842	890	934	975	990	1013	1005	990	965	929	898	836	789	715
8/29/2018	677	642	615	638	601	629	664	700	749	780	795	826	799	797	805	807	810	809	792	787	780	733	664	614
8/30/2018	592	564	549	540	542	567	616	635	660	701	749	800	841	882	900	896	893	879	851	836	806	767	715	648
8/31/2018	608	578	566	563	559	582	614	649	680	725	768	818	848	888	917	911	864	842	811	784	764	720	681	628
9/1/2018	590	572	555	542	525	514	519	531	562	608	657	714	754	778	783	802	822	818	787	750	727	688	651	611
9/2/2018	580	541	523	497	486	488	488	508	550	624	674	736	779	805	831	847	867	851	814	789	757	720	668	632
9/3/2018	585	559	531	524	516	512	506	532	576	649	714	764	808	831	854	864	874	868	841	810	788	733	681	631
9/4/2018	603	578	548	548	549	574	611	655	704	763	824	882	925	962	981	988	980	974	941	920	881	832	770	715
9/5/2018	676	654	632	617	609	627	658	681	734	775	847	889	930	967	980	970	934	906	885	863	834	791	739	683
9/6/2018	647	621	600	593	592	610	649	674	705	758	820	860	882	898	825	812	786	763	745	745	731	706	643	600
9/7/2018	570	551	535	533	532	563	611	651	662	701	744	797	852	888	904	889	831	766	737	728	708	687	662	614
9/8/2018	592	577	561	561	556	558	562	560	590	604	631	635	634	638	650	651	664	628	619	613	603	580	551	510
9/9/2018	488	473	457	456	457	454	456	474	495	508	516	525	526	534	532	532	531	537	528	545	544	514	489	465
9/10/2018	451	437	432	425	446	485	532	546	567	556	587	598	603	630	633	654	658	647	636	647	635	603	563	527
9/11/2018	503	488	483	480	483	502	536	558	586	616	635	656	674	678	685	682	683	669	655	660	651	619	589	550
9/12/2018	527	513	501	496	494	507	550	566	584	608	627	646	671	691	708	704	701	682	682	683	675	645	600	568
9/13/2018	540	520	520	507	509	530	572	596	626	673	711	745	786	827	861	888	893	881	846	824	798	746	685	632
9/14/2018	591	574	541	530	535	557	598	620	652	698	754	796	834	869	897	911	915	892	854	816	788	754	701	652
9/15/2018	612	585	557	547	536	525	517	533	578	625	689	747	803	842	868	884	879	872	832	805	767	729	681	641
9/16/2018	595	566	550	531	519	508	513	528	562	617	673	715	757	777	790	800	804	797	769	766	725	685	625	584
9/17/2018	555	534	517	518	523	559	604	629	653	683	745	786	831	863	893	905	907	901	861	836	800	751	690	635

Dt	Hour1	Hour2	Hour3	Hour4	Hour5	Hour6	Hour7	Hour8	Hour9	Hour10	Hour11	Hour12	Hour13	Hour14	Hour15	Hour16	Hour17	Hour18	Hour19	Hour20	Hour21	Hour22	Hour23	Hour24
9/18/2018	596	572	567	542	548	564	604	633	650	705	764	819	872	901	904	894	898	888	851	845	801	743	684	630
9/19/2018	603	563	538	532	527	556	601	611	661	717	779	835	888	933	950	954	943	915	879	862	820	775	713	655
9/20/2018	622	590	575	564	569	590	629	662	715	768	834	886	927	969	976	982	975	946	895	881	842	791	753	719
9/21/2018	677	653	634	624	608	629	664	691	742	787	843	886	927	929	930	935	912	872	840	812	791	743	682	626
9/22/2018	588	559	539	522	517	503	509	508	523	531	539	539	535	535	528	531	518	519	529	527	521	509	489	475
9/23/2018	460	450	434	429	429	444	444	457	467	489	475	513	530	534	537	541	544	548	551	566	555	539	511	493
9/24/2018	478	469	463	462	476	510	559	602	616	613	631	654	658	685	672	672	681	680	679	694	690	674	628	595
9/25/2018	568	561	544	541	550	578	624	647	663	689	691	690	683	683	727	744	760	762	749	761	747	714	676	617
9/26/2018	590	574	563	557	550	573	602	610	620	616	632	645	653	668	683	689	681	666	642	639	625	592	560	525
9/27/2018	512	502	492	484	497	511	549	563	569	573	581	577	578	582	583	581	578	577	569	590	580	564	529	502
9/28/2018	481	479	465	468	471	483	521	538	544	558	567	571	586	594	593	607	605	586	581	581	572	548	528	499
9/29/2018	472	461	456	446	444	438	441	450	460	482	495	505	532	541	556	572	583	579	566	561	547	522	493	468
9/30/2018	442	433	422	411	414	415	417	425	445	470	505	535	560	592	613	642	652	649	624	630	590	562	521	487
10/1/2018	460	447	437	439	447	482	534	553	581	618	644	678	704	747	759	760	749	741	730	734	709	671	623	582
10/2/2018	557	536	536	525	533	554	606	624	641	670	717	753	798	825	856	869	885	837	818	800	769	715	670	616
10/3/2018	581	570	546	545	543	566	609	629	664	696	752	795	836	853	882	881	879	853	829	816	788	749	714	661
10/4/2018	624	607	584	573	568	599	634	660	688	722	757	787	810	834	847	844	833	803	769	759	725	687	644	604
10/5/2018	564	543	528	520	521	547	600	624	652	706	774	812	848	879	881	898	881	852	822	792	753	719	681	633
10/6/2018	606	568	548	537	525	521	524	525	572	628	667	705	750	773	797	804	793	768	744	712	688	652	604	565
10/7/2018	534	498	482	464	458	457	467	477	515	566	618	664	718	741	765	782	786	769	744	723	698	652	606	574
10/8/2018	538	524	503	508	517	537	582	607	641	695	744	793	826	846	866	877	872	844	819	802	777	732	687	639
10/9/2018	605	587	565	552	553	571	602	621	654	694	730	763	799	839	844	852	842	821	794	782	750	705	665	608
10/10/2018	579	569	548	556	542	561	620	632	637	645	657	678	689	697	712	750	747	724	723	720	701	667	615	559
10/11/2018	529	509	493	486	484	493	543	557	557	568	582	584	589	593	592	595	588	584	587	589	576	551	518	481
10/12/2018	477	465	468	458	466	483	533	542	545	541	546	550	549	547	551	540	531	535	538	545	528	529	501	470
10/13/2018	459	455	455	449	445	449	460	466	486	492	502	494	482	483	471	474	476	480	498	500	492	475	454	437
10/14/2018	417	416	402	403	404	413	427	439	455	467	475	476	480	478	481	483	492	502	511	505	500	479	454	430
10/15/2018	421	416	410	418	431	459	499	533	537	549	552	561	563	566	571	566	562	564	586	582	573	561	525	501
10/16/2018	490	481	467	474	481	508	556	566	574	566	566	563	566	561	562	555	563	556	577	590	581	561	527	514
10/17/2018	501	501	491	493	496	524	569	574	556	563	566	557	551	556	552	551	551	539	562	570	565	545	520	493
10/18/2018	482	468	457	467	465	502	544	554	555	557	549	548	552	553	549	554	546	544	566	566	567	548	527	491
10/19/2018	492	488	476	493	492	510	556	573	562	561	564	557	558	568	551	557	545	548	556	554	547	530	512	480
10/20/2018	464	457	453	442	441	438	454	447	463	474	478	477	473	477	473	465	466	463	483	483	482	474	457	446
10/21/2018	431	429	426	425	433	447	463	475	486	488	479	479	472	465	469	464	468	489	512	527	525	508	493	479
10/22/2018	464	458	462	470	485	515	574	587	585	572	569	558	562	557	551	546	544	544	564	572	561	544	515	487
10/23/2018	484	477	468	473	480	499	552	561	558	558	557	550	558	545	550	541	538	536	560	566	557	540	508	488
10/24/2018	479	469	470	476	483	507	556	540	541	554	538	553	558	553	552	551	546	548	567	567	567	545	517	498
10/25/2018	485	474	474	476	486	500	548	567	569	568	571	566	569	566	555	557	555	555	578	569	559	538	511	493
10/26/2018	469	462	460	460	462	488	531	551	550	552	558	567	558	552	550	549	542	540	549	549	543	532	506	481
10/27/2018	453	454	455	447	451	454	460	467	484	487	496	478	473	471	469	462	459	474	489	488	480	480	457	437
10/28/2018	428	424	420	416	414	423	435	442	452	469	463	468	464	468	468	468	476	483	503	506	499	477	452	439
10/29/2018	422	411	420	430	450	482	546	568	572	561	558	560	551	557	559	551	556	546	571	558	561	532	514	486
10/30/2018	473	469	467	459	469	497	543	557	562	550	561	552	567	566	572	576	560	560	570	568	563	547	516	497
10/31/2018	478	465	457	461	466	482	525	548	553	569	570	571	583	585	573	579	563	568	569	567	556	551	498	480
11/1/2018	463	463	458	449	460	486	530	562	560	578	570	567	576	578	570	571	560	576	583	590	572	562	544	505
11/2/2018	491	485	479	475	483	511	559	566	569	571	563	561	556	552	542	534	527	527	556	555	555	527	512	487
11/3/2018	481	467	468	469	476	481	493	491	498	493	488	481	472	476	465	472	474	485	504	494	497	488	467	450
11/4/2018	433	429	419	472	422	426	436	448	453	477	480	482	487	485	493	492	497	513	528	526	525	500	488	468
11/5/2018	448	438	436	443	434	455	482	521	549	560	561	561	554	559	570	573	575	591	602	595	587	579	559	535
11/6/2018	502	491	488	484	489	495	511	555	557	569	575	582	575	587	577	573	573	566	580	588	595	578	557	534
11/7/2018	506	498	492	492	504	500	527	573	579	588	579	582	582	571	568	570	564	571	593	589	593	588	569	547
11/8/2018	518	518	513	513	514	529	551	593	608	620	617	616	614	619	607	602	612	606	632	621	614	606	580	562
11/9/2018	533	530	511	514	512	523	551	582	593	609	611	617	617	619	624	624	636	637	641	638	638	634	622	598
11/10/2018	586	579	579	579	582	591	598	598	602	590	587	578	557	552	534	536	540	556	591	593	590	596	589	571
11/11/2018	556	555	557	551	566	561	564	564	574	592	575	556	539	486	532	531	540	559	584	577	574	567	549	539
11/12/2018	526	510	515	504	513	525	552	591	613	620	625	636	635	645	637	633	637	655	661	665	658	652	619	600
11/13/2018	577	569	562	568	573	590	626	666	676	683	695	700	700	699	691	700	696	715	733	725	728	712	694	660
11/14/2018	635	644	630	627	634	644	673	712	725	717	727	715	722	703	699	678	674	673	687	676	668	667	641	604
11/15/2018	587	553	551	544	540	563	574	615	627	633	622	629	630	635	602	630	628	635	635	656	639	629	606	581
11/16/2018	559	557	549	550	552	563	587	629	623	609	593	585	573	564	560	549	547	559	587	580	593	584	569	556
11/17/2018	530	526	529	521	524	532	541	539	547	545	530	512	502	480	481	476	478	485	513	510	498	501	489	472
11/18/2018	465	446	453	439	444	447	462	479	479	498	481	477	463	461	471	456	468	498	519	525	524	519	490	475
11/19/2018	460	442	437	437	442	457	493	545	554	573	575	578	577	577	579	580	584	599	603	597	593	588	565	542
11/20/2018	521	508	503	505	499	504	539	582	602	610	618	626	618	619	620	630	634	628	644	638	631	628	607	593
11/21/2018	571	567	555	563	564	576	604	633	635	621	610	588	569	561	553	546	535	544	578	581	578	572	554	510

Dt	Hour1	Hour2	Hour3	Hour4	Hour5	Hour6	Hour7	Hour8	Hour9	Hour10	Hour11	Hour12	Hour13	Hour14	Hour15	Hour16	Hour17	Hour18	Hour19	Hour20	Hour21	Hour22	Hour23	Hour24
11/22/2018	480	473	463	455	442	451	458	464	475	464	470	453	438	403	384	373	376	385	405	414	416	418	414	406
11/23/2018	397	391	391	387	394	399	411	421	437	443	454	459	452	447	445	443	454	462	472	472	464	459	451	432
11/24/2018	414	404	388	390	391	394	400	424	437	456	464	466	462	452	450	443	445	456	483	488	482	476	478	458
11/25/2018	441	425	422	421	419	429	435	447	459	459	461	461	465	462	464	476	478	498	532	519	515	508	487	467
11/26/2018	458	450	459	460	479	501	541	602	616	625	629	636	644	638	640	641	648	664	671	673	672	653	633	608
11/27/2018	581	570	572	561	575	592	613	660	663	668	663	670	674	671	673	675	682	695	709	706	701	690	663	637
11/28/2018	608	609	604	598	611	624	667	708	692	687	676	662	631	628	625	613	625	643	662	665	656	640	622	590
11/29/2018	559	561	540	537	538	550	561	601	620	598	600	593	579	581	582	569	566	587	596	588	579	572	550	519
11/30/2018	491	472	470	469	460	472	499	529	542	563	555	564	554	550	555	551	546	556	578	563	560	549	546	514
12/1/2018	476	446	459	456	450	448	453	465	463	480	497	509	503	491	498	497	501	521	526	530	510	501	486	465
12/2/2018	446	426	407	409	416	424	427	444	450	455	465	468	465	466	469	469	483	509	537	541	533	530	504	478
12/3/2018	459	444	436	440	446	466	498	557	573	588	599	621	616	613	616	615	619	633	642	641	633	630	609	577
12/4/2018	560	540	538	530	541	551	564	612	626	637	641	637	628	624	620	619	627	644	660	654	651	643	625	588
12/5/2018	587	569	572	576	571	589	606	644	659	646	639	644	624	629	622	605	595	624	649	648	649	643	627	596
12/6/2018	572	556	543	550	545	564	585	631	631	628	623	625	603	601	606	602	606	616	622	621	625	610	604	566
12/7/2018	546	537	532	527	525	549	578	605	628	635	616	605	594	585	588	578	583	598	620	611	621	621	608	590
12/8/2018	564	542	542	537	543	536	544	568	580	595	608	610	603	607	598	594	600	619	626	612	608	592	581	559
12/9/2018	536	524	519	507	515	516	519	532	543	554	547	541	527	524	517	521	526	563	591	594	588	592	565	542
12/10/2018	529	519	517	522	537	562	600	641	650	642	630	615	595	576	576	579	568	608	640	641	642	654	637	615
12/11/2018	596	596	599	602	603	614	645	682	674	645	615	619	603	588	618	571	579	597	633	630	640	631	608	586
12/12/2018	551	542	547	538	543	553	575	622	619	614	604	590	570	569	555	555	551	575	597	586	588	582	566	531
12/13/2018	507	488	484	481	479	490	517	564	577	581	586	586	574	584	562	570	571	588	585	584	590	574	559	527
12/14/2018	492	479	473	469	474	487	504	550	566	571	577	572	571	572	569	565	569	581	583	574	574	566	551	524
12/15/2018	499	479	480	468	467	467	468	474	487	490	509	507	509	504	492	500	504	529	530	531	523	510	503	484
12/16/2018	456	448	433	427	435	432	441	462	467	470	473	464	470	453	458	451	455	482	520	530	529	528	511	496
12/17/2018	475	467	467	464	480	494	531	590	593	588	569	560	549	533	546	528	539	552	579	587	584	586	573	544
12/18/2018	516	509	503	508	520	529	558	611	614	603	581	567	560	543	540	535	540	554	582	595	598	598	593	557
12/19/2018	535	520	515	512	521	525	540	581	590	575	569	550	547	536	530	528	528	552	580	572	566	563	546	521
12/20/2018	489	479	471	467	461	472	494	531	543	548	556	554	548	542	546	551	546	567	572	573	566	559	547	512
12/21/2018	477	462	453	454	454	468	482	524	532	552	569	566	566	564	568	566	557	574	583	577	567	554	539	502
12/22/2018	486	463	462	444	451	442	460	466	481	478	483	479	464	462	457	441	444	468	498	499	499	494	484	479
12/23/2018	454	450	432	429	440	440	452	467	473	493	510	504	506	506	500	486	484	510	527	521	519	519	500	485
12/24/2018	458	438	432	429	427	436	452	469	468	476	462	451	440	423	410	402	405	420	444	436	430	439	432	415
12/25/2018	403	384	375	371	376	382	388	403	415	425	430	429	403	390	369	367	374	387	423	425	435	434	431	417
12/26/2018	404	396	388	400	401	418	448	477	495	498	492	484	480	469	472	462	475	490	515	517	506	497	479	458
12/27/2018	441	427	413	416	412	427	435	471	488	496	512	506	509	506	507	512	514	512	529	521	512	500	479	456
12/28/2018	430	418	408	405	392	403	423	457	472	480	486	497	499	496	495	490	493	510	536	537	528	518	518	496
12/29/2018	475	458	455	443	451	455	469	489	491	508	516	519	522	519	517	508	507	523	550	541	524	528	513	493
12/30/2018	476	461	443	448	445	451	471	482	498	498	501	485	468	468	441	451	451	483	515	516	509	501	486	459
12/31/2018	447	422	413	411	412	420	418	446	462	473	487	491	495	502	490	478	482	483	493	485	469	458	445	429

Attachment 4.3 2019 MISO LOLE Study Report

CenterPoint Energy
Cause No. 45501
Petitioner's Exhibit 4
MAR WP1 (Public)

Planning Year 2019-2020 Loss of Load Expectation Study Report

Loss of Load Expectation Working Group

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Revision History

Reason for Revision	**Revised by:**	**Date:**
Draft Posted	MISO	10/03/2018
Final Posted	MISO	10/17/2018

1 Executive Summary

Midcontinent Independent System Operator (MISO) conducts an annual Loss of Load Expectation (LOLE) study to determine a Planning Reserve Margin Unforced Capacity (PRM UCAP), zonal per-unit Local Reliability Requirements (LRR), Zonal Import Ability (ZIA), Zonal Export Ability (ZEA), Capacity Import Limits (CIL) and Capacity Export Limits (CEL). The results of the study and its deliverables supply inputs to the MISO Planning Resource Auction (PRA).

The 2019-2020 Planning Year LOLE Study:

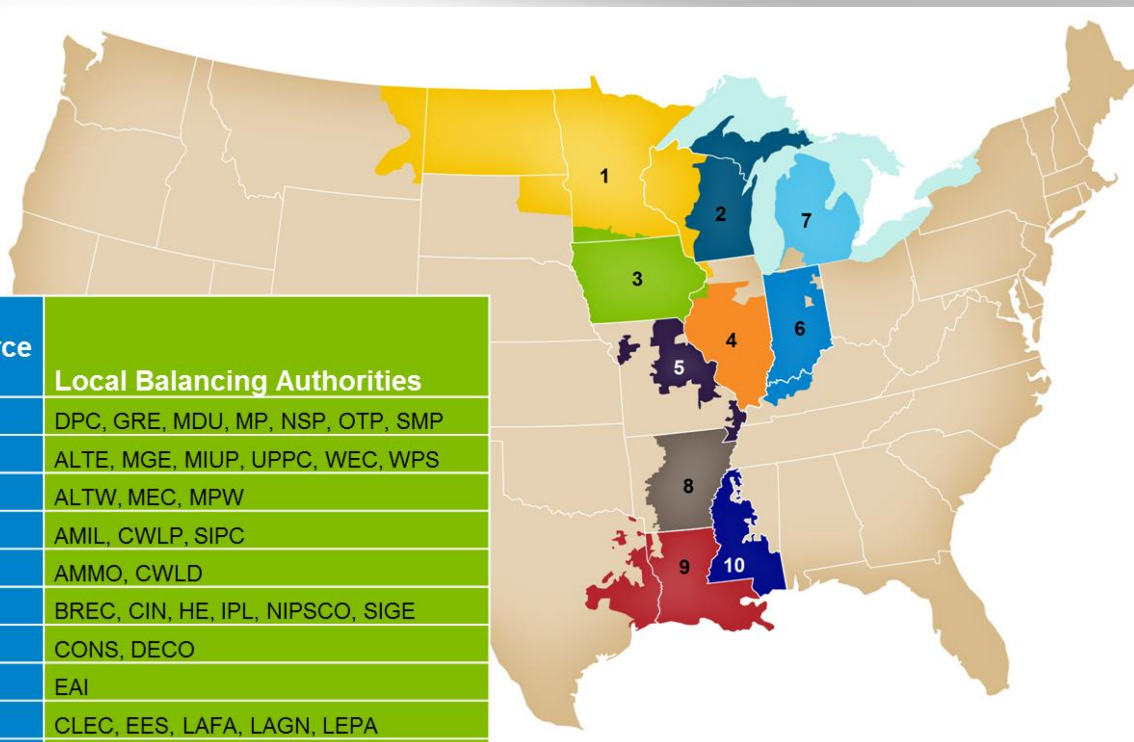
- Establishes a PRM UCAP of 7.9 percent to be applied to the Load Serving Entity (LSE) coincident peaks for the planning year starting June 2019 and ending May 2020
- Uses the Strategic Energy Risk Valuation Model (SERVM) software for Loss of Load analysis to provide results applicable across the MISO market footprint
- Provides initial zonal ZIA, ZEA, CIL and CEL for each Local Resource Zone (LRZ) (Figure 1-1). These values may be adjusted in March 2019 based on changes to MISO units with firm capacity commitments to non-MISO load, and equipment rating changes since the LOLE analysis. The Simultaneous Feasibility Test (SFT) process can further adjust CIL and CEL to assure the resources cleared in the auction are simultaneously reliable.
- Determines a minimum planning reserve margin that would result in the MISO system experiencing a less than one-day loss of load event every 10 years, as per the MISO Tariff.[1] The MISO analysis shows that the system would achieve this reliability level when the amount of installed capacity available is 1.168 times that of the MISO system coincident peak.
- Sets forth initial zonal-based (Table 1-1) PRA deliverables in the LOLE charter.

The stakeholder review process played an integral role in this study. The MISO staff would like to thank the Loss of Load Expectation Working Group (LOLEWG) for its help. Stakeholder advice led to revisions in LOLE results, including updated transfer limits due to improved redispatch, use of existing Op Guides, and constraint invalidation.

PRA and LOLE Metrics	LRZ 1	LRZ 2	LRZ 3	LRZ 4	LRZ 5	LRZ 6	LRZ 7	LRZ 8	LRZ 9	LRZ 10
PRM UCAP	7.90%	7.90%	7.90%	7.90%	7.90%	7.90%	7.90%	7.90%	7.90%	7.90%
LRR UCAP per-unit of LRZ Peak Demand	1.151	1.161	1.156	1.244	1.251	1.152	1.172	1.358	1.127	1.472
Capacity Import Limit (CIL) (MW)	4,078	1,713	3,037	6,845	5,013	7,066	3,211	4,424	3,950	3,906
Capacity Export Limit (CEL) (MW)	3,048	979	4,440	3,693	2,122	1,435	1,358	5,089	1,905	1,607
Zonal Import Ability (ZIA) (MW)	3,747	1,713	2,813	5,210	5,013	6,924	3,211	4,185	3,631	3,792
Zonal Export Ability (ZEA) (MW)	3,379	979	4,664	5,332	2,122	1,577	1,358	5,328	2,224	1,721

Table 1-1: Initial Planning Resource Auction Deliverables

[1] A one-day loss of load in 10 years (0.1 day/year) is not necessarily equal to 24 hours loss of load in 10 years (2.4 hours/year).



Local Resource Zone	Local Balancing Authorities
1	DPC, GRE, MDU, MP, NSP, OTP, SMP
2	ALTE, MGE, MIUP, UPPC, WEC, WPS
3	ALTW, MEC, MPW
4	AMIL, CWLP, SIPC
5	AMMO, CWLD
6	BREC, CIN, HE, IPL, NIPSCO, SIGE
7	CONS, DECO
8	EAI
9	CLEC, EES, LAFA, LAGN, LEPA
10	EMBA, SME

Figure 1-1: Local Resource Zones (LRZ)

2 LOLE Study Process Overview

In compliance with Module E-1 of the MISO Tariff, MISO performed its annual LOLE study to determine the 2019-2020 PY MISO system unforced capacity (UCAP) Planning Reserve Margin (PRM) and the per-unit Local Reliability Requirements (LRR) of Local Resource Zone (LRZ) Peak Demand.

In addition to the LOLE analysis, MISO performed transfer analysis to determine initial Zonal Import Ability (ZIA), Zonal Export Ability (ZEA), Capacity Import Limits (CIL) and Capacity Export Limits (CEL). CIL,CEL, and ZIA are used, in conjunction with the LOLE analysis results, in the Planning Resource Auction (PRA). ZEA is informational and not used in the PRA.

The 2019-2020 per-unit LRR UCAP multiplied by the updated LRZ Peak Demand forecasts submitted for the 2019-2020 PRA determines each LRZ's LRR. Once the LRR is determined, the ZIA values and non-pseudo tied exports are subtracted from the LRR to determine each LRZ's Local Clearing Requirement (LCR) consistent with Section 68A.6[2] of Module E-1. An example calculation pursuant to Section 68A.6 of the current effective Module E-1[3] shows how these values are reached (Table 2-1).

The actual effective PRM Requirement (PRMR) will be determined after the updated LRZ Peak Demand forecasts are submitted by November 1, 2018, for the 2019-2020 PRA. The ZIA, ZEA, CIL and CEL values are subject to updates in March 2019 based on changes to exports of MISO resources to non-

[2] https://www.misoenergy.org/Library/Tariff/Pages/Tariff.aspx#
[3] Effective Date: September 21, 2015

MISO load, changes to pseudo tied commitments, and updates to facility ratings since completion of the LOLE.

Finally, the simultaneous feasibility test (SFT) is performed as part of the PRA to ensure reliability and is maintained by adjusting CIL and CEL values as needed.

Local Resource Zone (LRZ) EXAMPLE	Example LRZ	Formula Key
Installed Capacity (ICAP)	17,442	[A]
Unforced Capacity (UCAP)	16,326	[B]
Adjustment to UCAP (1d in 10yr)	50	[C]
Local Reliability Requirement (LRR) (UCAP)	16,376	[D]=[B]+[C]
LRZ Peak Demand	14,270	[E]
LRR UCAP per-unit of LRZ Peak Demand	114.8%	[F]=[D]/[E]
Zonal Import Ability (ZIA)	3,469	[G]
Zonal Export Ability (ZEA)	2,317	[H]
Proposed PRA (UCAP) EXAMPLE	**Example LRZ**	**Formula Key**
Forecasted LRZ Peak Demand	14,270	[I]
Forecasted LRZ Coincident Peak Demand	13,939	[J]
Non-Pseudo Tied Exports UCAP	150	[K]
Local Reliability Requirement (LRR) UCAP	16,376	[L]=[F]x[I]
Local Clearing Requirement (LCR)	12,757	[M]=[L]-[G]-[K]
Zone's System Wide PRMR	15,040	[N]=[1.079]X[J]
PRMR	15,040	[O] = Higher of [M] or [N]
Planning Reserve Margin (PRM)	7.9%	[P]=[O]/[J]-1

Table 2-1: Example LRZ Calculation

2.1 Locational Tariff LOLE Study Enhancements

The Tariff filing referred to as the “Locational” filing resulted in several changes to the LOLE study process for the 2019-2020 Planning Year. The filing aligned CILs and CELs with the Zones where resources are accredited in the Planning Resource Auction (PRA). It also adjusted these limits to represent the share of transfers which can clear in the PRA. Below are more details regarding the filing’s effect on the LOLE study:

- Updates to match how resources are accredited in the PRA
  - Resources outside the MISO boundary (External Resources) will continue to be modeled at their physical location
  - External Resources which meet physical and operational criteria to obtain credit within a MISO LRZ will be included as generation within that Zone for LRR and transfer analysis
- Adjusted limits to represent the share of transfer which can clear in the PRA
  - Two new values, Zonal Import Ability (ZIA) and Zonal Export Ability (ZEA) represent the transfer ability prior to making adjustments for exports to non-MISO load
  - Exports to non-MISO load are removed from these values to determine the transfer limits available for the PRA
  - Adjustment applied to both CEL and CIL; previously only applied to CIL

- Updates to the Local Clearing Requirement calculation aligned with the above changes
  - ZIA replaces CIL
  - Non-pseudo tied exports expanded to reference 'controllable exports'

2.2 Future Study Improvement Considerations

In response to stakeholder feedback received through the LOLEWG, MISO has committed to reviewing two aspects of the transfer analysis process. MISO will examine the redispatch process for external constraints and the Generation Limited Transfer methodology with stakeholders early next year. MISO and stakeholders will consider any identified improvement for the next LOLE study.

3 Transfer Analysis

3.1 Calculation Methodology and Process Description

Transfer analyses determined initial ZIA, ZEA, CIL and CEL for LRZs for the 2019-2020 Planning Year. The objective of transfer analysis is to determine constraints caused by the transfer of capacity between zones and the associated transfer capability. Multiple factors impacted the analysis when compared to previous studies, including:

- Completion of MTEP transmission projects
- Generation retirements and commissioning of new units
- External system dispatch changes

3.1.1 Generation pools

To determine an LRZ's import or export limit, a transfer is modeled by ramping generation up in a source subsystem and ramping generation down in a sink subsystem. The source and sink definitions depend on the limit being tested. The LRZ studied for import limits is the sink subsystem and the adjacent MISO areas are the source subsystem. The LRZ studied for export limits is the source subsystem and the rest of MISO is the sink subsystem.

Transfers can cause potential issues, which are addressed through the study assumptions. First, an abundantly large source pool spreads the impact of the transfer widely, which potentially masks constraints. Second, ramping up generation from remote areas could cause electrically distant constraints for any given LRZ, which should not determine a zone's limit. For example, export constraints due to dispatch of LRZ 1 generation in the northwest portion of the footprint should not limit the import capability of LRZ 10, which covers the MISO portion of Mississippi.

To address these potential issues, the transfer studies limit the source pool for the import studies to the areas adjacent to the study zone. Since export study subsystems are defined by the LRZ, these issues only apply to import studies. Generation within the zone studied for an export limit is ramped up and constraints are expected to be near the zone because the ramped-up generation concentrates in a particular area.

3.1.2 Redispatch

Limited redispatch is applied after performing transfer analyses to mitigate constraints. Redispatch ensures constraints are not caused by the base dispatch and aligns with potential actions that can be implemented for the constraint in MISO operations. Redispatch scenarios can be designed to address multiple constraints as required and may be used for constraints that are electrically close to each other or to further optimize transfer limits for several constraints requiring only minor redispatch. The redispatch assumptions include:

- The use of no more than 10 conventional fuel units or wind plants
- Redispatch limit at 2,000 MW total (1,000 MW up and 1,000 MW down)
- No adjustments to nuclear units
- No adjustments to the portions of pseudo-tied units committed to non-MISO load

3.1.3 Generation Limited Transfer for CIL/CEL and ZIA/ZEA

When conducting transfer analysis to determine import or export limits, the source subsystem might run out of generation to dispatch before identifying a constraint caused by a transmission limit. MISO developed a Generation Limited Transfer (GLT) process to identify transmission constraints in these situations, when possible, for both imports and exports.

After running the First Contingency Incremental Transfer Capability (FCITC) analysis to determine limits for each LRZ, MISO will determine whether a zone is experiencing a GLT (e.g. whether the first constraint would only occur after all the generation is dispatched at its maximum amount). If the LRZ experiences a GLT, MISO will adjust the base model based on whether it is an import or export analysis and re-run the transfer analysis.

For an export study, when a transmission constraint has not been identified after dispatching all generation within the exporting system (LRZ under study) MISO will decrease load and generation dispatch in the study zone. The adjustment creates additional capacity to export from the zone. After the adjustments are complete, MISO will rerun the transfer analysis. If a GLT reappears, MISO will make further adjustments to the load and generation of the study zone.

For an import study, when a transmission constraint has not been identified after dispatching all generation within the source subsystem, MISO will adjust load and generation in the source subsystem. This increases the import capacity for the study zone. After the adjustments are complete, MISO will run the transfer analysis again. If a GLT reappears, MISO will make further adjustments to the model’s load and generation in the source subsystem.

FCITC could indicate the transmission system can support larger thermal transfers than would be available based on installed generation for some zones. However, large variations in load and generation for any zone may lead to unreliable limits and constraints. Therefore, MISO limits load scaling for both import and export studies to 50 percent of the zone’s load.

Upon further review of LRZ-5 export GLT by the LOLEWG, it was determined that the ZEA value would be set at last year’s value of 2,122 MWs.

3.1.4 Voltage Limited Transfer for CIL/CEL and ZIA/ZEA

Zonal imports may be limited by voltage constraints due to a decrease in the generation in the zone prior to the thermal limits determined by linear FCITC. LOLE studies may evaluate Power-Voltage curves for LRZs with known voltage-based transfer limitations identified through prior MISO or Transmission Owner studies. Such evaluation may also happen if an LRZ’s import reaches a level where the majority of the zone’s load would be served using imports from resources outside of the zone. MISO will coordinate with stakeholders as it encounters these scenarios.

3.2 Powerflow Models and Assumptions

3.2.1 Tools used

MISO used the Siemens PTI Power System Simulator for Engineering (PSS E) and Transmission Adequacy and Reliability Assessment (TARA) as transfer analysis tools.

3.2.2 Inputs required

Thermal transfer analysis requires powerflow models and input files. MISO used contingency files from MTEP[4] reliability assessment studies. Single-element contingencies in MISO/seam areas were also evaluated.

MISO developed a subsystem file to monitor its footprint and seam areas. LRZ definitions were developed as sources and sinks in the study. See Appendix B for maps containing adjacent area definitions (Tiers 1 and 2) used for this study. The monitored file includes all facilities under MISO functional control and single elements in the seam areas of 100 kV and above.

3.2.3 Powerflow Modeling

The summer peak 2019 study model was built using MISO's Model on Demand (MOD) model data repository, with the following base assumptions (Table 3-1).

Scenario	Effective Date	Projects Applied	External Modeling	Load and Generation Profile
2019	6/1/2019	MTEP18 Appendix A and Target A	2017 Series 2019 Summer ERAG MMWG	Summer Peak

Table 3-1: Model assumptions

MISO excluded several types of units from the transfer analysis dispatch; these units' base dispatch remained fixed.

- Nuclear dispatch does not change for any transfer
- Intermittent resources can be ramped down, but not up
- Pseudo-tied resources were modeled at their expected commitments to non-MISO load, although portions of these units committed to MISO could participate in transfer analyses

System conditions such as load, dispatch, topology and interchange have an impact on transfer capability. The model was reviewed as part of the base model build for MTEP18 analyses, with study files made available on the MTEP ftp site. MISO worked closely with transmission owners and stakeholders in order to model the transmission system accurately, as well as to validate constraints and redispatch. Like other planning studies, transmission outage schedules were not included in the analysis. This is driven partly by limited availability of outage information as well as by current standard requirements. Although no outage schedules were evaluated, all single element contingencies were evaluated. This includes BES lines, transformers, and generators. Contingency coverage covers most of category P1 and some of category P2.

3.2.4 General Assumptions

MISO uses TARA to process the powerflow model and associated input files to determine the import and export limits of each LRZ by determining the transfer capability. Transfer capability measures the ability of interconnected power systems to reliably transfer power from one area to another under specified system conditions. The incremental amount of power that can be transferred will be determined through FCITC analysis. FCITC analysis and base power transfers provide the information required to calculate the First Contingency Total Transfer Capability (FCTTC), which indicates the total amount of transferrable power before a constraint is identified. FCTTC is the base power transfer plus the incremental transfer capability (Equation 3-1). All published limits are based on the zone's FCTTC and may be adjusted for capacity exports.

[4] Refer to the Transmission Planning BPM for more information regarding MTEP input files. https://www.misoenergy.org/_layouts/MISO/ECM/Redirect.aspx?ID=19215

$$First\ Contingency\ Total\ Transfer\ Capability\ (FCTTC) = FCITC + Base\ Power\ Transfer$$

Equation 3-1: Total Transfer Capability

Facilities were flagged as potential constraints for loadings of 100 percent or more in two scenarios: the normal rating for system intact conditions and the emergency rating for single event contingencies. Linear FCITC analysis identifies the limiting constraints using a minimum transfer Distribution Factor (DF) cutoff of 3 percent, meaning the transfer and contingency must increase the loading on the overloaded element by 3 percent or more.

A pro-rata dispatch is used, which ensures all available generators will reach their maximum dispatch level at the same time. The pro-rata dispatch is based on the MW reserve available for each unit and the cumulative MW reserve available in the subsystem. The MW reserve is found by subtracting a unit's base model generation dispatch from its maximum dispatch, which reflects the available capacity of the unit.

Table 3-2 and Equation 3-2 show an example of how one unit's dispatch is set, given all machine data for the source subsystem.

Machine	Base Model Unit Dispatch (MW)	Minimum Unit Dispatch (MW)	Maximum Unit Dispatch (MW)	Reserve MW (Unit Dispatch Max – Unit Dispatch Min)
1	20	20	100	80
2	50	10	150	100
3	20	20	100	80
4	450	0	500	50
5	500	100	500	0
			Total Reserve	310

Table 3-2: Example subsystem

$$\boldsymbol{Machine\ 1\ Incremental\ Post\ Transfer\ Dispatch = \frac{Machine\ 1\ Reserve\ MW}{Source\ Subsystem\ Reserve\ MW} \times Transfer\ Level\ MW}$$

$$Machine\ 1\ Incremental\ Post\ Transfer\ Dispatch = \frac{80}{310} \times 100 = 25.8$$

$$Machine\ 1\ Incremental\ Post\ Transfer\ Dispatch = 25.8$$

Equation 3-2: Machine 1 dispatch calculation for 100 MW transfer

3.3 Results for CIL/CEL and ZIA/ZEA

Constraints limiting transfers and the associated ZIA, ZEA, CIL, and CEL for each LRZ were presented and reviewed through the LOLEWG. Preliminary results for Planning Year 2019/20 were presented in the September 2018 meeting and updates were presented in an October 2018 WebEx/conference call.

Detailed constraint and redispatch information for all limits is found in the Transfer Analysis section of this report. Table 3-3 presents a summary of the Planning Year 2019-20 Capacity Import Limits.

LRZ	Tier	19-20 CIL (MW)[5]	19-20 ZIA (MW)	Monitored Element	Contingent Element	Figure 3.3-1 Map ID	GLT applied	Generation Redispatch (MW)	18-19 CIL (MW)[6]
1	1&2	4,078	3,747	Sherman Street to Sunnyvale 115 kV	Arpin to Rocky Run 115 kV	1	No	1,992	4,546
2	1&2	1,713	1,713	University Park to East Frankfort 345 kV	Dumont to Wilton 765 kV	2	No	2,000	2,317
3	1&2	3,037	2,813	Sub 3458 to Sub 3456 345 kV	Sub 3455 to Sub 3740 345 kV	3	No	2,000	2,812
4	N/A	6,845	5,210	Hallock Bus 138 kV voltage	Clinton Generation	4	No	N/A	6,278
5	1&2	5,013	5,013	Joppa 345/161 kV	Shawnee 500/345 kV	5	No	1,820	3,580
6	1&2	7,066	6,924	Paradise to BRTAP 161 kV	Phipps Bend to Volunteer 500 kV	6	No	2,000	7,375
7	N/A	3,211	3,211	Pioneer 120 kV bus voltage	Wayne – Monroe 345 kV	7	No	N/A	3,785
8	1&2	4,424	4,185	Moon Lake-Ritchie 230 kV	Cordova TN to Benton MS500 kV	8	No	2,000	4,778
9	1&2	3,950	3,631	Sterlington to Downsville 115 kV	Mt. Olive to El Dorado 500 kV	9	No	2,000	3,679
10	1	3,906	3,792	Freeport to Twinkletown 230 kV	Freeport to Horn Lake 230 kV	10	No	2,000	2,618

Table 3-3: Planning Year 2019–2020 Import Limits

[5] Results after applying redispatch and adjusted for exports to non-MISO load per the FERC locational filing.
[6] Results after applying redispatch and shift factor adjustments for the Dec. 31, 2015, FERC order.

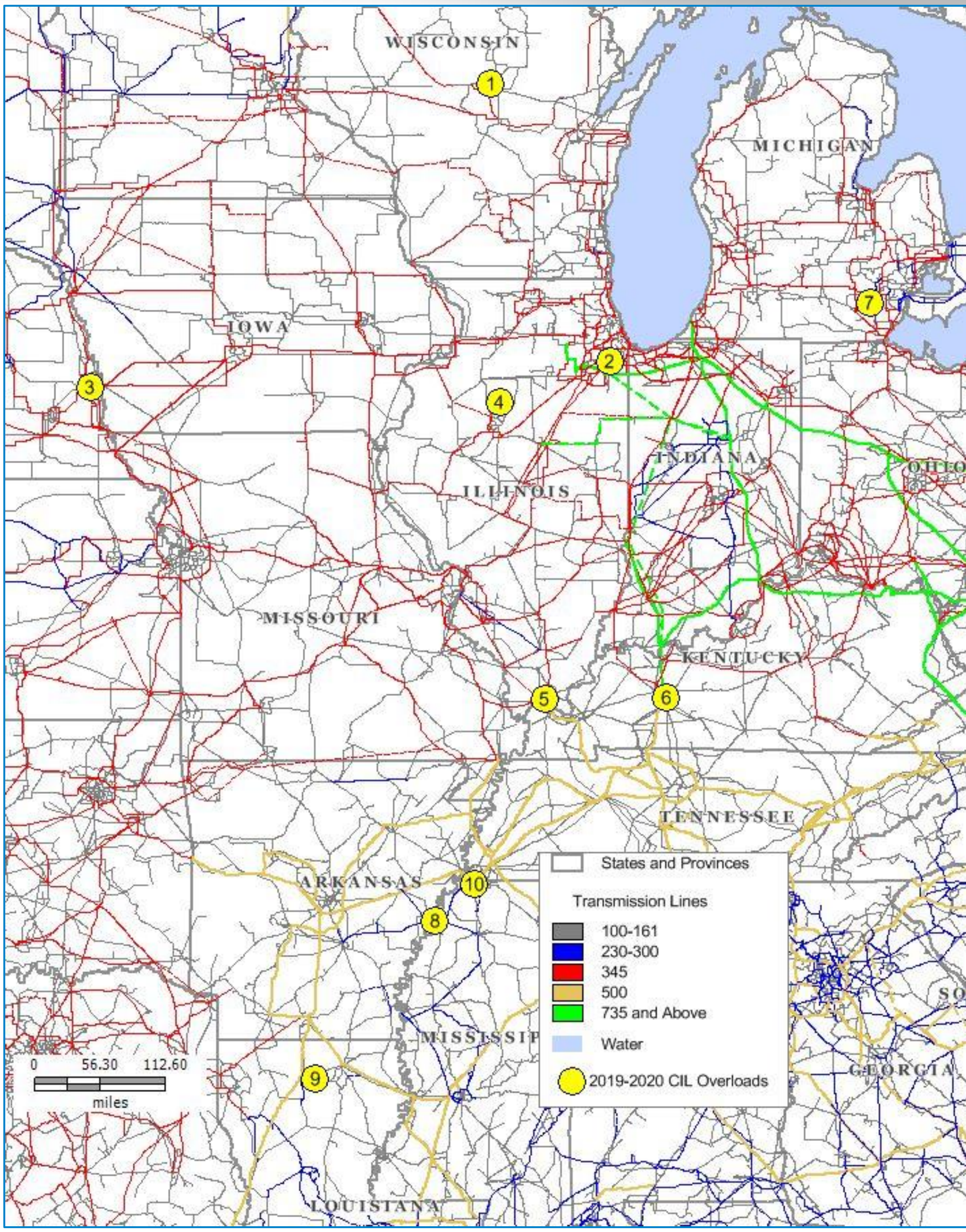


Figure 3-1: Planning Year 2019-20 Import Constraint Map

Capacity Exports Limits were found by increasing generation in the zone being studied and decreasing generation in the rest of the MISO footprint. Table 3-4 summarizes Planning Year 2019-20 Capacity Export Limits.

LRZ	19-20 CEL (MW)	19-20 ZEA (MW)	Monitored Element	Contingent Element	Figure 3.3-2 Map ID	Generation Redispatch (MW)	GLT applied	18-19 CEL (MW)
1	3,048	3,379	Seneca to Gran Grae 161 kV	Arpin to Eau Claire 345 kV	1	400	Yes	516
2	979	979	Wempleton 345/138 kV	Cherry Valley 345/138 kV	2	1,208	Yes	2,017
3	4,440	4,664	Fargo 345/138 kV	Mapleridge to Tazwell 345 kV	3	350	Yes	5,430
4	3,693	5,332	Pontiac to Brokaw 345 kV	Pontiac to Bluemond 345 kV	4	350	Yes	4,280
5	2,122	2,122	No Constraint found	System Intact	5	0	Yes	2,122
6	1,435	1,577	University Park to East Frankfort 345 kV	Dumont to Wilton 765 kV	7	0	Yes	3,249
7	1,358	1,358	University Park to East Frankfort 345 kV	Dumont to Wilton 765 kV	6	1400	No	2,578
8	5,089	5,328	Russelville South to Dardanelle 161 kV	Arkansas Nuclear to Fort Smith 500 kV	8	0	Yes	2,424
9	1,905	2,224	Addis to Tiger 230 kV	Dow meter to Chenango 230 kV	9	800	No	2,149
10	1,607	1,721	Batesville to Tallahachie 161 kV	Choctaw to Clay 500 kV	10	100	Yes	1,824

Table 3-4: Planning Year 2019–2020 Export Limits

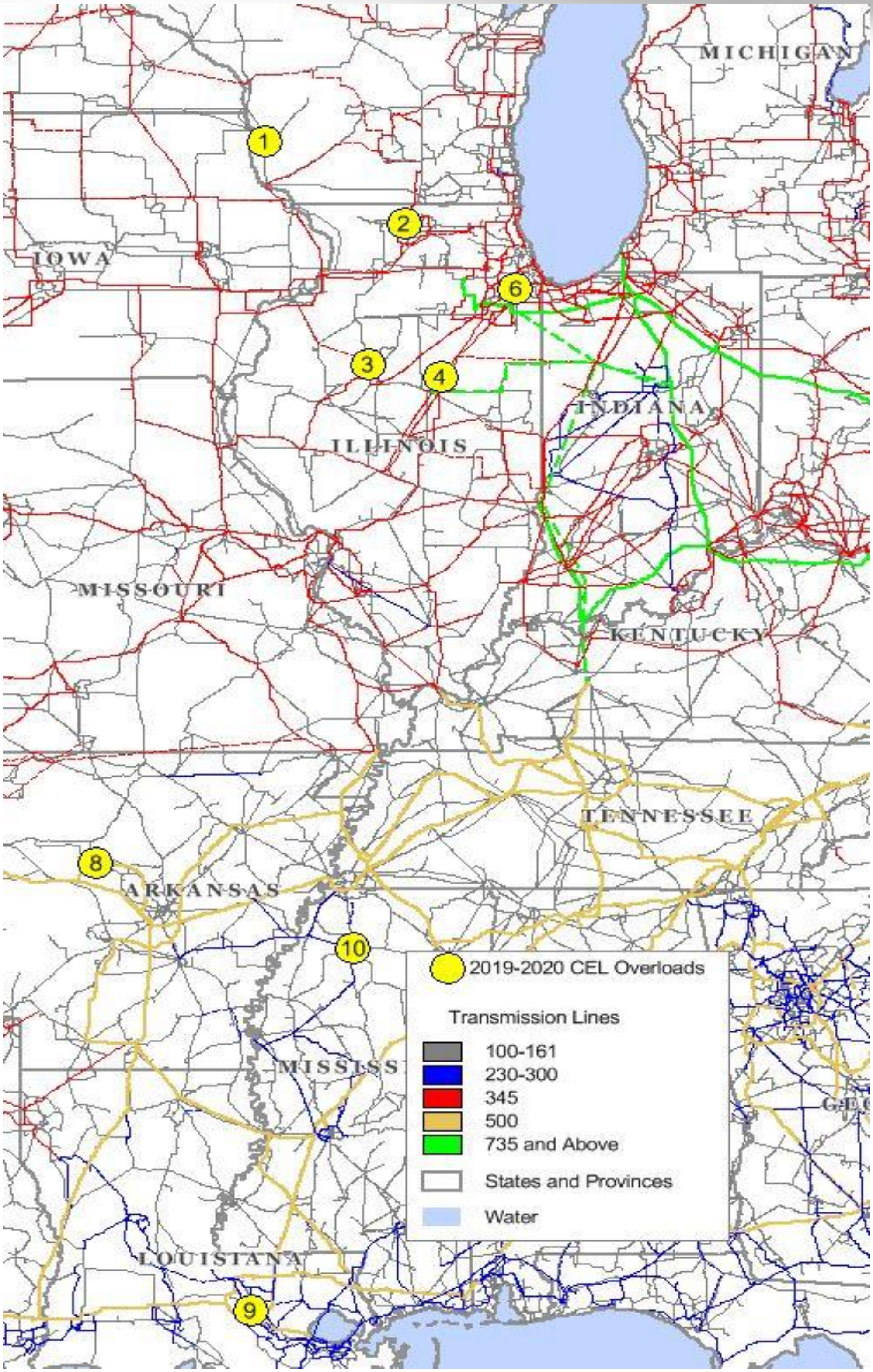


Figure 3-2: Planning Year 2019-20 Export Constraint Map

3.3.1 Out-Year Analysis

In 2018, MISO and its stakeholders redesigned the out-year LOLE transfer analysis process through the LOLEWG and Resource Adequacy Subcommittee (RASC). The out-year analysis will now be performed after the near-term analyses are complete. The out-year results will be documented outside of the LOLE report and recorded in LOLEWG meeting materials.

4 Loss of Load Expectation Analysis

4.1 LOLE Modeling Input Data and Assumptions

MISO uses a program managed by Astrapé Consulting called SERVM to calculate the LOLE for the applicable planning year. SERVM uses a sequential Monte Carlo simulation to model a generation system and to assess the system's reliability based on any number of interconnected areas. SERVM calculates the annual LOLE for the MISO system and each LRZ by stepping through the year chronologically and taking into account generation, load, load modifying and energy efficiency resources, equipment forced outages, planned and maintenance outages, weather and economic uncertainty, and external support.

Building the SERVM model is the most time-consuming task of the PRM study. Many scenarios are built in order to determine how certain variables impact the results. The base case models determine the MISO PRM Installed Capacity (ICAP), PRM UCAP and the LRRs for each LRZ for years one, four and six.

4.2 MISO Generation

4.2.1 Thermal Units

The 2019-2020 planning year LOLE study used the 2018 PRA converted capacity as a starting point for which resources to include in the study. This ensured that only resources eligible as a Planning Resources were included in the LOLE study. An exception was made for resources with a signed GIA with an anticipated in-service date for the 2019-2020 PY. These resources were also included. All internal Planning Resources were modeled in the LRZ in which they are physically located. Additionally, Coordinating Owners and Border External Resources were modeled as being internal to the LRZ in which they are committed to serving load.

Forced outage rates and planned maintenance factors were calculated over a five-year period (January 2013 to December 2017) and modeled as one value for each unit. Some units did not have five years of historical data in MISO's Generator Availability Data System (PowerGADS). However, if they had at least 12 consecutive months of data then unit-specific information was used to calculate their forced outage rates and maintenance factors. Units with fewer than 12 consecutive months of unit-specific data were assigned the corresponding MISO class average forced outage rate and planned maintenance factor based on their fuel type. Any MISO class with fewer than 30 units were assigned the overall MISO weighted class average forced outage rate of 9.28 percent.

Nuclear units have a fixed maintenance schedule, which was pulled from publicly available information and was modeled for each of the study years.

The historical class average outage rates as well as the MISO fleet wide weighted average forced outage rate are in Table 4-1.

Pooled EFORd GADS Years	2013-2017 (%)	2012-2016 (%)	2011-2015 (%)	2010-2014 (%)	2009-2013 (%)	2008-2012 (%)
LOLE Study Planning Year	2019-2020 PY LOLE Study	2018-2019 PY LOLE Study	2017-2018 PY LOLE Study	2016-2017 PY LOLE Study	2015-2016 PY LOLE Study	2014-2015 PY LOLE Study
Combined Cycle	5.37	4.62	3.56	3.78	3.92	4.74
Combustion Turbine (0-20 MW)	23.18	29.02	24.2	23.58	18.39	27.22
Combustion Turbine (20-50 MW)	15.76	13.48	13.94	16.03	53.12	25.27
Combustion Turbine (50+ MW)	5.18	6.19	5.94	5.69	5.61	5.76
Diesel Engines	10.26	10.42	13.12	12.51	14.00	9.83
Fluidized Bed Combustion	*	*	*	*	**	**
HYDRO (0-30MW)	*	*	*	*	**	**
HYDRO (30+ MW)	*	*	*	*	**	**
Nuclear	*	*	*	*	**	**
Pumped Storage	*	*	*	*	**	**
Steam - Coal (0-100 MW)	4.60	5.14	5.99	7.12	8.45	8.82
Steam - Coal (100-200 MW)	*	*	*	*	6.39	6.85
Steam - Coal (200-400 MW)	9.82	9.77	8.64	8.46	8.44	8.33
Steam - Coal (400-600 MW)	*	*	*	7.04	6.99	6.98
Steam - Coal (600-800 MW)	8.22	7.90	7.42	7.58	7.36	**
Steam - Coal (800-1000 MW)	*	*	*	*	**	**
Steam - Gas	11.56	11.94	11.68	10.18	8.79	**
Steam - Oil	*	*	*	*	**	**
Steam - Waste Heat	*	*	*	*	**	**
Steam - Wood	*	*	*	*	**	**
MISO System Wide Weighted	9.28	9.16	8.21	7.98	7.67	7.55

*MISO system-wide weighted forced outage rate used in place of class data for those with less than 30 units reporting 12 or more months of data
**Prior to 2015-2016PY the NERC class average outage rate was used for units with less than 30 units reporting 12 or more months of data

Table 4-1: Historical Class Average Forced Outage Rates

4.2.2 Behind-the-Meter Generation

Behind-the-Meter generation data came from the Module E Capacity Tracking (MECT) tool. These resources were explicitly modeled just as any other thermal generator with a monthly capacity and forced outage rate. Performance data was pulled from PowerGADS.

4.2.3 Sales

This year's LOLE analysis incorporated firm sales to neighboring capacity markets as well as firm transactions off system where information was available. For units with capacity sold off-system, the monthly capacities were reduced by the megawatt amount sold. This totaled 3,195 MW UCAP for Planning Year 2019-2020. See Section 4.4 for a more detailed breakdown. These values came from PJM's Reliability Pricing Model (RPM) as well as exports to other external areas taken from the Independent Market Monitor (IMM) exclusion list.

4.2.4 Attachment Y

For the 2019-2020 planning year, generating units with approved suspensions or retirements (as of June 1, 2018) through MISO's Attachment Y process were removed from the LOLE analysis. Any unit retiring, suspending, or coming back online at any point during the planning year was excluded from the year-one analysis. This same methodology is used for the four- and six-year analyses.

4.2.5 Future Generation

Future thermal generation and upgrades were added to the LOLE model based on unit information in the MISO Generator Interconnection Queue. The LOLE model included units with a signed interconnection agreement (as of June 1, 2018). These new units were assigned class-average forced outage rates and planned maintenance factors based on their particular unit class. Units upgraded during the study period reflect the megawatt increase for each month, beginning the month the upgrade was finished. The LOLE analysis also included future wind and solar generation at the MISO capacity accreditation amount (wind at 15.2 percent and solar at 50 percent).

4.2.6 Intermittent Resources

Intermittent resources such as run-of-river hydro, biomass and wind were explicitly modeled as demand-side resources. Non-wind intermittent resources, such as run-of-river hydro and biomass, provide MISO with up to 15 years of historical summer output data for the hours ending 15:00 EST through 17:00 EST. This data is averaged and modeled in the LOLE analysis as UCAP for all months. Each individual unit is modeled and put in the corresponding LRZ.

Each wind-generator Commercial Pricing Node (CPNode) received a capacity credit based on its historical output from MISO's top eight peak days in each of the past years for which data were available. The megawatt value corresponding to each CPNode's wind capacity credit was used for each month of the year. Units new to the commercial model without a wind capacity credit as part of the 2018 Wind Capacity Credit analysis received the MISO-wide wind capacity credit of 15.2 percent as established by the 2018 Wind Capacity Credit Effective Load Carrying Capability (ELCC) study. The capacity credit established by the ELCC analysis determines the maximum percent of the wind unit that can receive credit in the PRA while the actual amount could be less due to other factors such as transmission limitations. Each wind CPNode receives its actual wind capacity credit based on the capacity eligible to participate in the PRA. Only Network Resource Interconnection Service or Energy Resource Interconnection Service with firm point-to-point is considered an eligible capacity resource. The final value from the 2018 PRA for each wind unit was modeled at a flat capacity profile for the planning year. The detailed methodology for establishing the MISO-wide and individual CPNode Wind Capacity Credits can be found in the 2018 Wind Capacity Credit Report.

4.2.7 Demand Response

Demand response data came from the MECT tool. These resources were explicitly modeled as dispatch-limited resources. Each demand response program was modeled individually with a monthly capacity, limited to the number of times each program can be called upon, and limited by duration.

4.3 MISO Load Data

The 2019-2020 LOLE analysis used a load training process with neural net software to create a neural-net relationship between historical weather and load data. This relationship was then applied to 30 years of hourly historical weather data to create 30 different load shapes for each LRZ in order to capture both load diversity and seasonal variations. The average monthly loads of the predicted load shapes were adjusted to match each LRZ's Module E 50/50 monthly zonal peak load forecasts for each study year. The results of this process are shown as the MISO System Peak Demand (Table 5-1) and LRZ Peak Demands (Table 6-1).

Direct Control Load Management and Interruptible Demand types of demand response were explicitly included in the LOLE model as resources. These demand resources are implemented in the LOLE simulation before accumulating LOLE or shedding of firm load.

4.3.1 Weather Uncertainty

MISO has adopted a six-step load training process in order to capture the weather uncertainty associated with the 50/50 load forecasts. The first step of this process requires the collection of five years of historical real-time load modifying resource (LMR) performance and load data, as well as the collection of 30 years of historical weather data. Both the LMR and load data are taken from the MISO market for each LBA, while the historical weather data is collected from the National Oceanic and Atmospheric Administration (NOAA) for each LRZ. After collecting the data the hourly gross load for each LRZ is calculated using the five years of historical data.

The second step of the process is to normalize the five years of load data to consistent economics. With the load growth due to economics removed from 5 years of historical LRZ load, the third step of the process utilizes neural network software to establish functional relationships between the five years of historical weather and load data. In the fourth step of the process the neural network relationships are applied to the 30 years of historical weather data in order to predict/create 30 years' worth of load shapes for each LRZ.

In the fifth step of the load training process, MISO undertakes extreme temperature verification on the 30 years of load shapes to ensure that the hourly load data is accurate at extremely hot or cold temperatures. This is required since there are fewer data points available at the temperature extremes when determining the neural network functional relationships. This lack of data at the extremes can result in inaccurate predictions when creating load shapes, which will need to be corrected before moving forward.

The sixth and final step of the load training process is to average the monthly peak loads of the predicted load shapes and adjust them to match each LRZ's Module E 50/50 monthly zonal peak load forecasts for each study year. In order to calculate this adjustment, the ratio of the first year's non-coincident peak forecast to the zonal coincident peak forecast is applied to future year's non-coincident peak forecast.

By adopting this new methodology for capturing weather uncertainty MISO is able to model multiple load shapes based off a functional relationship with weather. This modeling approach provides a variance in load shapes, as well as the peak loads observed in each load shape. This approach also provides the ability to capture the frequency and duration of severe weather patterns.

4.3.2 Economic Load Uncertainty

To account for economic load uncertainty in the 2019-2020 planning year LOLE model MISO utilized a normal distribution of electric utility forecast error accounting for projected and actual Gross Domestic Product (GDP), as well as electricity usage. The historic projections for GDP growth were taken from the Congressional Budget Office (CBO), the actual GDP growth was taken from the Bureau of Economic Analysis (BEA), and the electric use was taken from the U.S. Energy Information Administration (EIA). Due to lack of statewide projected GDP data MISO relied on United States aggregate level data when calculating the economic uncertainty.

In order to calculate the electric utility forecast error, MISO first calculated the forecast error of GDP between the projected and actual values. The resulting GDP forecast error was then translated into electric utility forecast error by multiply by the rate at which electric load grows in comparison to the GDP. Finally, a standard deviation is calculated from the electric utility forecast error and used to create a normal distribution representing the probabilities of the load forecast errors (LFE) as shown in Table 4-2.

	LFE Levels				
	-2.0%	-1.0%	0.0%	1.0%	2.0%
Standard Deviation in LFE	Probability assigned to each LFE				
1.19%	10.4%	23.3%	32.6%	23.3%	10.4%

Table 4-2: Economic Uncertainty

As a result of stakeholder feedback MISO is exploring possible alternative methods for determining economic uncertainty to be used in the LOLE process.

4.4 External System

Within the LOLE study, a 1 MW increase of non-firm support from external areas leads to a 1 MW decrease in the reserve margin calculation. It is important to account for the benefit of being part of the eastern interconnection while also providing a stable result. In order to provide a more stable result and remove the false sense of precision, the external non-firm support was set at an ICAP of 2,987 MW and a UCAP of 2,331 MW.

Firm imports from external areas to MISO are modeled at the individual unit level. The specific external units were modeled with their specific installed capacity amount and their corresponding Equivalent Forced Outage Rate demand (EFORd). This better captures the probabilistic reliability impact of firm external imports. These units are only modeled within the MISO PRM analysis and are not modeled when calculating the LRZ LRRs. Due to the locational Tariff filing, Border External Resources and Coordinating Owners are no longer considered firm imports. Instead, these resources are modeled as internal MISO units and are included in the PRM and LRR analysis. The external resources to include for firm imports were based on the amount offered into the 2018-19 planning year PRA. This is a historically accurate indicator of future imports. For 2018-19 planning year this amount was 1,883 MW ICAP.

Firm exports from MISO to external areas were modeled the same as previous years. As stated in Section 4.2.3, capacity ineligible as MISO capacity due to transactions with external areas is removed from the model. Table 4-3 shows the amount of firm imports and exports in this year's study.

Contracts	ICAP (MW)	UCAP (MW)
Imports (MW)	1,883	1,809
Exports (MW)	3,526	3,195
Net	**-1,643**	**-1,386**

Table 4-3: 2018 Planning Year Firm Imports and Exports

4.5 Loss of Load Expectation Analysis and Metric Calculations

Upon completion of the SERVM database, MISO determined the appropriate PRM ICAP and PRM UCAP for the 2019-2020 planning year as well as the appropriate Local Reliability Requirement for each of the 10 LRZ's. These metrics were determined by a probabilistic LOLE analysis such that the LOLE for the planning year was one day in 10 years, or 0.1 day per year.

4.5.1 MISO-Wide LOLE Analysis and PRM Calculation

For the MISO-wide analysis, generating units were modeled as part of their appropriate LRZ as a subset of a larger MISO pool. The MISO system was modeled with no internal transmission limitations. In order to meet the reliability criteria of 0.1 day per year LOLE, capacity is either added or removed from the MISO pool. The minimum amount of capacity above the 50/50 net internal MISO Coincident Peak Demand required to meet the reliability criteria was used to establish the PRM values.

The minimum PRM requirement is determined using the LOLE analysis by either adding or removing capacity until the LOLE reaches 0.1 day per year. If the LOLE is less than 0.1 day per year, a perfect negative unit with zero forced outage rate is added until the LOLE reaches 0.1 day per year. The perfect negative unit adjustment is akin to adding load to the model. If the LOLE is greater than 0.1 day per year, proxy units based on a unit of typical size and forced outage rate will be added to the model until the LOLE reaches 0.1 day per year.

For the 2019-2020 planning year, the MISO PRM analysis removed capacity (6,250 MW) using the perfect unit adjustment.

The formulas for the PRM values for the MISO system are:

PRM ICAP = ((Installed Capacity + Firm External Support ICAP + ICAP Adjustment to meet a LOLE of 0.1 days per year) – MISO Coincident Peak Demand)/MISO Coincident Peak Demand

PRM UCAP = (Unforced Capacity + Firm External Support UCAP + UCAP Adjustment to meet a LOLE of 0.1 days per year) – MISO Coincident Peak Demand)/MISO Coincident Peak Demand

Where Unforced Capacity (UCAP) = Installed Capacity (ICAP) x (1 – XEFORd)

4.5.2 LRZ LOLE Analysis and Local Reliability Requirement Calculation

For the LRZ analysis, each LRZ included only the generating units within the LRZ (including Coordinating Owners and Border External Resources) and was modeled without consideration of the benefit of the LRZ's import capability. Much like the MISO analysis, unforced capacity is either added or removed in each LRZ such that a LOLE of 0.1 day per year is achieved. The minimum amount of unforced capacity above each LRZ's Peak Demand that was required to meet the reliability criteria was used to establish each LRZ's LRR.

The 2019-2020 LRR is determined using the LOLE analysis by either adding or removing capacity until the LOLE reaches 0.1 day per year for the LRZ. If the LOLE is less than 0.1 day per year, a perfect negative unit with zero forced outage rate will be added until the LOLE reaches 0.1 day per year. If the LOLE is greater than 0.1 day per year, proxy units based on a unit of typical size and forced outage rate will be added to the model until the LOLE reaches 0.1 day per year.

For the 2019-2020 planning year, only LRZ-3 and LRZ-8 had sufficient capacity, internal to the LRZ to achieve the LOLE of 0.1 day per year as an island. In the eight zones without sufficient capacity as an island, proxy units of typical size (160 MW) and class-average EFORd (5.17 percent) were added to the LRZ. When needed, a fraction of the final proxy unit was added to achieve the exact LOLE of 0.1 day per year for the LRZ.

5 MISO System Planning Reserve Margin Results

5.1 Planning Year 2019-2020 MISO Planning Reserve Margin Results

For the 2019-2020 planning year, the ratio of MISO capacity to forecasted MISO system peak demand yielded a planning ICAP reserve margin of 16.8 percent and a planning UCAP reserve margin of 7.9 percent. These PRM values assume 1,809 MW UCAP of firm and 2,331 MW UCAP of non-firm external support. Numerous values and calculations went into determining the MISO system PRM ICAP and PRM UCAP (Table 5-1).

MISO Planning Reserve Margin (PRM)	2019/2020 PY (June 2019 - May 2020)	Formula Key
MISO System Peak Demand (MW)	125,501	[A]
Installed Capacity (ICAP) (MW)	153,896	[B]
Unforced Capacity (UCAP) (MW)	142,132	[C]
Firm External Support (ICAP) (MW)	1,883	[D]
Firm External Support (UCAP) (MW)	1,809	[E]
Adjustment to ICAP {1d in 10yr} (MW)	-6,250	[F]
Adjustment to UCAP {1d in 10yr} (MW)	-6,250	[G]
Non-Firm External Support (ICAP) (MW)	2,987	[H]
Non-Firm External Support (UCAP) (MW)	2,331	[I]
ICAP PRM Requirement (PRMR) (MW)	146,543	[J]=[B]+[D]+[F]-[H]
UCAP PRM Requirement (PRMR) (MW)	135,360	[K]=[C]+[E]+[G]-[I]
MISO PRM ICAP	**16.8%**	[L]=([J]-[A])/[A]
MISO PRM UCAP	**7.9%**	[M]=([K]-[A])/[A]

Table 5-1: Planning Year 2019-2020 MISO System Planning Reserve Margins

5.1.1 LOLE Results Statistics

In addition to the LOLE results SERVM has the ability to calculate several other probabilistic metrics (Table 5-2). These values are given when MISO is at its PRM UCAP of 7.9 percent. The LOLE of 0.1 day/year is what the model is driven to and how the PRM is calculated. The loss of load hours is defined as the number of hours during a given time period where system demand will exceed the generating capacity during a given period. Expected Unserved Energy (EUE) is energy-centric and analyzes all hours of a particular planning year. Results are calculated in megawatt-hours (MWh). EUE is the summation of the expected number of MWh of load that will not be served in a given planning year as a result of demand exceeding the available capacity across all hours.

MISO LOLE Statistics	
Loss of Load Expectation - LOLE [Days/Yr]	0.100
Loss of Load Hours - LOLH [hrs/yr]	0.339
Expected Unserved Energy - EUE [MWh/yr]	732.9

Table 5-2: MISO Probabilistic Model Statistics

5.2 Comparison of PRM Targets Across Eight Years

Figure 5-1 compares the PRM UCAP values over the last nine planning years. The last endpoint of the blue line shows the Planning Year 2019-2020 PRM value.

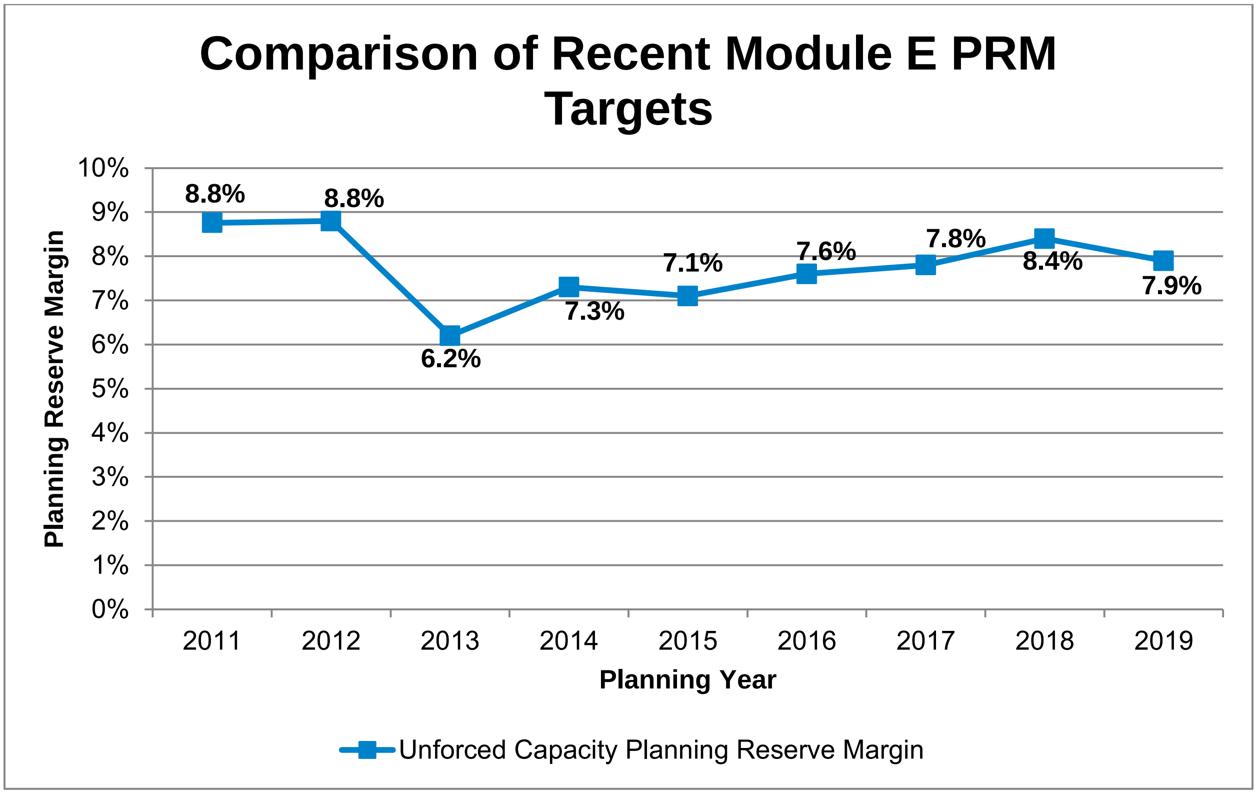


Figure 5-1: Comparison of PRM targets across eight years

5.3 Future Years 2019 through 2028 Planning Reserve Margins

Beyond the planning year 2019-2020 LOLE study analysis, an LOLE analysis was performed for the four-year-out planning year of 2022-2023, and the six-year-out planning year of 2024-2025. Table 5-3 shows all the values and calculations that went into determining the MISO system PRM ICAP and PRM UCAP values for those years. Those results are shown as the underlined values of Table 5-4. The values from the intervening years result from interpolating the 2019, 2022, and 2024 results. Note that the MISO system PRM results assume no limitations on transfers within MISO.

The 2022-2023 planning year PRM increased slightly from the 2019-2020 planning year driven mainly by new unit additions and retirements. The forecasts for the 2024-2025 Planning Year PRM decreased primarily because of LSE load forecasts.

MISO Planning Reserve Margin (PRM)	**2022/2023 PY** (June 2022 - May 2023)	**2024/2025 PY** (June 2024 - May 2025)	**Formula Key**
MISO System Peak Demand (MW)	126,768	127,259	[A]
Installed Capacity (ICAP) (MW)	156,422	156,686	[B]
Unforced Capacity (UCAP) (MW)	144,815	145,037	[C]
Firm External Support (ICAP) (MW)	1,883	1,883	[D]
Firm External Support (UCAP) (MW)	1,809	1,809	[E]
Adjustment to ICAP {1d in 10yr} (MW)	-7,225	-7,615	[F]
Adjustment to UCAP {1d in 10yr} (MW)	-7,225	-7,615	[G]
Non-Firm External Support (ICAP) (MW)	2,987	2,987	[H]
Non-Firm External Support (UCAP) (MW)	2,331	2,331	[I]
ICAP PRM Requirement (PRMR) (MW)	148,093	147,967	[J]=[B]+[D]+[F]-[H]
UCAP PRM Requirement (PRMR) (MW)	137,068	136,900	[K]=[C]+[E]+[G]-[I]
MISO PRM ICAP	16.8%	16.3%	[L]=([J]-[A])/[A]
MISO PRM UCAP	8.1%	7.6%	[M]=([K]-[A])/[A]

Table 5-3: Future Planning Year MISO System Planning Reserve Margins

Metric	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**
PRM ICAP	**16.8%**	**16.8%**	**16.8%**	**16.8%**	**16.8%**	**16.3%**	**16.3%**	**16.2%**	**16.1%**	**16.1%**
PRM UCAP	**7.9%**	**8.0%**	**8.0%**	**8.1%**	**8.1%**	**7.6%**	**7.7%**	**7.7%**	**7.6%**	**7.6%**

Table 5-4: MISO System Planning Reserve Margins 2019 through 2028
(Years without underlined results indicate values that were calculated through interpolation)

6 Local Resource Zone Analysis – LRR Results

6.1 Planning Year 2019-2020 Local Resource Zone Analysis

MISO calculated the per-unit LRR of LRZ Peak Demand for years one, four and six (Table 6-1, Table 6-2, and Table 6-3). The UCAP values in Table 6-1 reflect the UCAP within each LRZ, including Border External Resources and Coordinating Owners. The adjustment to UCAP values are the megawatt adjustments needed in each LRZ so that the reliability criterion of 0.1 days per year LOLE is met. The LRR is the summation of the UCAP and adjustment to UCAP megawatts. The LRR is then divided by each LRZ's Peak Demand to determine the per-unit LRR UCAP. The 2019-2020 per unit LRR UCAP values will be multiplied by the updated demand forecasts submitted for the 2019-2020 PRA to determine each LRZ's LRR.

Local Resource Zone (LRZ)	**LRZ-1 MN/ND**	**LRZ-2 WI**	**LRZ-3 IA**	**LRZ-4 IL**	**LRZ-5 MO**	**LRZ-6 IN**	**LRZ-7 MI**	**LRZ-8 AR**	**LRZ-9 LA/TX**	**LRZ-10 MS**	**Formula Key**
2019-2020 Planning Reserve Margin (PRM) Study											
Installed Capacity (ICAP) (MW)	20,794	14,439	11,394	12,382	8,699	19,835	24,228	11,529	24,492	6,096	[A]
Unforced Capacity (UCAP) (MW)	19,762	13,629	10,863	11,012	7,766	18,529	22,171	10,823	22,509	5,061	[B]
Adjustment to UCAP {1d in 10yr} (MW)	702	1,038	-12	702	2,342	1,731	2,674	-273	811	2,025	[C]
LRR (UCAP) (MW)	20,464	14,667	10,851	11,713	10,108	20,259	24,845	10,550	23,320	7,086	[D]=[B]+[C]
Peak Demand (MW)	17,780	12,629	9,391	9,415	8,079	17,584	21,208	7,770	20,693	4,814	[E]
LRR UCAP per-unit of LRZ Peak Demand	**115.1%**	**116.1%**	**115.6%**	**124.4%**	**125.1%**	**115.2%**	**117.2%**	**135.8%**	**112.7%**	**147.2%**	[F]=[D]/[E]

Table 6-1: Planning Year 2019-2020 LRZ Local Reliability Requirements

Local Resource Zone (LRZ)	**LRZ-1 MN/ND**	**LRZ-2 WI**	**LRZ-3 IA**	**LRZ-4 IL**	**LRZ-5 MO**	**LRZ-6 IN**	**LRZ-7 MI**	**LRZ-8 AR**	**LRZ-9 LA/TX**	**LRZ-10 MS**	**Formula Key**
2022-2023 Planning Reserve Margin (PRM) Study											
Installed Capacity (ICAP) (MW)	20,976	15,211	11,600	13,115	8,721	20,540	22,924	11,617	25,612	6,096	[A]
Unforced Capacity (UCAP) (MW)	19,942	14,364	11,064	11,717	7,787	19,196	21,224	10,910	23,542	5,061	[B]
Adjustment to UCAP {1d in 10yr} (MW)	1,091	479	90	223	2,380	1,348	3,177	-195	391	1,974	[C]
LRR (UCAP) (MW)	21,032	14,843	11,154	11,940	10,167	20,544	24,401	10,715	23,933	7,036	[D]=[B]+[C]
Peak Demand (MW)	18,303	12,761	9,648	9,394	8,119	17,827	21,038	7,990	20,763	4,839	[E]
LRR UCAP per-unit of LRZ Peak Demand	**114.9%**	**116.3%**	**115.6%**	**127.1%**	**125.2%**	**115.2%**	**116.0%**	**134.1%**	**115.3%**	**145.4%**	[F]=[D]/[E]

Table 6-2: Planning Year 2022-2023 LRZ Local Reliability Requirements

Local Resource Zone (LRZ)	LRZ-1 MN/ND	LRZ-2 WI	LRZ-3 IA	LRZ-4 IL	LRZ-5 MO	LRZ-6 IN	LRZ-7 MI	LRZ-8 AR	LRZ-9 LA/TX	LRZ-10 MS	Formula Key
2024-2025 Planning Reserve Margin (PRM) Study											
Installed Capacity (ICAP) (MW)	20,976	15,211	11,600	13,115	8,721	20,540	23,188	11,617	25,612	6,096	[A]
Unforced Capacity (UCAP) (MW)	19,942	14,364	11,064	11,717	7,787	19,196	21,446	10,910	23,542	5,061	[B]
Adjustment to UCAP {1d in 10yr} (MW)	1,313	578	261	114	2,487	1,181	2,323	-220	711	2,010	[C]
LRR (UCAP) (MW)	21,255	14,942	11,324	11,831	10,274	20,377	23,769	10,690	24,253	7,072	[D]=[B]+[C]
Peak Demand (MW)	18,519	12,837	9,809	9,287	8,173	17,663	20,982	8,055	20,999	4,875	[E]
LRR UCAP per-unit of LRZ Peak Demand	**114.8%**	**116.4%**	**115.5%**	**127.4%**	**125.7%**	**115.4%**	**113.3%**	**132.7%**	**115.5%**	**145.1%**	[F]=[D]/[E]

Table 6-3: Planning Year 2024-2025 LRZ Local Reliability Requirements

Weather Year Time of Peak Demand (ESTHE)	MISO	LRZ-1 MN/ND	LRZ-2 WI	LRZ-3 IA	LRZ-4 IL	LRZ-5 MO	LRZ-6 IN	LRZ-7 MI	LRZ-8 AR	LRZ-9 LA/TX	LRZ-10 MS
1988	8/1/88 16:00	8/1/88 16:00	8/1/88 16:00	7/31/88 16:00	8/16/88 16:00	8/15/88 17:00	7/9/88 17:00	7/6/88 18:00	7/19/88 15:00	8/15/88 15:00	7/2/88 18:00
1989	7/10/89 16:00	7/9/89 18:00	7/9/89 18:00	7/10/89 19:00	7/10/89 17:00	7/10/89 19:00	7/10/89 16:00	6/26/89 16:00	8/27/89 16:00	12/24/89 9:00	8/27/89 16:00
1990	7/3/90 17:00	7/3/90 18:00	8/27/90 16:00	7/3/90 16:00	9/6/90 16:00	9/6/90 16:00	7/9/90 17:00	8/28/90 15:00	7/10/90 16:00	8/6/90 16:00	8/27/90 18:00
1991	7/19/91 16:00	7/18/91 17:00	7/18/91 15:00	7/17/91 18:00	7/6/91 18:00	8/2/91 17:00	8/2/91 17:00	7/19/91 16:00	7/24/91 16:00	8/20/91 18:00	8/2/91 16:00
1992	8/10/92 16:00	8/9/92 17:00	8/10/92 18:00	7/8/92 16:00	7/2/92 15:00	7/2/92 16:00	7/14/92 16:00	8/27/92 15:00	7/16/92 17:00	8/10/92 16:00	7/11/92 17:00
1993	8/27/93 15:00	8/11/93 16:00	8/24/93 16:00	8/22/93 19:00	7/17/93 17:00	7/27/93 16:00	7/25/93 16:00	8/27/93 15:00	7/28/93 15:00	8/19/93 16:00	8/20/93 17:00
1994	7/6/94 14:00	6/14/94 19:00	6/15/94 16:00	7/19/94 18:00	7/5/94 18:00	7/5/94 17:00	7/20/94 15:00	6/18/94 18:00	8/14/94 16:00	8/14/94 16:00	1/19/94 9:00
1995	7/13/95 17:00	7/13/95 17:00	7/13/95 17:00	7/12/95 16:00	7/13/95 17:00	7/13/95 16:00	7/13/95 16:00	7/13/95 17:00	7/14/95 16:00	8/16/95 16:00	8/31/95 16:00
1996	8/6/96 17:00	8/6/96 17:00	6/29/96 17:00	7/18/96 17:00	7/18/96 18:00	7/18/96 17:00	7/19/96 17:00	8/7/96 15:00	7/1/96 15:00	2/5/96 7:00	7/3/96 16:00
1997	7/16/97 16:00	7/16/97 18:00	7/16/97 17:00	7/26/97 20:00	7/27/97 17:00	7/26/97 17:00	7/27/97 15:00	7/16/97 16:00	7/22/97 15:00	8/31/97 17:00	7/25/97 16:00
1998	7/20/98 16:00	7/13/98 18:00	6/25/98 16:00	7/20/98 18:00	7/20/98 16:00	7/20/98 17:00	7/19/98 17:00	6/25/98 16:00	7/7/98 15:00	8/28/98 17:00	8/28/98 17:00

1999	7/30/99 15:00	7/25/99 15:00	7/30/99 15:00	7/25/99 17:00	7/19/99 0:00	7/26/99 19:00	7/30/99 15:00	7/30/99 14:00	7/28/99 15:00	8/5/99 16:00	8/20/99 18:00
2000	8/15/00 16:00	8/14/00 19:00	7/17/00 17:00	8/31/00 19:00	8/29/00 16:00	8/17/00 18:00	9/2/00 16:00	8/9/00 15:00	8/29/00 18:00	8/30/00 16:00	8/30/00 17:00
2001	8/9/01 15:00	8/7/01 16:00	8/9/01 17:00	7/31/01 18:00	7/23/01 17:00	7/23/01 17:00	8/7/01 16:00	8/8/01 16:00	7/12/01 15:00	1/4/01 8:00	7/20/01 17:00
2002	7/2/02 16:00	7/6/02 18:00	8/1/02 15:00	7/20/02 19:00	7/9/02 17:00	8/1/02 16:00	8/3/02 15:00	7/3/02 16:00	7/30/02 16:00	8/7/02 17:00	7/10/02 16:00
2003	8/21/03 16:00	8/24/03 17:00	8/21/03 16:00	7/26/03 18:00	8/21/03 16:00	8/21/03 18:00	8/27/03 17:00	8/21/03 16:00	7/29/03 16:00	1/24/03 7:00	7/17/03 17:00
2004	7/13/04 16:00	6/7/04 18:00	6/8/04 17:00	7/20/04 17:00	7/13/04 16:00	7/13/04 16:00	1/31/04 4:00	7/22/04 15:00	7/14/04 15:00	8/1/04 17:00	7/24/04 16:00
2005	7/24/05 17:00	7/17/05 17:00	7/24/05 16:00	7/25/05 17:00	7/24/05 17:00	7/24/05 17:00	7/25/05 16:00	7/24/05 18:00	7/27/05 15:00	8/20/05 17:00	8/21/05 15:00
2006	7/31/06 17:00	7/31/88 17:00	7/31/06 15:00	7/19/06 18:00	7/31/06 18:00	8/2/06 17:00	7/31/06 16:00	8/3/06 15:00	8/10/06 18:00	8/15/06 18:00	8/15/06 17:00
2007	8/1/07 17:00	8/10/07 17:00	8/2/07 16:00	7/17/07 15:00	8/15/07 18:00	8/15/07 17:00	8/7/07 16:00	7/31/07 18:00	8/14/07 16:00	8/21/07 15:00	8/14/07 18:00
2008	7/17/08 15:00	7/11/08 18:00	7/7/08 17:00	8/3/08 16:00	7/20/08 16:00	7/20/08 17:00	8/23/08 15:00	8/24/08 12:00	7/22/08 15:00	8/6/08 18:00	7/22/08 16:00
2009	6/25/09 16:00	6/22/09 19:00	6/25/09 16:00	7/24/09 18:00	8/9/09 17:00	8/9/09 16:00	1/16/09 4:00	6/25/09 16:00	7/11/09 19:00	7/2/09 16:00	7/11/09 17:00
2010	8/3/10 18:00	8/8/10 18:00	8/20/10 14:00	7/17/10 18:00	8/10/10 17:00	8/3/10 16:00	8/13/10 16:00	9/1/10 15:00	7/21/10 15:00	8/1/10 17:00	8/2/10 16:00
2011	7/20/11 16:00	7/18/11 17:00	7/20/11 16:00	7/20/11 16:00	9/1/11 16:00	8/2/11 18:00	7/20/11 16:00	7/2/11 16:00	8/3/11 16:00	8/18/11 16:00	8/31/11 17:00
2012	7/6/12 17:00	7/31/88 17:00	7/13/95 17:00	7/25/12 17:00	7/6/12 18:00	7/24/12 18:00	7/5/12 17:00	7/6/12 17:00	7/30/12 17:00	8/16/12 17:00	7/3/12 16:00
2013	7/17/13 17:00	8/27/13 15:00	8/27/13 17:00	7/18/13 17:00	9/10/13 16:00	8/31/13 17:00	8/31/13 15:00	7/19/13 14:00	7/18/13 16:00	8/7/13 16:00	8/9/13 16:00
2014	7/22/14 16:00	7/21/14 17:00	7/7/14 16:00	7/22/14 16:00	8/24/14 16:00	7/26/14 15:00	1/24/14 9:00	7/22/14 16:00	7/14/14 16:00	1/8/14 3:00	8/24/14 17:00
2015	7/29/15 16:00	8/14/15 16:00	8/14/15 17:00	7/13/15 16:00	9/2/15 16:00	9/9/15 16:00	7/29/15 16:00	7/29/15 16:00	7/28/15 15:00	8/12/15 16:00	7/21/15 15:00
2016	7/20/16 15:00	6/25/16 15:00	8/11/16 14:00	7/20/16 14:00	9/7/16 15:00	9/7/16 16:00	9/8/16 16:00	9/7/16 14:00	7/22/16 15:00	8/23/16 15:00	8/3/16 15:00
2017	7/20/17 16:00	7/6/17 17:00	9/25/17 15:00	7/20/17 16:00	7/12/17 14:00	7/20/17 14:00	9/22/17 15:00	9/25/17 15:00	7/21/17 16:00	8/20/17 15:00	7/20/17 16:00

Table 6-4: Time of Peak Demand for all 30 weather years

Appendix A: Comparison of Planning Year 2018 to 2019

Multiple study sensitivity analyses were performed to compute changes in the PRM target on an UCAP basis, from the 2018-2019 planning year to the 2019-2020 planning year. These sensitivities included one-off incremental changes of input parameters to quantify how each change affected the PRM result independently. Note the impact of the incremental PRM changes from 2018 to 2019 in the waterfall chart of Figure A-1; see Section A.1 Waterfall Chart Details for an explanation.

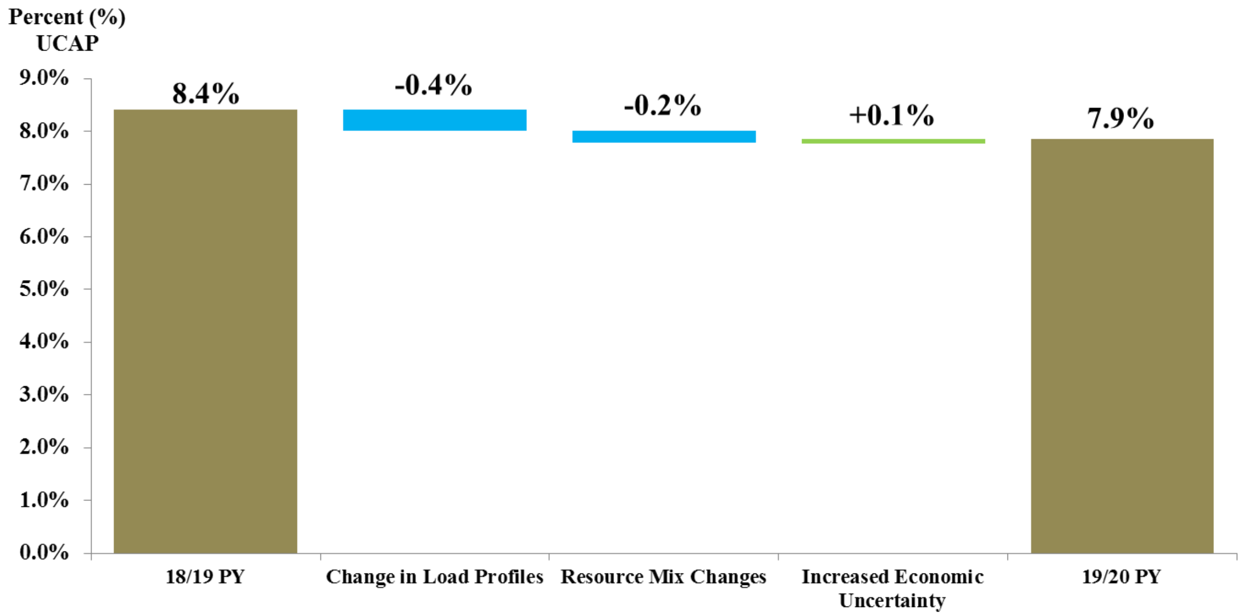


Figure A-1: Waterfall Chart of 2018 PRM UCAP to 2019 PRM UCAP

A.1 Waterfall Chart Details

A.1.1 Load

The MISO Coincident Peak Demand decreased from the 2018-2019 planning year, which was driven by the updated actual load forecasts submitted by the LSEs. The reduction was mainly driven by reduction in anticipated load growth and changes in diversity. The monthly load profiles submitted by LSE's resulted in more peaked load shapes compared to the 2018-2019 PY. This caused a 0.4 percentage point decrease to the PRM.

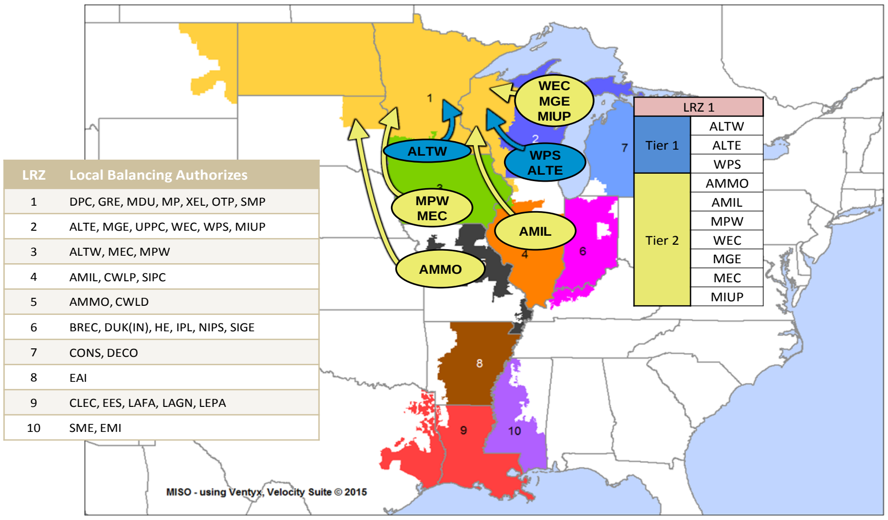
An increase of economic load uncertainty, detailed in Section 4.3.2, in the 2019-2020 planning year resulted in a 0.1 percentage point increase in the PRM UCAP. The modeling of economic load uncertainty effectively increases the risk associated with high peak loads, thus resulting in larger adjustment to UCAP for the same MISO peak load. Upon incorporating the increased adjustment into the equations of Section 4.5.1 of the report, the mathematical calculations result in a higher PRM in percentage.

A.1.2 Units

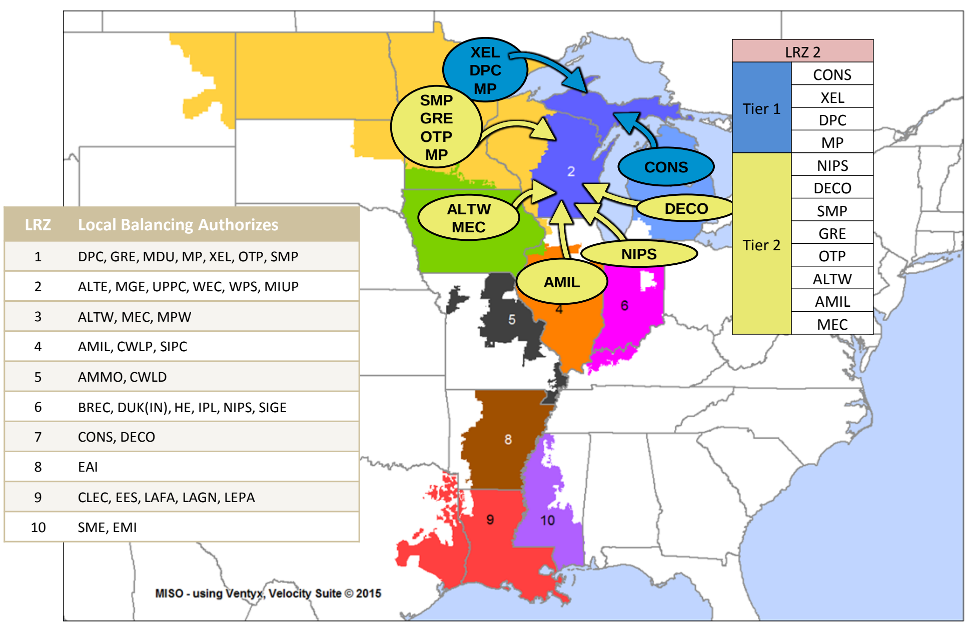
Changes from 2018-2019 planning year values are due to changes in Generation Verification Test Capacity (GVTC); EFORd or equivalent forced outage rate demand with adjustment to exclude events outside management control (XEFORd); new units; retirements; suspensions; and changes in the resource mix. The MISO fleet weighted average forced outage rate increased from 9.16 percent to 9.28 percent from the previous study to this study. An increase in unit outage rates will generally lead to an increase in reserve margin in order to cover the increased risk of loss of load. Although the MISO-wide average EFORd increased slightly for the 2019-2020 PY, new units and retirements led to a resource mix that improved reliability overall.

Appendix B: Capacity Import Limit source subsystem definitions (Tiers 1 & 2)

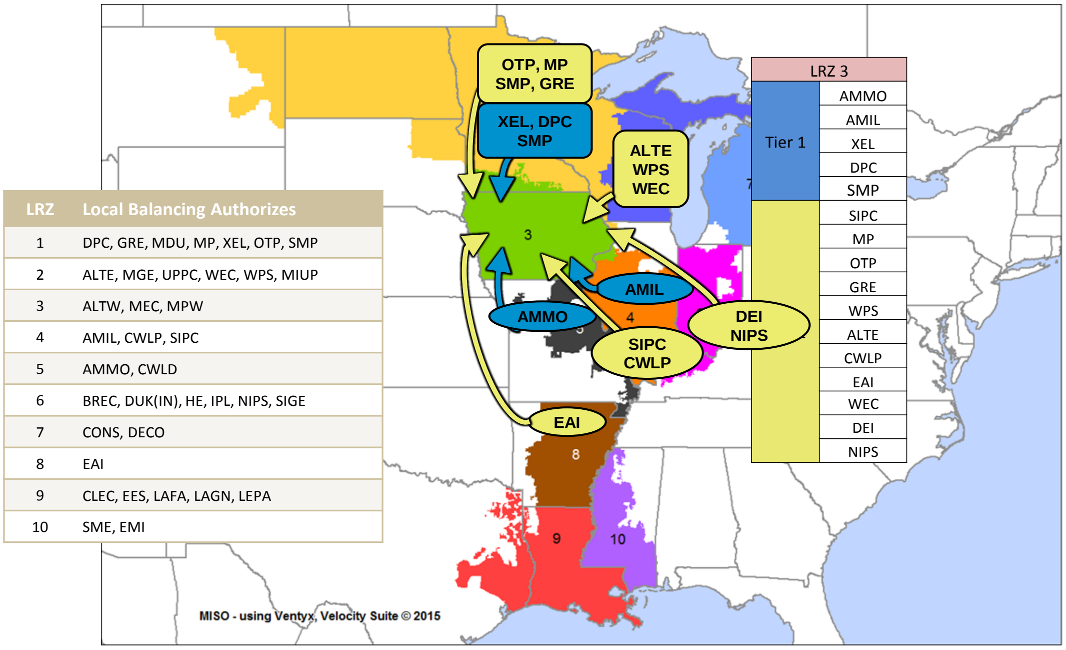
MISO Local Resource Zone 1



MISO Local Resource Zone 2



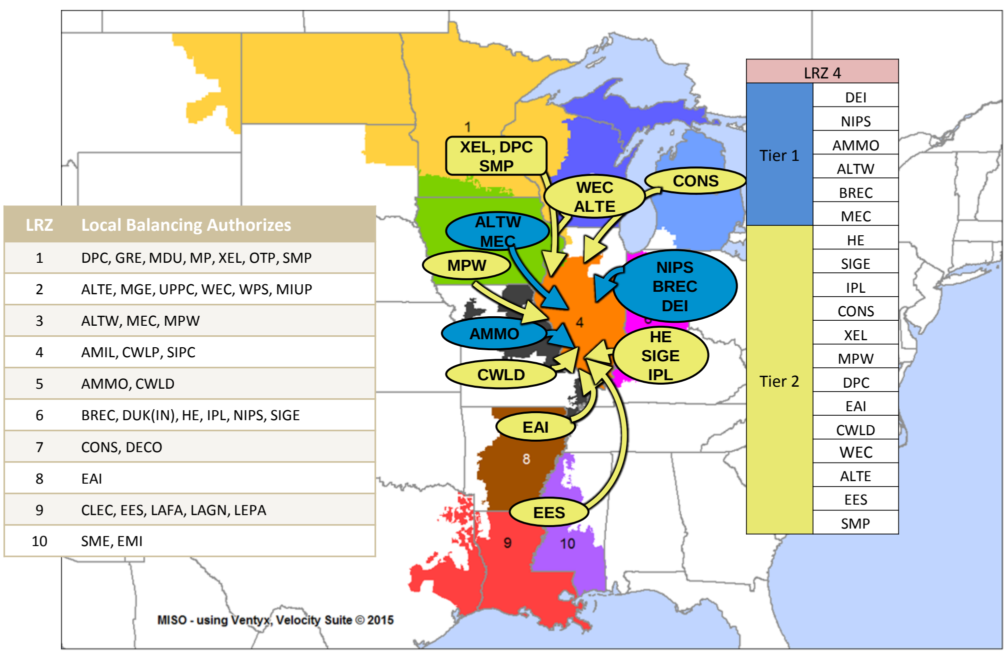
MISO Local Resource Zone 3



LRZ	Local Balancing Authorizes
1	DPC, GRE, MDU, MP, XEL, OTP, SMP
2	ALTE, MGE, UPPC, WEC, WPS, MIUP
3	ALTW, MEC, MPW
4	AMIL, CWLP, SIPC
5	AMMO, CWLD
6	BREC, DUK(IN), HE, IPL, NIPS, SIGE
7	CONS, DECO
8	EAI
9	CLEC, EES, LAFA, LAGN, LEPA
10	SME, EMI

LRZ 3	
Tier 1	AMMO
	AMIL
	XEL
	DPC
	SMP
	SIPC
	MP
	OTP
	GRE
	WPS
	ALTE
	CWLP
	EAI
	WEC
	DEI
	NIPS

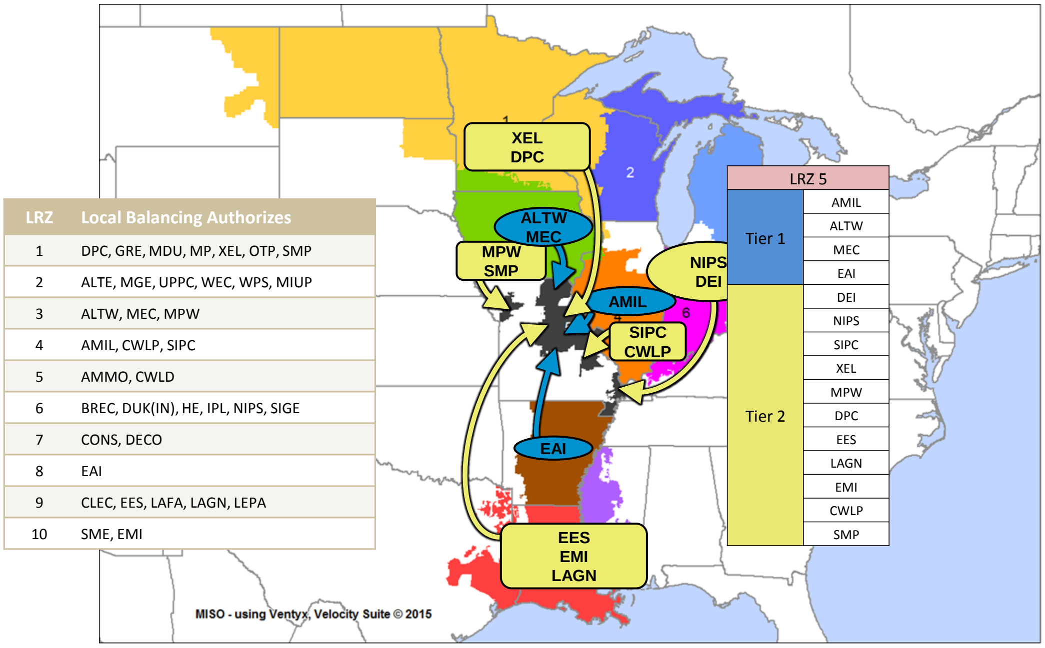
MISO Local Resource Zone 4



LRZ	Local Balancing Authorizes
1	DPC, GRE, MDU, MP, XEL, OTP, SMP
2	ALTE, MGE, UPPC, WEC, WPS, MIUP
3	ALTW, MEC, MPW
4	AMIL, CWLP, SIPC
5	AMMO, CWLD
6	BREC, DUK(IN), HE, IPL, NIPS, SIGE
7	CONS, DECO
8	EAI
9	CLEC, EES, LAFA, LAGN, LEPA
10	SME, EMI

LRZ 4	
Tier 1	DEI
	NIPS
	AMMO
	ALTW
	BREC
	MEC
Tier 2	HE
	SIGE
	IPL
	CONS
	XEL
	MPW
	DPC
	EAI
	CWLD
	WEC
	ALTE
	EES
	SMP

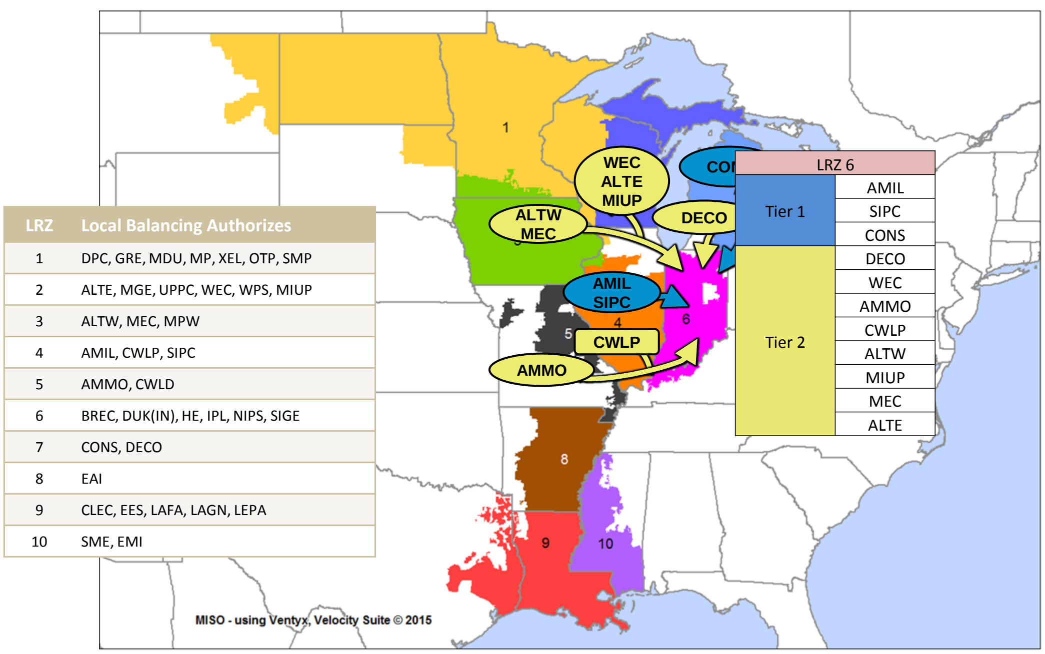
MISO Local Resource Zone 5



LRZ	Local Balancing Authorities
1	DPC, GRE, MDU, MP, XEL, OTP, SMP
2	ALTE, MGE, UPPC, WEC, WPS, MIUP
3	ALTW, MEC, MPW
4	AMIL, CWLP, SIPC
5	AMMO, CWLD
6	BREC, DUK(IN), HE, IPL, NIPS, SIGE
7	CONS, DECO
8	EAI
9	CLEC, EES, LAFA, LAGN, LEPA
10	SME, EMI

LRZ 5	
Tier 1	AMIL
	ALTW
	MEC
	EAI
Tier 2	DEI
	NIPS
	SIPC
	XEL
	MPW
	DPC
	EES
	LAGN
	EMI
	CWLP
	SMP

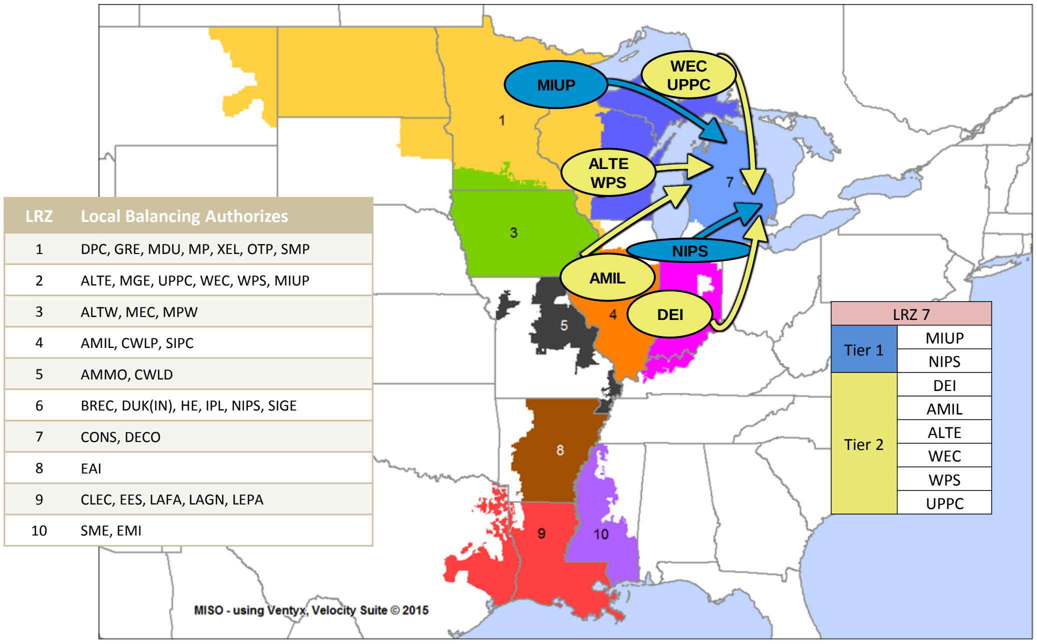
MISO Local Resource Zone 6



LRZ	Local Balancing Authorities
1	DPC, GRE, MDU, MP, XEL, OTP, SMP
2	ALTE, MGE, UPPC, WEC, WPS, MIUP
3	ALTW, MEC, MPW
4	AMIL, CWLP, SIPC
5	AMMO, CWLD
6	BREC, DUK(IN), HE, IPL, NIPS, SIGE
7	CONS, DECO
8	EAI
9	CLEC, EES, LAFA, LAGN, LEPA
10	SME, EMI

LRZ 6	
Tier 1	AMIL
	SIPC
	CONS
Tier 2	DECO
	WEC
	AMMO
	CWLP
	ALTW
	MIUP
	MEC
	ALTE

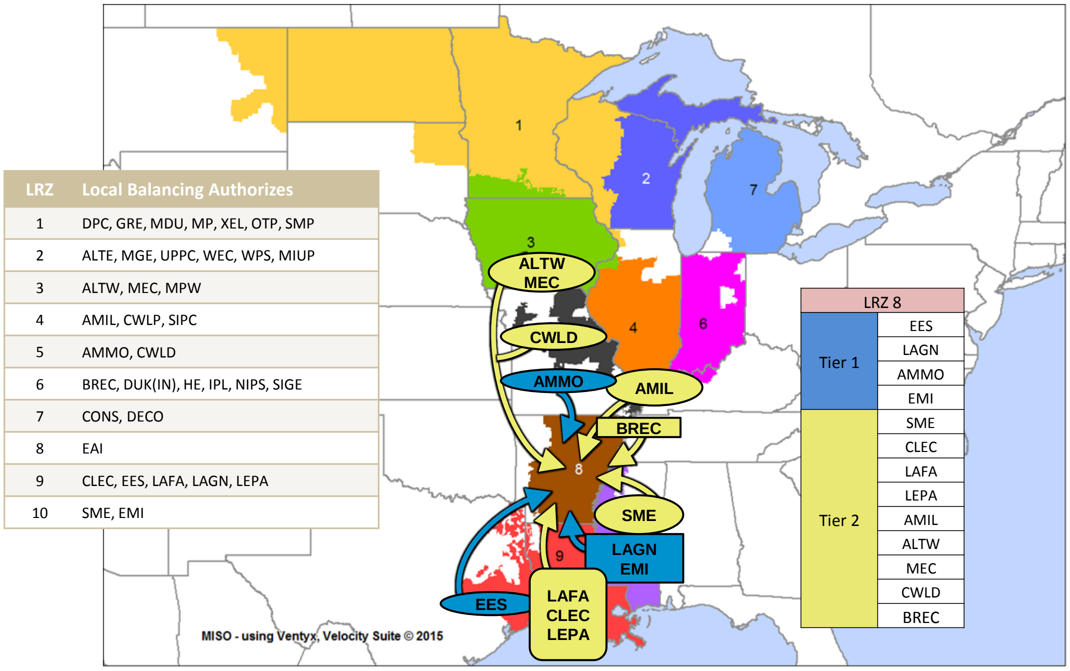
MISO Local Resource Zone 7



LRZ	Local Balancing Authorizes
1	DPC, GRE, MDU, MP, XEL, OTP, SMP
2	ALTE, MGE, UPPC, WEC, WPS, MIUP
3	ALTW, MEC, MPW
4	AMIL, CWLP, SIPC
5	AMMO, CWLD
6	BREC, DUK(IN), HE, IPL, NIPS, SIGE
7	CONS, DECO
8	EAI
9	CLEC, EES, LAFA, LAGN, LEPA
10	SME, EMI

LRZ 7	
Tier 1	MIUP
	NIPS
Tier 2	DEI
	AMIL
	ALTE
	WEC
	WPS
	UPPC

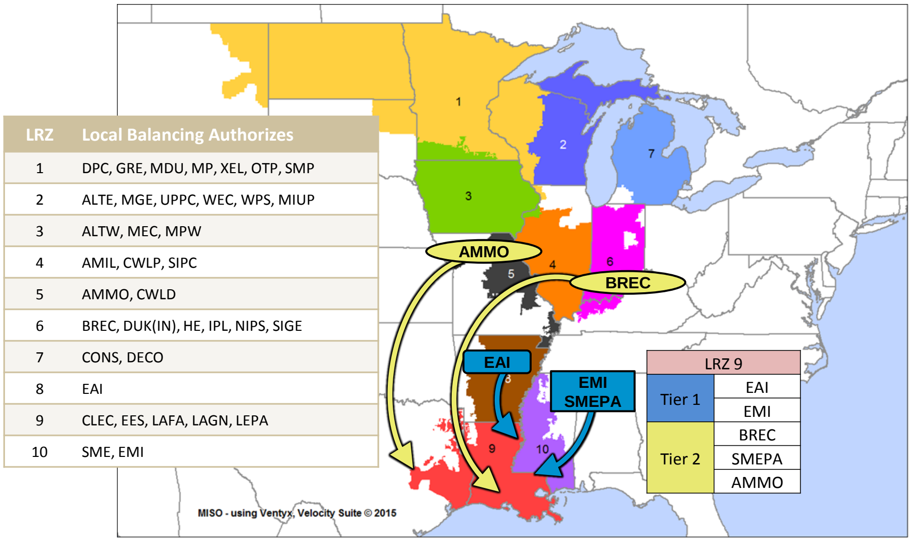
MISO Local Resource Zone 8



LRZ	Local Balancing Authorizes
1	DPC, GRE, MDU, MP, XEL, OTP, SMP
2	ALTE, MGE, UPPC, WEC, WPS, MIUP
3	ALTW, MEC, MPW
4	AMIL, CWLP, SIPC
5	AMMO, CWLD
6	BREC, DUK(IN), HE, IPL, NIPS, SIGE
7	CONS, DECO
8	EAI
9	CLEC, EES, LAFA, LAGN, LEPA
10	SME, EMI

LRZ 8	
Tier 1	EES
	LAGN
	AMMO
	EMI
Tier 2	SME
	CLEC
	LAFA
	LEPA
	AMIL
	ALTW
	MEC
	CWLD
	BREC

MISO Local Resource Zone 9

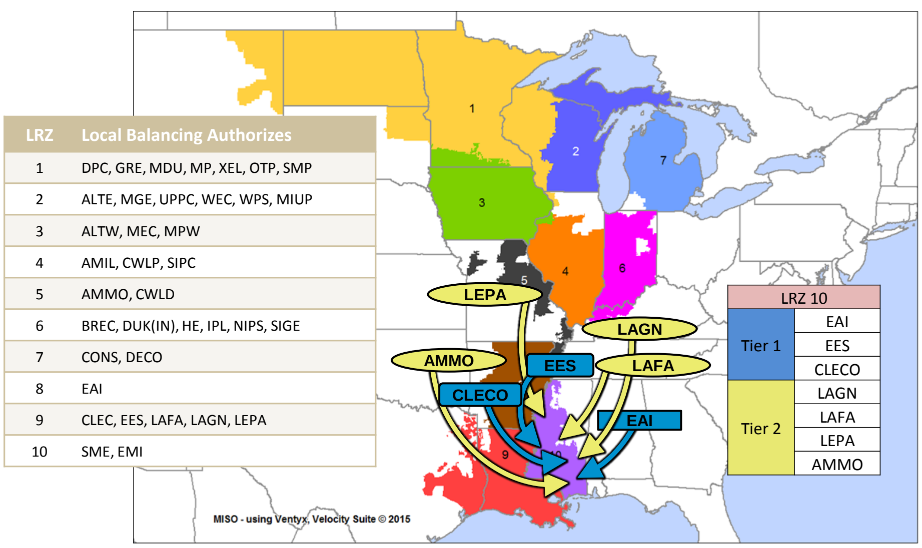


LRZ	Local Balancing Authorizes
1	DPC, GRE, MDU, MP, XEL, OTP, SMP
2	ALTE, MGE, UPPC, WEC, WPS, MIUP
3	ALTW, MEC, MPW
4	AMIL, CWLP, SIPC
5	AMMO, CWLD
6	BREC, DUK(IN), HE, IPL, NIPS, SIGE
7	CONS, DECO
8	EAI
9	CLEC, EES, LAFA, LAGN, LEPA
10	SME, EMI

LRZ 9	
Tier 1	EAI
	EMI
Tier 2	BREC
	SMEPA
	AMMO

* BRAZ, DERS, EES-EMI, and BCA now modeled in EES power flow area

MISO Local Resource Zone 10



LRZ	Local Balancing Authorizes
1	DPC, GRE, MDU, MP, XEL, OTP, SMP
2	ALTE, MGE, UPPC, WEC, WPS, MIUP
3	ALTW, MEC, MPW
4	AMIL, CWLP, SIPC
5	AMMO, CWLD
6	BREC, DUK(IN), HE, IPL, NIPS, SIGE
7	CONS, DECO
8	EAI
9	CLEC, EES, LAFA, LAGN, LEPA
10	SME, EMI

LRZ 10	
Tier 1	EAI
	EES
	CLECO
Tier 2	LAGN
	LAFA
	LEPA
	AMMO

Appendix C: Compliance Conformance Table

Requirements under: Standard BAL-502-RF-03	Response
R1 The Planning Coordinator shall perform and document a Resource Adequacy analysis annually. The Resource Adequacy analysis shall:	The Planning Year 2019 LOLE Study Report is the annual Resource Adequacy Analysis for the peak season of June 2019 through May 2020 and beyond. Analysis of Planning Year 2019 is in Sections 5.1 and 6.1 Analysis of Future Years 2020-2028 is in Sections 5.3 and 6.1
R1.1 Calculate a planning reserve margin that will result in the sum of the probabilities for loss of Load for the integrated peak hour for all days of each planning year[1] analyzed (per R1.2) being equal to 0.1. (This is comparable to a “one day in 10 year” criterion).	Section 4.5 of this report outlines the utilization of LOLE in the reserve margin determination. “These metrics were determined by a probabilistic LOLE analysis such that the LOLE for the planning year was one day in 10 years, or 0.1 day per year.”
R1.1.1 The utilization of Direct Control Load Management or curtailment of Interruptible Demand shall not contribute to the loss of Load probability.	Section 4.3 of this report. “Direct Control Load Management and Interruptible Demand types of demand response were explicitly included in the LOLE model as resources. These demand resources are implemented in the LOLE simulation before accumulating LOLE or shedding of firm load.”
R1.1.2 The planning reserve margin developed from R1.1 shall be expressed as a percentage of the median forecast peak Net Internal Demand (planning reserve margin).	Section 4.5.1 of this report. “The minimum amount of capacity above the 50/50 net internal MISO Coincident Peak Demand required to meet the reliability criteria was used to establish the PRM values.”
R1.2 Be performed or verified separately for each of the following planning years.	Covered in the segmented R1.2 responses below.
R1.2.1 Perform an analysis for Year One.	In Sections 5.1 and 6.1, a full analysis was performed for planning year 2019.
R1.2.2 Perform an analysis or verification at a minimum for one year in the 2 through 5 year period and at a minimum one year in the 6 though 10 year period.	Sections 5.3 and 6.1 show a full analysis was performed for future planning years 2022 and 2024.
R1.2.2.1 If the analysis is verified, the verification must be supported by current or past studies for the same planning year.	Analysis was performed.
R1.3 Include the following subject matter and documentation of its use:	Covered in the segmented R1.3 responses below.

R1.3.1 Load forecast characteristics: • Median (50:50) forecast peak load • Load forecast uncertainty (reflects variability in the Load forecast due to weather and regional economic forecasts). • Load diversity. • Seasonal Load variations. • Daily demand modeling assumptions (firm, interruptible). • Contractual arrangements concerning curtailable/Interruptible Demand.	Median forecasted load – In Section 4.3 of this report: "The average monthly loads of the predicted load shapes were adjusted to match each LRZ's Module E 50/50 monthly zonal peak load forecasts for each study year." Load Forecast Uncertainty – A detailed explanation of the weather and economic uncertainties are given in Sections 4.3.1 and 4.3.2. Load Diversity/Seasonal Load Variations — In Section 4.3 of this report: "For the 2019-2020 LOLE analysis, a load training process utilizing neural net software was used to create a neural-net relationship between historical weather and load data. This relationship was then applied to 30 years of hourly historical weather data in order to create 30 different load shapes for each LRZ in order to capture both load diversity and seasonal variations." Demand Modeling Assumptions/Curtailable and Interruptible Demand — All Load Modifying Resources must first meet registration requirements through Module E. As stated in Section 4.2.7: "Each demand response program was modeled individually with a monthly capacity and was limited to the number of times each program can be called upon as well as limited by duration."
R1.3.2 Resource characteristics: • Historic resource performance and any projected changes • Seasonal resource ratings • Modeling assumptions of firm capacity purchases from and sales to entities outside the Planning Coordinator area. • Resource planned outage schedules, deratings, and retirements. • Modeling assumptions of intermittent and energy limited resource such as wind and cogeneration. • Criteria for including planned resource additions in the analysis.	Section 4.2 details how historic performance data and seasonal ratings are gathered, and includes discussion of future units and the modeling assumptions for intermittent capacity resources. A more detailed explanation of firm capacity purchases and sales is in Section 4.4.
R1.3.3 Transmission limitations that prevent the delivery of generation reserves	Annual MTEP deliverability analysis identifies transmission limitations preventing delivery of generation reserves. Additionally, Section 3 of this report details the transfer analysis to capture transmission constraints limiting capacity transfers.
R1.3.3.1 Criteria for including planned Transmission Facility additions in the analysis	Inclusion of the planned transmission addition assumptions is detailed in Section 3.2.3.
R1.3.4 Assistance from other interconnected systems including multi-area assessment considering Transmission limitations into the study area.	Section 4.4 provides the analysis on the treatment of external support assistance and limitations.

R1.4 Consider the following resource availability characteristics and document how and why they were included in the analysis or why they were not included: • Availability and deliverability of fuel. • Common mode outages that affect resource availability. • Environmental or regulatory restrictions of resource availability. • Any other demand (Load) response programs not included in R1.3.1. • Sensitivity to resource outage rates. • Impacts of extreme weather/drought conditions that affect unit availability. • Modeling assumptions for emergency operation procedures used to make reserves available. • Market resources not committed to serving Load (uncommitted resources) within the Planning Coordinator area.	Fuel availability, environmental restrictions, common mode outage and extreme weather conditions are all part of the historical availability performance data that goes into the unit's EFORd statistic. The use of the EFORd values is covered in Section 4.2. The use of demand response programs are mentioned in Section 4.2. The effects of resource outage characteristics on the reserve margin are outlined in Section 4.5.2 by examining the difference between PRM ICAP and PRM UCAP values.
R1.5 Consider Transmission maintenance outage schedules and document how and why they were included in the Resource Adequacy analysis or why they were not included	Transmission maintenance schedules were not included in the analysis of the transmission system due to the limited availability of reliable long-term maintenance schedules and minimal impact to the results of the analysis. However, Section 3 treats worst-case theoretical outages by Perform First Contingency Total Transfer Capability (FCTTC) analysis for each LRZ, by modeling NERC Category P0 (system intact) and Category P1 (N-1) contingencies.
R1.6 Document that capacity resources are appropriately accounted for in its Resource Adequacy analysis	MISO internal resources are among the quantities documented in the tables provided in Sections 5 and 6.
R1.7 Document that all Load in the Planning Coordinator area is accounted for in its Resource Adequacy analysis	MISO load is among the quantities documented in the tables provided in Sections 5 and 6.
R2 The Planning Coordinator shall annually document the projected Load and resource capability, for each area or Transmission constrained sub-area identified in the Resource Adequacy analysis.	In Sections 5 and 6, the peak load and estimated amount of resources for planning years 2019, 2022, and 2024 are shown. This includes the detail for each transmission constrained sub-area.
R2.1 This documentation shall cover each of the years in Year One through ten.	Section 5.3 and Table 5-4 shows the three calculated years, and in-between years estimated by interpolation. Estimated transmission limitations may be determined through a review of the 2019 LOLE study transfer analysis shown in Section 3 of this report, along with the results from previous LOLE studies.
R2.2 This documentation shall include the Planning Reserve margin calculated per requirement R1.1 for each of the three years in the analysis.	Section 5.3 and Table 5-4 shows the three calculated years underlined.
R2.3 The documentation as specified per requirement R2.1 and R2.2 shall be publicly posted no later than 30 calendar days prior to the beginning of Year One.	The 2019 LOLE Study Report documentation is posted on November 1 prior to the planning year.

R3 The Planning Coordinator shall identify any gaps between the needed amount of planning reserves defined in Requirement R1, Part 1.1 and the projected planning reserves documented in Requirement R2.	In Sections 5 and 6, the difference between the needed amount and the projected planning reserves for planning years 2019, 2022, and 2024 are shown the adjustments to ICAP and UCAP in Table 5-1, Table 5-3, Table 6-1, Table 6-2, and Table 6-3.

Appendix D: Acronyms List Table

CEL	Capacity Export Limit
CIL	Capacity Import Limit
CPNode	Commercial Pricing Node
DF	Distribution Factor
EFORd	Equivalent Forced Outage Rate demand
ELCC	Effective Load Carrying Capability
ERZ	External Resource Zone
EUE	Expected Unserved Energy
FERC	Federal Energy Regulatory Commission
FCITC	First Contingency Incremental Transfer Capability
FCTTC	First Contingency Total Transfer Capability
GADS	Generator Availability Data System
GLT	Generation Limited Transfer
GVTC	Generation Verification Test Capacity
ICAP	Installed Capacity
LBA	Local Balancing Authority
LCR	Local Clearing Requirement
LFE	Load Forecast Error
LFU	Load Forecast Uncertainty
LOLE	Loss of Load Expectation
LOLEWG	Loss of Load Expectation Working Group
LRR	Local Reliability Requirement
LRZ	Local Resource Zones
LSE	Load Serving Entity
MARS	Multi-Area Reliability Simulation
MECT	Module E Capacity Tracking
MISO	Midcontinent Independent System Operator
MOD	Model on Demand
MTEP	MISO Transmission Expansion Plan
MW	Megawatt
MWh	Megawatt hours
NERC	North American Electric Reliability Corp.
PRA	Planning Resource Auction
PRM	Planning Reserve Margin
PRM ICAP	PRM Installed Capacity

PRM UCAP	PRM Unforced Capacity
PRMR	Planning Reserve Margin Requirement
PSS E	Power System Simulator for Engineering
RCF	Reciprocal Coordinating Flowgate
RPM	Reliability Pricing Model
SERVM	Strategic Energy & Risk Valuation Model
SPS	Special Protection Scheme
TARA	Transmission Adequacy and Reliability Assessment
UCAP	Unforced Capacity
XEFORd	Equivalent forced outage rate demand with adjustment to exclude events outside management control
ZIA	Zonal Import Ability
ZEA	Zonal Export Ability

Attachment 6.1 Vectren Electric 2018-2020 DSM Plan

Vectren South 2018-2020
Electric Energy Efficiency Plan

Prepared by:
Southern Indiana Gas & Electric Company d/b/a Vectren Energy Delivery of Indiana Inc. (Vectren South)

4/7/2017

Table of Contents

List of Acronyms & Abbreviations

Acronym	Description
AEG	Applied Energy Group
ARCA	Appliance Recycling Centers of America Inc.
BAS	Building Automation System
BTU	Building Tune-Up
BYOT	Bring Your Own Thermostat
C&I	Commercial and Industrial
CAC	Central Air Conditioning
CFL	Compact Fluorescent Lamp
CVR	Conservation Voltage Reduction
DLC	Direct Load Control
DR	Demand Response
DSM	Demand Side Management
EAD	Energy Design Assistance
EAP	Energy Assistance Program
ECM	Electronically Commutated Motors
EE	Energy Efficiency
EISA	Energy Independence and Security Act
EM&V	Evaluation, Measurement and Verification
ES	ENERGY STAR
HEA	Home Energy Assessment & Weatherization
HERS	Home Efficiency Rating System
HVAC	Heating, Ventilation and Air Conditioning
IQW	Income Qualified & Weatherization
IRP	Integrated Resource Plan
IURC	Indiana Utility Regulatory Commission
kW/kWh	Kilowatt, Kilowatt hour
LED	Light Emitting Diode
MISO	Midcontinent Independent Transmission System Operator, Inc.
MPS	Market Potential Study
MW,MWh	Megawatt, Megawatt hour
NEF	National Energy Foundation
NPV	Net Present Value
O&M	Operations and Maintenance
PCT	Participant Cost Test
RFQ	Request for Qualification
RIM	Ratepayer Impact Measure
RNC	Residential New Construction
TRM	Technical Reference Manual
UCT	Utility Cost Test

1. Introduction

Southern Indiana Gas and Electric Company d/b/a Vectren Energy Delivery of Indiana, Inc. ("Vectren South") provides energy delivery services to approximately 144,000 electric customers and 111,000 natural gas customers located in Southwestern Indiana. Vectren South is a direct, wholly owned subsidiary of Vectren Utility Holdings, Inc. and an indirect subsidiary of Vectren Corporation ("Vectren"), headquartered in Evansville, IN. This Vectren South 2018-2020 Electric Demand Side Management (DSM) Plan ("2018-2020 Plan" or "Plan") describes the details of the electric Energy Efficiency (EE) and Demand Response (DR) programs Vectren South plans to offer in its service territory in 2018-2020.

Vectren South is proposing a 2018-2020 Plan designed to cost effectively reduce energy use by approximately 1% of eligible retail sales each year over the three-year plan. The EE savings goals are consistent with Vectren South's 2016 Integrated Resource Plan ("2016 IRP"), reasonably achievable and cost effective. The Plan includes program budgets, including the direct and indirect costs of energy efficiency programs. The 2018-2020 Plan recommends electric EE and DR programs for the residential and commercial & industrial (C&I) sectors in Vectren South's service territory. Where appropriate, it also describes opportunities for coordination with some of Vectren South's gas EE programs to leverage the best total EE and DR opportunities for customers and to share costs of delivery. Vectren South utilizes a portfolio of DSM programs to achieve demand reductions and energy savings, thereby providing reliable electric service to its customers. Vectren's DSM programs have been approved by the Indiana Utility Regulatory Commission ("Commission" or "IURC") and implemented pursuant to various IURC orders over the years.

2. Vectren South DSM Strategy

Energy efficiency remains at the core of Vectren's culture as the utility strives to partner with customers to help them use energy wisely. The company's tagline, Live Smart, originated from Vectren's turn toward energy efficiency in 2006 with the emergence natural gas energy efficiency programs, and then that effort was bolstered when electric energy efficiency programs were launched in 2010. Vectren employees receive regular communication on the progress toward the company's annual energy efficiency goals and rely on their workforce to serve as ambassadors in driving participation in its energy efficiency programs. One of the utility's goals is to "Be a leader in customer conservation and energy efficiency," and Vectren proactively works with its oversight boards in each state it serves to assemble progressive, cost-effective programs that work toward achieving that objective.

The preferred portfolio of Vectren South's recently filed 2016 Integrated Resource Plan ("2016 IRP") includes EE programs for all customer classes and sets an annual savings target of 1% of retail sales for 2018-2020. The framework for the 2018 - 2020 Plan was modeled at a savings level of 1% of retail sales adjusted for an opt-out rate of 73% eligible load, as provided for in Indiana Code § 8-1-8.5-10 ("Section 10"). The load forecast also includes an ongoing level of EE related to codes and standards embedded in the load forecast projections. Ongoing EE and DR programs are also important given the integration of Vectren South's natural gas and electric EE and DR programs.

A. Integration with Vectren South Gas

Opportunities exist to gain both natural gas and electric savings from some EE programs and measures. In these instances, energy savings will be captured by the respective utility. For the programs where integration opportunities exist, Vectren South has allocated implementation costs based on the net benefits split between natural gas and electric. Below is a list of programs that Vectren South has identified as integrated:

- Residential Prescriptive
- Residential New Construction
- Home Energy Assessment & Weatherization
- Income Qualified Weatherization
- Energy Efficient Schools
- Residential Behavioral Savings
- Commercial and Industrial (C&I) Custom
- Small Business Direct Install
- C&I New Construction
- Building Tune-up
- Multi-Family Retrofit

B. Vectren Oversight Board

The Vectren Oversight Board (VOB) provides input into the planning and evaluation of Vectren South's EE programs. The VOB was formed in 2010 pursuant to the Final Order issued in Cause No. 43427 and included the Indiana Office of the Utility Consumer Counselor (OUCC) and Vectren South as voting members. The Citizens Action Coalition (CAC) was added as a voting member of the VOB in 2013 pursuant to the Final Order issued in Cause No. 44318. In 2014, the Vectren South Electric Oversight Board merged with the Vectren South Gas Oversight Board and Vectren North Gas Oversight to form one governing body, the VOB. Vectren and the VOB have worked collaboratively over the last several years and Vectren requests to continue the current voting structure.

3. Vectren South Planning Process

Vectren South has offered a variety of EE programs since April 2010 and has engaged in a similar planning process each time a new portfolio is presented to the Commission for approval.

The 2018-2020 Plan was developed in conjunction with the 2016 IRP planning process and therefore the 2016 IRP served as a key input into the 2018-2020 Plan. As such, this process aligns with Indiana Code § 8-1-8.5-10 ("Section 10"), which requires that EE goals be consistent with an electricity supplier's IRP.

Consistent with the 2016 IRP preferred portfolio, the framework for the 2018 - 2020 Plan was modeled at a savings level of 1% of retail sales with opt-out assumptions incorporated. Once the level of EE programs to be offered from 2018 through 2020 was established, Vectren South engaged in a process to develop the 2018-2020 Plan. The objective of the planning process was to develop a plan based upon market-specific information for Vectren South's territory, which could be successfully implemented utilizing realistic assessments of achievable market potential.

The program design used an Electric Market Potential Study (MPS) for guidance to validate that the plan estimates were reasonable. While building from the bottom up with estimates from program implementers to help determine participation, this comparison to the MPS allowed the planning team to determine if the results were reasonable.

In 2013, Vectren South engaged EnerNOC, Inc., to conduct an MPS and Action Plan. For this effort, EnerNOC evaluated electric energy efficiency resources in the residential, commercial, and industrial sectors for the years 2015-2019. The study included a detailed, bottom-up assessment of the Vectren South market in the Evansville metropolitan area to deliver a projection of baseline electric energy use, forecasts of the energy savings achievable through efficiency measures, and program designs and strategies to optimally deliver those savings. The study assessed various tiers of technical, economic and achievable potential by sector, customer type and measure.

Given this Plan 2018 through 2020, and the most recent MPS ended in 2019, Vectren South, with VOB approval, engaged Applied Energy Group (AEG), previously EnerNOC, to refresh the MPS for 2018 and 2019 and to extend the analysis to include 2020. Several key data elements of the analysis were updated as part of this effort, specifically:

- Load forecast, which is approximately 4% lower in 2018-2020 than the load forecast used for those years in the original analysis
- The impact of large customer opt-outs on the market potential for the commercial and industrial (C&I) sectors, where 73% of eligible C&I load has elected to opt out of energy efficiency programs and the accompanying surcharge that would otherwise appear on their bill
- LED lighting measures cost and performance data
- Vectren South EE Program performance and budgets
- Projections of avoided energy, capacity, and transmission and distribution (T&D) infrastructure costs
- Vectren South retail rates, discount rates, and line losses

In addition, vendors and other implementation partners who operate the current programs were involved in the planning process by providing suggestions for program changes and enhancements. The vendors and partners also provided technical information about measures to include recommended incentives, estimated participation and estimated implementation costs. This data provided a foundation for the 2018-2020 Plan based on actual experience within Vectren South's territory. These companies also bring their experience operating programs for other utilities. Once the draft version of the 2018-2020 Plan was developed, Vectren South solicited feedback from the VOB for consideration in the final design.

Other sources of program information were also considered. Current evaluations and the Indiana Technical Resource Manual (TRM) were used for adjustments to inputs. In addition, best practices were researched and reviewed to gain insights into the program design of successful EE and DR programs implemented by other utility companies.

VOB feedback was incorporated into the planning process, as applicable.

4. Cost Effectiveness Analysis

Vectren South's last step of the planning process was the cost benefit analysis. Vectren South retained Dr. Richard Stevie, Vice President of Forecasting with Integral Analytics, to complete the cost benefit modeling. Utilizing DSMore, the measures and programs were analyzed for cost effectiveness. The DSMore tool is nationally recognized and used in many states across the country to determine cost-effectiveness. Developed and licensed by Integral Analytics based in Cincinnati, OH, the DSMore cost-effectiveness modeling tool takes hourly prices and hourly energy savings from the specific measures/technologies being considered for the EE program, and then correlates both to weather. This tool looks at more than 30 years of historic weather variability to get the full weather variances appropriately modeled. In turn, this allows the model to capture the low probability, but high consequence weather events and apply appropriate value to them. Thus, a more accurate view of the value of the efficiency measure can be captured in comparison to other alternative supply options.

The outputs of DSMore include all the California Standard Practice Manual results including Total Resource Cost (TRC), Utility Cost Test (UCT), Participant Cost Test (PCT) and Ratepayer Impact Measure (RIM) tests. Inputs into the model include the following: participation rates, incentives paid, energy savings of the measure, life of the measure, implementation costs, and administrative costs, incremental costs to the participant of the high efficiency measure, and escalation rates and discount rates. Vectren South considers the results of each test and ensures that the portfolio passes the TRC test as it includes the total costs and benefits to both the utility and the consumer. The model includes a full range of economic perspectives typically used in EE and DSM analytics. The perspectives include:

- Total Resource Cost Test - shows the combined perspective of the utility and the participating customers. This test compares the level of benefits associated with the reduced energy supply costs to utility programs and participant costs.
- Utility Cost Test - shows the value of the program considering only avoided utility supply cost (based on the next unit of generation) in comparison to program costs.
- Participant Cost Test - shows the value of the program from the perspective of the utility's customer participating in the program. The test compares the participant's bill savings over the life of the EE/DR program to the participant's cost of participation.
- Ratepayer Impact Measure Test - shows the impact of a program on all utility customers through impacts in average rates. This perspective also includes the estimates of revenue losses, which may be experienced by the utility as a result of the program.

The cost effectiveness analysis produces two types of resulting metrics:

- Net Benefits (dollars) = NPV $\sum$ benefits – NPV $\sum$ costs
- Benefit Cost Ratio = NPV $\sum$ benefits ÷ NPV $\sum$ costs

Cost effectiveness analysis is performed using each of the four primary tests. The results of each test reflect a distinct perspective and have a separate set of inputs demonstrating the treatment of costs and benefits. A summary of benefits and costs included in each cost effectiveness test can be found in Appendix A.

5. 2018 - 2020 Plan Objectives and Impact

The framework for the 2018-2020 Plan aligns with the preferred portfolio as filed in the 2016 IRP and was designed to reach a reduction in sales of approximately 1% of eligible retail sales with opt-out assumptions incorporated. Table 1 below provides an overview of energy savings and demand impacts, participation and budget by the residential and C&I sectors and for the total portfolio. Table 2 provides an overview of budget and energy savings by program and by year.

Table 1: 2018-2020 Portfolio Summary of Participation, Impacts & Budget

Residential

Program Year	Participants/ Measures	Annual Energy Savings kWh	Annual Demand Savings kW	Direct Program Budget	First Year Cost/Kwh*
2018	327,374	21,520,612	5,782	$4,663,152	$0.22
2019	347,909	22,025,627	6,021	$4,865,148	$0.22
2020	217,427	19,294,127	5,977	$4,649,484	$0.24

Commercial & Industrial

Program Year	Participants/ Measures	Annual Energy Savings kWh	Annual Demand Savings kW	Direct Program Budget	First Year Cost/Kwh*
2018	7,252	15,135,729	1,648	$3,387,238	$0.22
2019	6,211	16,043,561	1,585	$3,568,128	$0.22
2020	7,638	17,053,515	1,773	$3,720,882	$0.22

Portfolio Participation, Impacts & Budget

Program Year	Participants/ Measures	Annual Energy Savings kWh	Annual Demand Savings kW	Res & C&I Direct Program Budget	Indirect Portfolio Level Budget	Other Costs Budget	Portfolio Total Budget Including Indirect & Other	First Year Cost/Kwh*
2018	334,626	36,656,341	7,430	$8,050,391	$937,436	$500,000	$9,487,827	$0.23
2019	354,120	38,069,188	7,607	$8,433,276	$960,110	$200,000	$9,593,386	$0.23
2020	225,065	36,347,642	7,750	$8,370,366	$960,225	$200,000	$9,530,591	$0.24

*Cost per kWh includes program and indirect costs for budget. First year costs are calculated by dividing total cost by total savings and do not include carry forward costs related to smart thermostat, BYOT and CVR programs.

Table 2: Vectren South 2018 - 2020 Plan Overview by Program

	Total Budget ($)			Total Savings (kWh)			Total Demand (kW)		
Residential Programs	**2018**	**2019**	**2020**	**2018**	**2019**	**2020**	**2018**	**2019**	**2020**
Residential Lighting	$ 942,125	$ 930,451	$ 691,256	7,610,617	8,340,595	6,075,005	942	1,029	791
Residential Prescriptive	$ 635,925	$ 681,609	$ 694,362	1,747,547	1,918,174	1,979,280	1,558	1,775	1,910
Residential New Construction	$ 85,345	$ 87,132	$ 88,940	187,038	187,038	187,038	118	118	118
Home Energy Assessment & Weatherization	$ 526,473	$ 533,934	$ 541,669	863,991	863,991	863,991	192	192	192
Income Qualified Weatherization	$ 841,848	$ 899,806	$ 958,593	959,988	1,046,148	1,130,945	459	499	540
Food Bank - LED Bulb Distribution	$ 174,141	$ 175,308	$ -	1,401,264	1,401,264	-	149	149	0
Energy Efficient Schools	$ 131,696	$ 136,805	$ 119,995	899,706	937,194	645,216	53	53	53
Residential Behavioral Savings	$ 305,622	$ 285,585	$ 286,545	6,470,000	5,970,000	5,600,000	1,351	1,248	1,153
Appliance Recycling	$ 174,759	$ 180,648	$ 186,532	913,771	894,534	884,915	121	118	117
Smart Thermostat Program	$ 97,639	$ 98,222	$ 98,798	-	-	-	-	-	-
CVR Residential	$ 118,786	$ 114,907	$ 230,134	-	-	1,461,047	-	-	263
SmartDLC - Wifi DR/DLC Change-out	$ 517,759	$ 562,148	$ 606,532	466,690	466,690	466,690	600	600	600
BYOT (Bring Your Own Thermostat)	$ 111,036	$ 178,592	$ 146,128	-	-	-	240	240	240
Residential Subtotal	**$ 4,663,152**	**$4,865,148**	**$4,649,484**	**21,520,612**	**22,025,627**	**19,294,127**	**5,782**	**6,021**	**5,977**
C&I Programs	**2018**	**2019**	**2020**	**2018**	**2019**	**2020**	**2018**	**2019**	**2020**
Commercial Prescriptive	$ 729,398	$ 655,370	$ 731,330	4,999,125	4,501,186	5,002,621	378	325	369
Commercial Custom	$ 1,019,072	$ 1,022,184	$ 1,160,256	5,000,000	5,000,000	5,500,000	476	476	524
Small Business Direct Install	$ 1,149,640	$ 1,182,037	$ 1,173,133	4,032,934	3,905,372	3,900,306	667	645	567
Commercial New Construction	$ 214,536	$ 386,092	$ 222,628	502,080	1,835,413	502,080	108	120	108
Building Tune-up	$ 130,880	$ 182,074	$ 261,266	500,000	700,000	1,000,000	1	1	1
Multi-Family Retrofit	$ 34,880	$ 35,074	$ 35,266	101,590	101,590	115,853	18	18	18
CVR Commercial	$ 108,834	$ 105,297	$ 137,003	-	-	1,032,655	-	-	186
Commercial Subtotal	**$ 3,387,238**	**$3,568,128**	**$3,720,882**	**15,135,729**	**16,043,561**	**17,053,515**	**1,648**	**1,585**	**1,773**
Residential & Commercial Subtotal	**$ 8,050,391**	**$8,433,276**	**$8,370,366**	**36,656,341**	**38,069,188**	**36,347,642**	**7,430**	**7,607**	**7,750**
Portfolio Level Costs Subtotal*	$ 937,436	$ 960,110	$ 960,225						
Other Costs Subtotal**	$ 500,000	$ 200,000	$ 200,000						
DSM Portfolio Total including Other Costs	**$ 9,487,827**	**$9,593,386**	**$9,530,591**	**36,656,341**	**38,069,188**	**36,347,642**	**7,430**	**7,607**	**7,750**

*Portfolio level costs include: Contact Center, Online Audit, Outreach & Education, and Evaluation.

**Other Costs include Market Potential Study and Emerging Markets.

A. Plan Savings

The planned savings goal for 2018-2020 was calculated based on a percentage of forecasted weather normalized electric sales for 2018 to 2020 with a target of 1% of eligible retail sales. The forecast is consistent with Vectren South's 2016 IRP sales forecast. Goals are based on gross energy savings with opt-out assumptions incorporated. Table 3 demonstrates the portfolio, residential and C&I energy savings targets at the 1% eligible retail sales level. Table 4 demonstrates the portfolio energy and demand savings by program and by year.

Table 3: Vectren South 2018 - 2020 Plan Portfolio Summary Planned Energy Savings

Portfolio Summary	kWh Savings			kW Savings		
	2018	**2019**	**2020**	**2018**	**2019**	**2020**
Residential Total	21,520,612	22,025,627	19,294,127	5,782	6,021	5,977
Commercial & Industrial Total	15,135,729	16,043,561	17,053,515	1,648	1,585	1,773
Portfolio Total	36,656,341	38,069,188	36,347,642	7,430	7,607	7,750

Table 4: Vectren South 2018 - 2020 Plan Portfolio Planned Energy Savings

Residential	2018 kWh	2018 kW	2019 kWh	2019 kW	2020 kWh	2020 kW
Residential Lighting	7,610,617	942	8,340,595	1,029	6,075,005	791
Residential Prescriptive	1,747,547	1,558	1,918,174	1,775	1,979,280	1,910
Residential New Construction	187,038	118	187,038	118	187,038	118
Home Energy Assessment & Weatherization	863,991	192	863,991	192	863,991	192
Income Qualified Weatherization	959,988	459	1,046,148	499	1,130,945	540
Food Bank - LED Bulb Distribution	1,401,264	149	1,401,264	149	0	0
Energy Efficient Schools	899,706	53	937,194	53	645,216	53
Residential Behavioral Savings	6,470,000	1,351	5,970,000	1,248	5,600,000	1,153
Appliance Recycling	913,771	121	894,534	118	884,915	117
Smart Thermostat Program	-	-	-	-	-	-
CVR Residential	-	-	-	-	1,461,047	263
SmartDLC - Wifi DR/DLC Change-out	466,690	600	466,690	600	466,690	600
BYOT (Bring Your Own Thermostat)	-	240	-	240	-	240
Residential Total	**21,520,612**	**5,782**	**22,025,627**	**6,021**	**19,294,127**	**5,977**
Commercial & Industrial	**2018 kWh**	**2018 kW**	**2019 kWh**	**2019 kW**	**2020 kWh**	**2020 kW**
Commercial Prescriptive	4,999,125	378	4,501,186	325	5,002,621	369
Commercial Custom	5,000,000	476	5,000,000	476	5,500,000	524
Small Business Direct Install	4,032,934	667	3,905,372	645	3,900,306	567
Commercial New Construction	502,080	108	1,835,413	120	502,080	108
Building Tune-up	500,000	1	700,000	1	1,000,000	1
Multi-Family Retrofit	101,590	18	101,590	18	115,853	18
CVR Commercial	-	-	-	-	1,032,655	186
Commercial & Industrial Total	**15,135,729**	**1,648**	**16,043,561**	**1,585**	**17,053,515**	**1,773**
Portfolio Total	**36,656,341**	**7,430**	**38,069,188**	**7,607**	**36,347,642**	**7,750**

B. Plan Budget

The total planned program budget includes the direct and indirect costs of implementing Vectren South's electric energy efficiency programs. In addition, a budget for other costs are being requested as described below.

Direct program costs include three main categories: vendor implementation, program incentives and administration costs. The program budgets were built based upon multiple resources. Program budgets were discussed with program implementers as a basis for the development of this plan. Vendor implementation budgets were estimated using historical data and estimates provided by the current vendors. This helps to assure that the estimates are realistic for successful delivery. Program incentives were calculated by assigning measures with appropriate incentive values based upon existing program incentives, evaluation results and vendor recommendations. Lastly, administrative costs are comprised of internal costs for Vectren South's management and oversight of the programs. Administrative costs were allocated back to programs based on the percent of savings these programs represent as well as estimated staff time spent on programs.

Indirect costs are costs that are not directly tied to a single program, but rather support multiple programs or the entire portfolio. These include: Contact Center, Online Audit, Outreach & Education, and Evaluation, Measurement and Verification (EM&V). These costs are budgeted at the portfolio level.

Other costs are also being requested in the 2018-2020 filed plan. Vectren South requests approval of a budget to include a Market Potential Study for 2020 and beyond and funding for Emerging Markets, which is discussed later in the Plan. Emerging Markets funding allows Vectren's EE portfolio to offer leading-edge program designs for next-generation technologies, services, and engagement strategies to growing markets in the Vectren South territory. This funding will not be used to support existing measures or programs, but rather support new program development or new measures within an existing program. Tables 5 through 8 below list the summary budgets by year, program and category.

Table 5: Vectren South 2018 – 2020 Summary Budgets by Year

Residential	2018	2019	2020	Total Budget
Residential Lighting	$942,125	$930,451	$691,256	$2,563,832
Residential Prescriptive	$635,925	$681,609	$694,362	$2,011,896
Residential New Construction	$85,345	$87,132	$88,940	$261,417
Home Energy Assessment & Weatherization	$526,473	$533,934	$541,669	$1,602,076
Income Qualified Weatherization	$841,848	$899,806	$958,593	$2,700,247
Food Bank - LED Bulb Distribution	$174,141	$175,308	$0	$349,449
Energy Efficient Schools	$131,696	$136,805	$119,995	$388,496
Residential Behavioral Savings	$305,622	$285,585	$286,545	$877,752
Appliance Recycling	$174,759	$180,648	$186,532	$541,939
Smart Thermostat Program	$97,639	$98,222	$98,798	$294,659
CVR Residential	$118,786	$114,907	$230,134	$463,827
SmartDLC - Wifi DR/DLC Change-out	$517,759	$562,148	$606,532	$1,686,439
BYOT (Bring Your Own Thermostat)	$111,036	$178,592	$146,128	$435,756
Residential Total	**$4,663,152**	**$4,865,148**	**$4,649,484**	**$14,177,784**
Commercial & Industrial	**2018**	**2019**	**2020**	**Total Budget**
Commercial Prescriptive	$729,398	$655,370	$731,330	$2,116,098
Commercial Custom	$1,019,072	$1,022,184	$1,160,256	$3,201,512
Small Business Direct Install	$1,149,640	$1,182,037	$1,173,133	$3,504,810
Commercial New Construction	$214,536	$386,092	$222,628	$823,256
Building Tune-up	$130,880	$182,074	$261,266	$574,220
Multi-Family Retrofit	$34,880	$35,074	$35,266	$105,220
CVR Commercial	$108,834	$105,297	$137,003	$351,134
Commercial & Industrial Total	**$3,387,238**	**$3,568,128**	**$3,720,882**	**$10,676,248**
Total Direct Program Costs	**$8,050,391**	**$8,433,276**	**$8,370,366**	**$24,854,032**
Indirect Portfolio Level Costs	**2018**	**2019**	**2020**	**Total Budget**
Contact Center	$63,000	$63,000	$63,000	$189,000
Online Audit	$36,444	$39,806	$42,911	$119,161
Outreach & Education	$410,000	$410,000	$410,000	$1,230,000
Evaluation	$427,992	$447,304	$444,314	$1,319,610
Indirect Portfolio Level Costs Subtotal	**$937,436**	**$960,110**	**$960,225**	**$2,857,771**
Total Portfolio	**$8,987,827**	**$9,393,386**	**$9,330,591**	**$27,711,803**
Other Costs	**2018**	**2019**	**2020**	**Total Budget**
Emerging Markets	$200,000	$200,000	$200,000	$600,000
Market Potential Study	$300,000	$0	$0	$300,000
Other Costs Subtotal	**$500,000**	**$200,000**	**$200,000**	**$900,000**
DSM Portfolio Total including Other Costs	**$9,487,827**	**$9,593,386**	**$9,530,591**	**$28,611,803**

Table 6: Vectren South 2018 Summary Budgets by Category

Residential	**Administrative**	**Implementation**	**Incentives**	**Total Budget**
Residential Lighting	$ 94,072	$ 225,000	$ 623,053	$ 942,125
Residential Prescriptive	$ 5,880	$ 219,860	$ 410,185	$ 635,925
Residential New Construction	$ 17,639	$ 39,856	$ 27,850	$ 85,345
Home Energy Assessment & Weatherization	$ 47,036	$ 479,437	$ -	$ 526,473
Income Qualified Weatherization	$ 35,277	$ 806,571	$ -	$ 841,848
Food Bank - LED Bulb Distribution	$ 35,277	$ 138,864	$ -	$ 174,141
Energy Efficient Schools	$ 44,096	$ 87,600	$ -	$ 131,696
Residential Behavioral Savings	$ 29,398	$ 276,224	$ -	$ 305,622
Appliance Recycling	$ 11,759	$ 115,500	$ 47,500	$ 174,759
Smart Thermostat Program	$ 17,639	$ 40,000	$ 40,000	$ 97,639
CVR Residential	$ 2,940	$ 115,846	$ -	$ 118,786
SmartDLC - Wifi DR/DLC Change-out	$ 11,759	$ 484,000	$ 22,000	$ 517,759
BYOT (Bring Your Own Thermostat)	$ 47,036	$ 26,000	$ 38,000	$ 111,036
Residential Subtotal	**$ 399,806**	**$ 3,054,758**	**$1,208,588**	**$ 4,663,152**
Commercial & Industrial	**Administrative**	**Implementation**	**Incentives**	**Total Budget**
Commercial Prescriptive	$ 29,398	$ 200,000	$ 500,000	$ 729,398
Commercial Custom	$ 94,072	$ 325,000	$ 600,000	$ 1,019,072
Small Business Direct Install	$ 2,940	$ 321,700	$ 825,000	$ 1,149,640
Commercial New Construction	$ 47,036	$ 102,500	$ 65,000	$ 214,536
Building Tune-up	$ 5,880	$ 100,000	$ 25,000	$ 130,880
Multi-Family Retrofit	$ 5,880	$ 10,000	$ 19,000	$ 34,880
CVR Commercial	$ 2,940	$ 105,894	$ -	$ 108,834
Commercial Subtotal	**$ 188,144**	**$ 1,165,094**	**$2,034,000**	**$ 3,387,238**
Residential & Commercial Subtotal	**$ 587,950**	**$ 4,219,853**	**$3,242,588**	**$ 8,050,391**
Indirect Costs				**Total Budget**
Contact Center				$ 63,000
Online Audit				$ 36,444
Outreach & Education				$ 410,000
Evaluation				$ 427,992
DSM Portfolio Total				**$ 8,987,827**
Other Costs				**Total Budget**
Emerging Markets				$ 200,000
Market Potential Study				$ 300,000
Other Costs Subtotal				**$ 500,000**
DSM Portfolio Total including Other Costs				**$ 9,487,827**

Table 7: Vectren South 2019 Summary Budgets by Category

Residential	Administrative	Implementation	Incentives	Total Budget
Residential Lighting	$ 97,184	$ 225,000	$ 608,267	$ 930,451
Residential Prescriptive	$ 6,074	$ 226,800	$ 448,735	$ 681,609
Residential New Construction	$ 18,222	$ 41,060	$ 27,850	$ 87,132
Home Energy Assessment & Weatherization	$ 48,592	$ 485,342	$ -	$ 533,934
Income Qualified Weatherization	$ 36,444	$ 863,362	$ -	$ 899,806
Food Bank - LED Bulb Distribution	$ 36,444	$ 138,864	$ -	$ 175,308
Energy Efficient Schools	$ 45,555	$ 91,250	$ -	$ 136,805
Residential Behavioral Savings	$ 30,370	$ 255,215	$ -	$ 285,585
Appliance Recycling	$ 12,148	$ 122,000	$ 46,500	$ 180,648
Smart Thermostat Program	$ 18,222	$ 40,000	$ 40,000	$ 98,222
CVR Residential	$ 3,037	$ 111,870	$ -	$ 114,907
SmartDLC - Wifi DR/DLC Change-out	$ 12,148	$ 506,000	$ 44,000	$ 562,148
BYOT (Bring Your Own Thermostat)	$ 48,592	$ 84,000	$ 46,000	$ 178,592
Residential Subtotal	**$ 413,032**	**$ 3,190,764**	**$1,261,352**	**$ 4,865,148**
Commercial & Industrial	**Administrative**	**Implementation**	**Incentives**	**Total Budget**
Commercial Prescriptive	$ 30,370	$ 200,000	$ 425,000	$ 655,370
Commercial Custom	$ 97,184	$ 325,000	$ 600,000	$ 1,022,184
Small Business Direct Install	$ 3,037	$ 319,000	$ 860,000	$ 1,182,037
Commercial New Construction	$ 48,592	$ 112,500	$ 225,000	$ 386,092
Building Tune-up	$ 6,074	$ 141,000	$ 35,000	$ 182,074
Multi-Family Retrofit	$ 6,074	$ 10,000	$ 19,000	$ 35,074
CVR Commercial	$ 3,037	$ 102,260	$ -	$ 105,297
Commercial Subtotal	**$ 194,368**	**$ 1,209,760**	**$2,164,000**	**$ 3,568,128**
Residential & Commercial Subtotal	**$ 607,400**	**$ 4,400,524**	**$3,425,352**	**$ 8,433,276**
Indirect Costs				**Total Budget**
Contact Center				$ 63,000
Online Audit				$ 39,806
Outreach & Education				$ 410,000
Evaluation				$ 447,304
DSM Portfolio Total				**$ 9,393,386**
Other Costs				**Total Budget**
Emerging Markets				$ 200,000
Market Potential Study				$ -
Other Costs Subtotal				**$ 200,000**
DSM Portfolio Total including Other Costs				**$ 9,593,386**

Table 8: Vectren South 2020 Summary Budgets by Category

Residential	Administrative	Implementation	Incentives	Total Budget
Residential Lighting	$ 100,256	$ 150,000	$ 441,000	$ 691,256
Residential Prescriptive	$ 6,266	$ 234,111	$ 453,985	$ 694,362
Residential New Construction	$ 18,798	$ 42,292	$ 27,850	$ 88,940
Home Energy Assessment & Weatherization	$ 50,128	$ 491,541	$ -	$ 541,669
Income Qualified Weatherization	$ 37,596	$ 920,997	$ -	$ 958,593
Food Bank - LED Bulb Distribution	$ -	$ -	$ -	$ -
Energy Efficient Schools	$ 46,995	$ 73,000	$ -	$ 119,995
Residential Behavioral Savings	$ 31,330	$ 255,215	$ -	$ 286,545
Appliance Recycling	$ 12,532	$ 128,000	$ 46,000	$ 186,532
Smart Thermostat Program	$ 18,798	$ 40,000	$ 40,000	$ 98,798
CVR Residential	$ 40,729	$ 189,405	$ -	$ 230,134
SmartDLC - Wifi DR/DLC Change-out	$ 12,532	$ 528,000	$ 66,000	$ 606,532
BYOT (Bring Your Own Thermostat)	$ 50,128	$ 42,000	$ 54,000	$ 146,128
Residential Subtotal	**$ 426,088**	**$ 3,094,561**	**$1,128,835**	**$ 4,649,484**
Commercial & Industrial	**Administrative**	**Implementation**	**Incentives**	**Total Budget**
Commercial Prescriptive	$ 31,330	$ 250,000	$ 450,000	$ 731,330
Commercial Custom	$ 100,256	$ 400,000	$ 660,000	$ 1,160,256
Small Business Direct Install	$ 3,133	$ 345,000	$ 825,000	$ 1,173,133
Commercial New Construction	$ 50,128	$ 107,500	$ 65,000	$ 222,628
Building Tune-up	$ 6,266	$ 205,000	$ 50,000	$ 261,266
Multi-Family Retrofit	$ 6,266	$ 10,000	$ 19,000	$ 35,266
CVR Commercial	$ 3,133	$ 133,870	$ -	$ 137,003
Commercial Subtotal	**$ 200,512**	**$ 1,451,370**	**$2,069,000**	**$ 3,720,882**
Residential & Commercial Subtotal	**$ 626,600**	**$ 4,545,931**	**$3,197,835**	**$ 8,370,366**
Indirect Costs				**Total Budget**
Contact Center				$ 63,000
Online Audit				$ 42,911
Outreach & Education				$ 410,000
Evaluation				$ 444,314
DSM Portfolio Total				**$ 9,330,591**
Other Costs				**Total Budget**
Emerging Markets				$ 200,000
Market Potential Study				$ -
Other Costs Subtotal				**$ 200,000**
DSM Portfolio Total including Other Costs				**$ 9,530,591**

C. Cost Effectiveness Results

The total portfolio for the Vectren South programs passes the TRC and UCT test for both the Residential and Commercial & Industrial sectors. Table 9 below confirms that all programs pass the TRC at greater than one. In completing the cost effectiveness testing, Vectren South used 7.29% as the weighted average cost of capital (WACC) as approved by the Commission on April 27, 2011 in Cause No. 43839. For the 2018 - 2020 Plan, Vectren South utilized the avoided costs from the 2016 IRP.

Table 9: Vectren South 2018-2020 Plan Cost Effectiveness Results without Performance Incentive

Residential	TRC	UCT	RIM	Participant	TRC NPV $	UCT NPV $	Lifetime Cost/kWh	1st Year Cost/kWh
Residential Lighting	4.20	6.19	0.86	5.18	$ 11,354,267	$ 12,498,117	$0.01	$0.12
Residential Prescriptive	1.28	2.68	0.99	1.04	$ 1,113,799	$ 3,153,088	$0.05	$0.36
Residential New Construction	1.25	2.02	0.79	1.39	$ 98,697	$ 248,511	$0.06	$0.47
Home Energy Assessment & Weatherization	1.19	1.19	0.48	n/a	$ 277,622	$ 277,622	$0.06	$0.62
Income Qualified Weatherization	1.30	1.30	0.59	n/a	$ 752,131	$ 752,131	$0.08	$0.86
Food Bank - LED Bulb Distribution	8.42	8.42	0.88	n/a	$ 2,503,138	$ 2,503,138	$0.01	$0.12
Energy Efficient Schools	3.28	3.28	0.53	n/a	$ 829,622	$ 829,622	$0.02	$0.16
Residential Behavioral Savings	1.54	1.54	0.50	n/a	$ 440,606	$ 440,606	$0.04	$0.05
Appliance Recycling	1.19	1.02	0.36	n/a	$ 83,146	$ 12,513	$0.05	$0.20
Smart Thermostat Program	-	-	-	n/a	$ (162,984)	$ (275,015)	n/a	n/a
CVR Residential	1.59	1.59	0.66	n/a	$ 580,613	$ 580,613	$0.07	$0.16
SmartDLC - Wifi DR/DLC Change-out	1.90	1.75	0.92	n/a	$ 1,301,580	$ 1,181,234	$0.10	$1.11
BYOT (Bring Your Own Thermostat)	2.80	1.92	1.92	n/a	$ 498,223	$ 370,438	n/a	n/a
Residential Portfolio	**2.18**	**2.64**	**0.76**	**4.06**	**$19,670,459**	**$22,572,616**	**$0.04**	**$0.21**
Commercial & Industrial	**TRC**	**UCT**	**RIM**	**Participant**	**TRC NPV $**	**UCT NPV $**	**Lifetime Cost/kWh**	**1st Year Cost/kWh**
Commercial Prescriptive	1.63	3.68	0.51	2.70	$ 2,811,420	$ 5,291,462	$0.02	$0.15
Commercial Custom	2.05	3.27	0.52	3.59	$ 5,003,931	$ 6,772,616	$0.02	$0.21
Small Business Direct Install	5.34	2.38	0.53	24.51	$ 6,333,499	$ 4,520,941	$0.03	$0.30
Commercial New Construction	2.01	1.69	0.45	9.55	$ 652,266	$ 530,199	$0.03	$0.29
Building Tune-up	1.09	1.13	0.34	9.35	$ 46,816	$ 67,027	$0.04	$0.26
Multi-Family Retrofit	3.99	2.28	0.53	24.86	$ 167,808	$ 125,751	$0.03	$0.33
CVR Commercial	1.30	1.30	0.55	n/a	$ 219,929	$ 219,929	$0.07	$0.13
Commercial & Industrial Total	**2.21**	**2.69**	**0.51**	**4.57**	**$15,235,668**	**$17,527,926**	**$0.02**	**$0.22**
Indirect Portfolio Level Costs					$ (2,666,479)	$ (2,666,479)		
Total Portfolio	**2.01**	**2.40**	**0.61**	**4.31**	**$32,239,647**	**$37,434,062**	**$0.03**	**$0.24**

First year costs are calculated by diving total cost by total savings and do not include carry forward costs related to smart thermostat, BYOT and CVR programs.

Table 9.1: Vectren South 2018-2020 Plan Cost Effectiveness Results including Performance Incentive

Including Performance Incentive	TRC	UCT	RIM	Participant	TRC NPV $	UCT NPV $	Lifetime Cost/kWh	1st Year Cost/kWh
Total Portfolio	**1.80**	**2.11**	**0.59**	**4.31**	**$28,624,007**	**$33,818,421**	**$0.04**	**$0.27**

*Utility Performance Incentive does not include IQW, 2016 Smart Tstat, or CVR.

6. New or Modified Program Initiatives

Vectren South's 2018-2020 filing largely extends the existing momentum of the portfolio of programs from 2016-2017 while applying the lessons learned from Vectren's program experience and evaluations as well as making refinements to key data and assumptions as described in this document.

Below is a summary which outlines notable changes for the 2018-2020 Plan from previous filings. More in depth details on the following topics can be found within the Program Descriptions portion of this document.

A. Residential Lighting

All programs within this filing will utilize light emitting diode (LED) lighting technologies per evaluation recommendations. This shift began in 2016 and the 2017 portfolio, as a whole, shifted focus from Compact Fluorescent Lamp (CFL) lamps to LED bulbs where performance, price and market readiness have all improved dramatically in recent years.

Additionally, new light bulbs standards are proposed to go into effect in 2020 due to the Energy Independence and Security Act (EISA). As proposed, this legislation would change the baseline and available savings for general service bulbs. The future of the 2020 EISA legislation is uncertain, thus Vectren will include LED bulbs in the plan for all three years. The incorporation of LED bulbs in 2020 is with the understanding that the measure's inclusion is pending regulatory outcomes.

There is still significant opportunity in the residential lighting market and thus Vectren plans to continue this offering as long as the market and legislation will allow. Lighting programs are consistently highly cost-effective and critical to the advancement of increased efficiency.

B. LED Food Bank

The LED Food Bank program was first offered in 2016 to help meet goals and serve the IQW population. This program will be part of the standard portfolio offering in 2018-2019 (2020 is not included due to EISA uncertainty). The program has been well received by food banks and pantries and Vectren South expects to see continued participation in 2018 and 2019.

C. Residential Prescriptive

Starting in 2018, duct sealing measure within the residential prescriptive program will require a small co-pay of $50 by the customer. The purpose of the duct sealing measure change is to increase participation and promotion of deeper retrofit measures in homes.

D. Smart Thermostat Program Expansion

In 2016, Vectren South conducted a field study designed to analyze the EE and DR benefits associated with smart thermostats. Between the months of April and May 2016, Vectren South installed approximately 2,000 smart thermostats (1,000 Honeywell and 1,000 Nest) in customer homes. The program is currently under evaluation to measure effectiveness. Vectren South anticipates continuing to pay incentives to these 2,000 customers, who are currently enrolled in Vectren South's Summer Cycler program. In addition, and as a result of the field study, Vectren South anticipates expanding its Smart Thermostat program by offering the following two new programs during 2018 through 2020: (1) DLC Change-out program and (2) Bring Your Own Thermostat (BYOT) program. A description of these new programs is included.

E. Commercial & Industrial Prescriptive

Based upon input from the VOB during the planning process, Vectren South added several agricultural measures to the prescriptive measure offering list including:

- Livestock Waterer
- Agriculture - Poultry Farm LED Lighting
- VSD Milk Pump
- High Volume Low Speed Fans
- High Speed Fans (Ventilation and Circulation)
- Dairy Plate Cooler
- Heat Mat (Single, ~14x60")
- Automatic Milker Take Off
- HE Diary Scroll Compressor
- Heat Reclaimer (No Pre-cooler Installed)

F. Commercial & Industrial Targeted Outreach

Vectren South's Commercial & Industrial Programs will seek out higher participation levels from schools, civic/government buildings and non-profit organizations and through a concentrated outreach approach. The concerted outreach will directly engage these segments to inform them of energy-saving opportunities and the available rebates through existing programs. Additional consideration can be provided to align program engagement with peak times to undertake energy efficiency projects: for schools, this means helping them schedule projects to be completed during summer vacations; for government institutions, this means planning around their fiscal cycles.

With this targeted outreach approach, Vectren South plans to assist 30 schools, 15 governmental buildings and 60 non-profit organizations in 2018-2020. Schools will likely receive support through the Prescriptive and Custom programs, while civic/government buildings and non-profit organizations may qualify for the Small Business Energy Savings program benefits.

G. Multi-Family Retrofit

The Multi-Family Retrofit program was offered as a small pilot starting in 2017 and will continue to be available to the Commercial & Industrial sector in 2018-2020. This program was initiated to continue to serve the multi-family sector as the integrated Multi-Family Direct Install program was discontinued in 2017 due to market saturation.

H. Emerging Markets

The Emerging Markets funding allows Vectren South's DSM portfolio to offer leading-edge program designs for next-generation technologies, services, and engagement strategies to growing markets in the Vectren South territory. Incentives promoted through this program may range from innovative rebate offerings to engineering and trade ally assistance to demand-control services that encourage early adoption of new, efficient technologies in high-impact market sectors. Depending on the development of certain technologies and growth areas in the service territory, a wide variety of projects and services are eligible. Because this program will focus on innovative new approaches and leading the DSM market, the exact list of measures cannot be set at this time. However, potential measures and services include: new technologies, such as Advanced Lighting Controls; new strategies for achieving significant energy savings, such as midstream incentives, contractor bids to provide energy efficiency projects, and targeting high-impact market sectors; and integrated DSM (iDSM) approaches, such as demand response, combined energy efficiency and demand response measures, and load shifting. This funding will not be used to support existing measures or programs, but rather support new program development or new measures within an existing program

7. Program Descriptions

A. Residential Lighting

The Residential Lighting Program is a market-based residential EE program designed to reach residential customers through retail outlets. The program consists of a buy-down strategy that provides incentives to consumers to facilitate the purchase of EE lighting products. The overall program goal is to increase the penetration of ENERGY STAR qualified lighting products based on the most up-to-date standards. As of 2017, the Residential Lighting program shifted 100% to LED bulbs.

There is still significant opportunity in the residential lighting market and thus Vectren plans to continue this offering as long as the market and legislation will allow. Lighting programs are consistently highly cost-effective and critical to the advancement of increased efficiency.

The future of the 2020 EISA legislation is uncertain, thus Vectren will include LED bulbs in the plan for all three years. The incorporation of LED bulbs in 2020 is with the understanding that the measure's inclusion is pending regulatory outcomes and uses conservative estimates.

Table 11: Residential Lighting Program Budget & Energy Savings Targets

Market	Program	2018	2019	2020	Total Program
Residential	**Residential Lighting**				
	Number of Measures	222,863	246,086	163,416	632,365
	Energy Savings kWh	7,610,617	8,340,595	6,075,005	22,026,217
	Peak Demand kW	942.2	1,028.9	791.4	2,762.4
	Total Program Budget $	942,125	930,451	691,256	2,563,832
	Per Participant Avg Energy Savings (kWh)*	34.1	33.9	37.2	34.8
	Per Participant Avg Demand Savings (kW)*				0.004
	Weighted Avg Measure Life*				15
	Net To Gross Ratio				67%

Eligible Customers

Any customer of a participating retailer in Vectren South's electric territory.

Marketing Plan

The program is designed to reach residential customers through retail outlets. Proposed marketing efforts include point of purchase promotional activities, the use of utility bill inserts and customer emails, utility web site and social media promotions and coordinated advertising with selected manufacturers and retail outlets.

Barriers/Theory

The program addresses the market barriers by empowering customers to take advantage of new lighting technologies through education and availability in the marketplace; accelerating the adoption of proven energy efficient technologies through incentives to lower price; and working with retailers to allow them to sell more high efficient products.

Initial Measures, Products and Services

The measures will include a variety of ENERGY STAR qualified lighting products currently available at retailers in Indiana, including LED bulbs, fixtures and ceiling fans.

Program Delivery

Vectren South will oversee the program and partner with Ecova to deliver the program.

Evaluation, Measurement and Verification

The implementation contractor will verify the paperwork of the participating retail stores. They will also spot check stores to assure that the program guidelines are being followed. A third party evaluator will evaluate the program using standard EM&V protocols.

B. Residential Prescriptive

Program Description

The program, also called Residential Efficient Products, is designed to incent customers to purchase energy efficient equipment by covering part of the incremental cost. The program also offers home weatherization rebates to residential customers for attic insulation, wall insulation and duct sealing. If a product vendor or contractor chooses to do so, the rebates can be presented as an "instant discount" to Vectren South residential customers on their invoice.

Table 12: Budget & Energy Savings Targets

Market	Program	2018	2019	2020	Total Program
Residential	**Residential Prescriptive**				
	Number of Measures	4,093	6,445	6,595	17,133
	Energy Savings kWh	1,747,547	1,918,174	1,979,280	5,645,001
	Peak Demand kW	1,558.1	1,775.2	1,910.2	5,243.5
	Total Program Budget $	635,925	681,609	694,362	4,037
	Per Participant Avg Energy Savings (kWh)*				329.5
	Per Participant Avg Demand Savings (kW)*				0.306
	Weighted Avg Measure Life*				17
	Net To Gross Ratio				52%

Eligible Customers

Any residential customer located in the Vectren South electric service territory. For the equipment rebates, the applicant must reside in a single-family home or multi-family complex with up to 12 units. Only single-family homes are eligible for insulation and duct sealing remediation measures.

Marketing Plan

The marketing plan includes program specific materials that will target contractors, trade allies, distributors, manufacturers, industry organizations and appropriate retail outlets in the Heating, Ventilation and Air Conditioning (HVAC) industry. Marketing outreach medium include targeted direct marketing, direct contact by vendor personnel, trade shows and trade associations. Vectren will also use web banners, bill inserts, customer emails, social media outreach, press releases and mass market advertising. Program marketing will direct customers and contractors to the Vectren South website or call center for additional information.

Barriers/Theory

The initial cost is one of the key barriers. Customers do not always understand the long-term benefits of the energy savings from efficient alternatives. Trade allies are also often reluctant to sell the higher cost items as they do not want to be the high cost bidder. Incentives help address the initial cost issue and provide a good reason for Trade Allies to promote these higher efficient options.

Initial Measures, Products and Services

Details of the measures, savings, and incentives can be found in Appendix B. Measures included in the program will change over time as baselines change, new technologies become available and customer needs are identified.

Program Delivery

Vectren South will oversee the program and will partner with CLEAResult to deliver the program.

Integration with Vectren South Gas

Vectren South will offer this integrated natural gas/electric EE program in its combined natural gas and electric service territory. Vectren South has allocated implementation costs based on the net benefits split between natural gas and electric.

Evaluation, Measurement and Verification

As part of the Quality Assurance/Quality Control process, the vendor will provide 100% paper verification that the equipment/products purchased meet the program efficiency standards and a field verification of 5% of the measures installed. A third party evaluator will review the program using appropriate EM&V protocols.

C. Residential New Construction

Program Description

The Residential New Construction (RNC) program produces long-term energy savings by encouraging the construction of single-family homes, duplexes, or end-unit townhomes with only one shared wall that are inspected and evaluated through the Home Efficiency Rating System (HERS). Builders can select from two rebate tiers for participation. Gold Star homes must achieve a HERS rating of 61 to 65. Platinum Star homes must meet a HERS rating of 60 or less.

The RNC Program provides incentives and encourages home builders to construct homes that are more efficient than current building codes and address the lost opportunities in this customer segment by promoting EE at the time the initial decisions are being made. The Residential New Construction Program will work closely with builders, educating them on the benefits of energy efficient new homes. Homes may feature additional insulation, better windows, and higher efficiency appliances. The homes should also be more efficient and comfortable than standard homes constructed to current building codes.

Table 13: Program Budget & Energy Savings Targets

Market	Program	2018	2019	2020	Total Program
Residential	**Residential New Construction**				
	Number of Homes	139	139	139	417
	Energy Savings kWh	187,038	187,038	187,038	561,114
	Peak Demand kW	118.0	118.0	118.0	354.0
	Total Program Budget $	85,345	87,132	88,940	261,417
	Per Participant Avg Energy Savings (kWh)*				1345.6
	Per Participant Avg Demand Savings (kW)*				0.849
	Weighted Avg Measure Life*				25
	Net To Gross Ratio				50%

Eligible Customers

Any customer or home builder constructing an eligible home in the Vectren South service territory.

Marketing Plan

In order to move the market toward an improved home building standard, education will be required for home builders, architects and designers as well as customers buying new homes. A combination of in-person meetings with these market participants as well as other educational methods will be necessary.

Barriers/Theory

The Residential New Construction program addresses the primary barriers of first cost as well as builder and customer knowledge. First cost is addressed by program incentives to help reduce the cost of the EE upgrades. The program provides opportunities for builders and developers to gain knowledge and skills concerning EE building practices and coaches them on application of these skills. The HERS rating system allows customers to understand building design and construction improvements through a rating system completed by professionals.

Incentive Strategy

Program incentives are designed to be paid to both all-electric and combination homes that have natural gas heating. It is important to note that the program is structured such that an incentive will not be paid for an all-electric home that has natural gas available to the home site. Incentives can be paid to either the home builder or the customer/account holder. Incentives will be based on the rating tier qualification. For all-electric homes, where Vectren South natural gas service is not available, the initial incentives will be:

Tier	HERS Rating	Total Incentive
Platinum	60 or less	$800
Gold	61 to 65	$700

For homes with central air conditioning and Vectren South natural gas space heating, the electric portion of the incentive will be:

Tier	HERS Rating	Total Incentive	Gas Portion	Electric Portion
Platinum	60 or less	$800	$600	$200
Gold	61 to 65	$700	$525	$175

Program Delivery

Vectren South will oversee the program and will partner with CLEAResult to deliver the program.

Integration with Vectren South Gas

Vectren South will offer this integrated natural gas/electric EE program in its combined natural gas and electric service territory.

Evaluation, Measurement and Verification

Field inspections will occur at least once during construction and upon completion by a certified HERS Rater. As part of the Quality Assurance/Quality Control process, the vendor will provide 100% paper verification that the equipment/products purchased meet the program efficiency standards. A third party evaluator will evaluate the program using standard EM&V protocols.

D. Home Energy Assessments & Weatherization

Program Description

The Home Energy Assessment and Weatherization Program will be offered jointly by Vectren South Gas and Electric. This program targets a hybrid phased approach that combines helping customers analyze and understand their energy use via an on-site energy assessment, providing direct installation of energy efficient measures including low-flow water fixtures, LED bulbs and thermostats, as well as provide deeper retrofit measures.

- Phase 1 - Assessors will perform a walk-through assessment of the home, collecting data for use in identifying cost-effective energy efficient improvements and appropriate direct install measures. Audit report provided to customer onsite will showcase deeper retrofit measure opportunities within the home.

- Phase 2 - If the home is eligible for air sealing and/or duct sealing, the Assessor will provide the information to the customer for scheduling the Phase 2 appointment via the online scheduling portal for a co-pay of $50. Customers who choose to install attic insulation will be referred to the Residential Energy Efficient Rebate Program.

Customers can schedule an assessment appointment in one of the following two ways: (1) by visiting vectren.com/saveenergy to schedule an appointment through self-booking tool; or (2) calling the call center to speak with a program representative. Customers who opt to receive email notifications will receive confirmation and appointment reminders prior to the assessment.

Table 14: Home Energy Assessments & Weatherization Budget & Energy Savings Targets

Market	Program	2018	2019	2020	Total Program
Residential	**Home Energy Assessment & Weatherization**				
	Number of Homes	1,210	1,210	1,210	3,630
	Energy Savings kWh	863,991	863,991	863,991	2,591,973
	Peak Demand kW	191.6	192.0	192.0	575.6
	Total Program Budget $	526,473	533,934	541,669	1,602,076
	Per Participant Avg Energy Savings (kWh)*				714.0
	Per Participant Avg Demand Savings (kW)*				0.159
	Weighted Avg Measure Life*				12
	Net To Gross Ratio				98%

Eligible Customers

Vectren South residential customers with electric service at a single-family residence, provided the home was not built within the past five years and has not had an audit within the last three years. Additionally, the home should be owner-occupied (or renter where occupants have the electric service in their name).

Marketing Plan

Proposed marketing efforts include utilizing direct mailers, email blasts, Vectren South online audit tools, bill inserts, social media outreach, as well as other outreach and education efforts and promotional campaigns throughout the year to ensure participation levels are maintained.

Barriers/Theory

The primary barrier addressed through this program is customer education and awareness. Often customers do not understand what opportunities exist to reduce their home energy use. This program not only informs the customer but helps them start down the path of energy savings by directly installing low-cost measures. The program is also a "gateway" to other Vectren South gas and electric programs.

Initial Measures, Products and Services

The direct install measures available for installation at no cost include:

- Kitchen & Bathroom Aerators
- Filter Whistle
- LED bulbs
- Low Flow Showerhead
- Pipe Wrap
- Water Heater Temperature Setback
- Wi-fi Thermostat

For customers who elect to move forward with Phase 2, Duct Sealing and Air Sealing are available for a $50 co-pay.

Program Delivery

Vectren South will oversee the program and will partner with CLEAResult to deliver the program.

Integration with Vectren South Gas

Vectren South will offer this integrated natural gas/electric EE program in its combined natural gas and electric service territory. Vectren South has allocated implementation costs based on the net benefits split between natural gas and electric.

Evaluation, Measurement and Verification

To assure compliance with program guidelines, field visits with auditors will occur as well as spot check verifications of measure installations. A third party evaluator will evaluate the program using standard EM&V protocols.

E. Income Qualified Weatherization

Program Description

The Income Qualified Weatherization program is designed to produce long-term energy and demand savings in the residential market. The program is designed to provide weatherization upgrades to low-income homes that otherwise would not have been able to afford the energy saving measures. The program provides direct installation of energy-saving measures and educates consumers on ways to reduce energy consumption. Customers eligible through the Income Qualified Weatherization Program will have opportunity to receive deeper retrofit measures including refrigerators, attic insulation, duct sealing, and air infiltration reduction. This year, we will engage with the manufactured homes population and offer the same measures offered to single family homes.

Collaboration and coordination between gas and electric low-income programs along with state and federal funding is recommended to provide the greatest efficiencies among all programs. The challenge of meeting the goals set for this program have centered on health and safety as well as customer cancellations and scheduling. Vectren South is committed to finding innovative solutions to these areas. A health and safety budget has been established, and we continue to work on improving methods of customer engagement with various confirmations via phone and email reminders prior to the appointment.

Table 15: Income Qualified Weatherization Budget & Energy Savings Targets

Market	Program	2018	2019	2020	Total Program
Residential	**Income Qualified Weatherization**				
	Number of Homes	475	500	525	1,500
	Energy Savings kWh	959,988	1,046,148	1,130,945	3,137,081
	Peak Demand kW	458.8	499.4	540.2	1,498.4
	Total Program Budget $	841,848	899,806	958,593	2,700,247
	Per Participant Avg Energy Savings (kWh)*				2091.4
	Per Participant Avg Demand Savings (kW)*				0.999
	Weighted Avg Measure Life*				14
	Net To Gross Ratio				100%

Eligible Customers

The Residential Low Income Weatherization Program targets single-family and manufactured homeowners and tenants who have electric service in their name with Vectren South and a total household income up to 200% of the federally-established poverty level.

Marketing Plan

Vectren South will provide a list to the implementation contractor of high consumption customers who have received Energy Assistance Program (EAP) funds within the past 12 months to help prioritize those customers who will benefit most from the program. This will also help in any direct marketing activities to specifically target those customers.

Barriers/Theory

Lower-income homeowners do not have the money to make even simple improvements to lower their energy usage and often live in homes with the most need for EE improvements. They may also lack the knowledge, experience, or capability to do the work. Health and safety can also be at risk for low-income homeowners, as their homes typically are not as "tight", and indoor air quality can be compromised. In order to increase participation and eligibility, Vectren South has incorporated a Health and Safety budget of $250 per home. This program provides those customers with basic improvements to help them start saving energy without needing to make the investment themselves.

Initial Measures, Products and Services

Measures available for installation will vary based on the home and include:

- LED bulbs/lamps
- Low flow kitchen and bath aerators
- Low flow showerheads
- Pipe wrap
- Filter whistles
- Infiltration reduction
- Attic insulation
- Duct repair, seal and insulation
- Refrigerator replacement
- Programmable/Smart thermostat
- Smart power strips

Program Delivery

Vectren South will oversee the program and will partner with CLEAResult to deliver the program.

Integration with Vectren South Gas

Vectren South will offer this integrated natural gas/electric EE program in its combined natural gas and electric service territory. Vectren South has allocated implementation costs based on the net benefits split between natural gas and electric.

Evaluation, Measurement and Verification

To assure quality installations, 5% of the installations will be field inspected. A third party evaluator will evaluate the program using standard EM&V protocols.

F. LED Food Bank

Program Description

The food bank program provides LED bulbs to food pantries in Vectren South's electric service territory. This program targets hard to reach, low income customers in the Vectren South electric territory. All food pantry recipients must provide proof of income qualification to receive the food baskets.

The program implementer purchases bulbs from a manufacturer and bulbs are shipped in bulk to the partner food bank. Food banks then distribute the bulbs to the respective food pantries in its network. Pantries include bulbs when assembling food packages and bulbs are provided to food recipients.

Table 16: LED Food Bank Budget & Energy Savings Targets

Market	Program	2018	2019	2020	Total Program
Residential	**Food Bank - LED Bulb Distribution**				
	Number of Measures	50,496	50,496	0	100,992
	Energy Savings kWh	1,401,264	1,401,264	0	2,802,528
	Peak Demand kW	148.8	148.8	0.0	297.6
	Total Program Budget $				349,449
	Per Participant Avg Energy Savings (kWh)*				27.8
	Per Participant Avg Demand Savings (kW)*				0.003
	Weighted Avg Measure Life*				15
	Net To Gross Ratio				100%

Eligible Customers

Any participant visiting a food pantry in Vectren South's electric territory.

Marketing Plan

The program will be marketed directly to food banks in the Vectren South electric service territory as well as other channels identified by the implementation contractor.

Barriers/Theory

Lower-income homeowners do not have the money to make even simple improvements to lower their energy usage and often live in homes with the most need for EE improvements. They may also lack the knowledge, experience, or capability to do the work. This program also addresses the barrier of education and awareness of EE opportunities. Working through food banks, participants receive LED bulbs and are educated about opportunities to save energy.

Initial Measures, Products and Services

Each participating food pantry will place a bundle of four (4) LED bulbs in food packages.

Program Delivery

Vectren South will oversee the program and will partner with CLEAResult and the Tri-State Area Food Bank to deliver the program.

Evaluation, Measurement and Verification

A third party evaluator will evaluate the program using standard EM&V protocols. A postcard will be provided to each participant to help acquire necessary information for EM&V. The postcard will be a postage paid reply card and ‘drop box’ will also be provided for customers to voluntarily supply their information for verification.

G. Energy Efficient Schools

Program Description

The Energy Efficient Schools Program is designed to impact students by teaching them how to conserve energy and to produce cost effective electric savings by influencing students and their families to focus on the efficient use of electricity.

The program consists of a school education program for 5th grade students attending schools served by Vectren South. To help in this effort, each child that participates will receive a take-home energy kit with various energy saving measures for their parents to install in the home. The kits, along with the in-school teaching materials, are designed to make a lasting impression on the students and help them learn ways to conserve energy.

Table 17: Energy Efficient Schools Budget & Energy Savings Targets

Market	Program	2018	2019	2020	Total Program
Residential	**Energy Efficient Schools**				
	Number of Kits	2,400	2,500	2,600	7,500
	Energy Savings kWh	899,706	937,194	645,216	2,482,115
	Peak Demand kW	52.8	52.8	52.8	158.4
	Total Program Budget $	131,696	136,805	119,995	388,496
	Per Participant Avg Energy Savings (kWh)*				330.9
	Per Participant Avg Demand Savings (kW)*				0.021
	Weighted Avg Measure Life*				10
	Net To Gross Ratio				100%

Eligible Customers

The program will be available to selected 5th grade students/schools in the Vectren South electric service territory.

Marketing Plan

The program will be marketed directly to elementary schools in Vectren South electric service territory as well as other channels identified by the implementation contractor. A list of the eligible schools will be provided by Vectren South to the implementation contractor for direct marketing to the schools via email, phone, and mail (if necessary) to obtain desired participation levels in the program.

Barriers/Theory

This program addresses the barrier of education and awareness of EE opportunities. Working through schools, both students and families are educated about opportunities to save. As well, the families receive energy savings devices they can install to begin their savings.

Initial Measures, Products and Services

The kits for students will include:

- Low flow showerhead
- Low flow kitchen aerator
- Low flow bathroom aerator (2)
- LED bulbs (2)
- LED nightlight
- Filter whistle

Program Delivery

Vectren South will oversee the program and will partner with National Energy Foundation (NEF) to deliver the program.

Integration with Vectren South Gas

Vectren South will offer this integrated natural gas/electric EE program in its combined natural gas and electric service territory. Vectren South has allocated implementation costs based on the net benefits split between natural gas and electric.

Evaluation, Measurement and Verification

Classroom participation will be tracked. A third party evaluator will evaluate the program using standard EM&V protocols.

H. Residential Behavior Savings

Program Description

The Residential Behavioral Savings Program motivates behavior change and provides relevant, targeted information to the consumer through regularly scheduled direct contact via mailed and emailed home energy reports. The report and web portal include a comparison against a group of similarly sized and equipped homes in the area, usage history comparisons, goal setting tools, and progress trackers. The Home Energy Report program anonymously compares customers' energy use with that of other customers with similar home size and demographics. Customers can view the past 12 months of their energy usage and compare and contrast their energy consumption and costs with others in the same neighborhood. Once a consumer understands better how they use energy, they can then start conserving energy.

Program data and design was provided by OPower, the implementation vendor for the program. OPower provides energy usage insight that drives customers to take action by selecting the most relevant information for each particular household, which ensures maximum relevancy and high response rate to recommendations.

Table 18: Residential Behavior Savings Program Budget & Energy Savings Targets

Market	Program	2018	2019	2020	Total Program
Residential	**Residential Behavioral Savings**				
	Number of Participants	41,348	38,203	35,298	114,849
	Energy Savings kWh	6,470,000	5,970,000	5,600,000	18,040,000
	Peak Demand kW	1,351	1,248	1,153	3,752
	Total Program Budget $	305,622	285,585	286,545	877,752
	Per Participant Avg Energy Savings (kWh)*				157.1
	Per Participant Avg Demand Savings (kW)*				0.033
	Weighted Avg Measure Life*				1
	Net To Gross Ratio				100%

Eligible Customers

Residential customers who receive electric service from Vectren South are eligible to participate in this integrated natural gas and electric EE program.

Barriers/Theory

The Residential Behavioral Savings program provides residential customers with better energy information through personalized reports delivered by mail, email and an integrated web portal to help them put their energy usage in context and make better energy usage decisions. Behavioral science research has demonstrated that peer-based comparisons are highly motivating ways to present information. The program will leverage a dynamically created comparison group for each residence and compare it to other similarly sized and located households.

Implementation & Delivery Strategy

The program will be delivered by OPower and include energy reports and a web portal. Customers typically receive between 4 to 6 reports annually and monthly emailed reports. These reports provide updates on energy consumption patterns compared to similar homes and provide energy savings strategies to reduce energy use. They also promote other Vectren South programs to interested customers. The web portal is an interactive system for customers to perform a self-audit, monitor energy usage over time, access energy savings tips and be connected to other Vectren South gas and electric programs.

Program Delivery

Vectren South will oversee the program and partner with OPower to deliver the program.

Integration with Vectren South Gas

Vectren South will offer this integrated natural gas/electric EE program in its combined natural gas and electric service territory. Vectren South has allocated implementation costs based on the net benefits split between natural gas and electric.

Evaluation, Measurement and Verification

A third party evaluator will complete the evaluation of this program and work with Vectren South to select the participant and non-participant groups.

I. Appliance Recycling

Program Description

The Residential Appliance Recycling program encourages customers to recycle their old inefficient refrigerators and freezers in an environmentally safe manner. The program recycles operable refrigerators and freezers so the appliance no longer uses electricity, and keeps 95% of the appliance out of landfills. An older refrigerator can use up to three times the amount of energy as new efficient refrigerators. An incentive of $50 will be provided to the customer for each operational unit picked up.

Table 19: Appliance Recycling Budget & Energy Savings Targets

Market	Program	2018	2019	2020	Total Program
Residential	**Appliance Recycling**				
	Number of Measures	950	930	920	2,800
	Energy Savings kWh	913,771	894,534	884,915	2,693,219
	Peak Demand kW	120.7	118.1	116.8	355.6
	Total Program Budget $	174,759	180,648	186,532	541,939
	Per Participant Avg Energy Savings (kWh)*				961.9
	Per Participant Avg Demand Savings (kW)*				0.127
	Weighted Avg Measure Life*				8
	Net To Gross Ratio				54%

Eligible Customers

Any residential customer with an operable secondary refrigerator or freezer receiving electric service from Vectren South.

Marketing Plan

The program will be marketed through a variety of mediums, including the use of utility bill inserts and customer emails, press releases, retail campaigns coordinated with appliance sales outlets as well as the potential for direct mail, web and social and mass media promotional campaigns.

Barriers/Theory

Many homes have second refrigerators and freezers that are very inefficient. Customers are not aware of the high energy consumption of these units. Customers also often have no way to move and dispose of the units, so they are kept in homes past their usefulness. This program educates customers about the waste of these units and provides a simple way for customers to dispose of the units.

Program Delivery

Vectren South will work directly with Appliance Recycling Centers of America Inc. (ARCA), to implement this program.

Evaluation, Measurement and Verification

Recycled units will be logged and tracked to assure proper handling and disposal. The utility will monitor the activity for disposal. Customer satisfaction surveys will also be used to understand the customer experience with the program. A third party evaluator will evaluate the program using standard EM&V protocols.

J. Smart Thermostat Program

Program Description

In 2016, Vectren South conducted a field study designed, in part, to analyze the different approaches to DR that are available through smart thermostats. Between the months of April and May, Vectren South installed approximately 2,000 smart thermostats (1,000 Honeywell and 1,000 Nest) in customer homes. Vectren South leveraged these thermostats to manage DR events during the summer in an effort to evaluate the reduction in peak system loads. These smart devices are connected to Wi-Fi and reside on the customer's side of the electric meter and are used to communicate with customer's air conditioning systems. The program provides Vectren South with increased customer contact opportunities and the ability to facilitate customers' shift of their energy usage to reduce peak system loads. Vectren South will not install additional thermostats pursuant to this program; however, incentives will continue to be paid to participating customers.

Table 20: Smart Thermostat Program Budget & Energy Savings Targets

Market	Program	2018	2019	2020	Total Program
Residential	**Smart Thermostat Program**				
	Number of Measures	0	0	0	0
	Energy Savings kWh				
	Peak Demand kW	0	0	0	0
	Total Program Budget $	97,639	98,222	98,798	294,659
	Per Participant Avg Energy Savings (kWh)*				0.0
	Per Participant Avg Demand Savings (kW)*				0.000
	Weighted Avg Measure Life*				15
	Net To Gross Ratio				100%

*No additional kWh or demand savings will be recorded.

Incentive Strategy

The program budget is for incentives for existing customers to participate in the Demand Response events for 2018-2020.

Program Delivery

Vectren South will oversee the program.

Evaluation, Measurement and Verification

A third party evaluator will evaluate the program using standard EM&V protocols.

K. Smart DLC – Wi-Fi/DLC Switchout Program

Program Description

Since 1992, Vectren South has operated a Direct Load Control (DLC) program called Summer Cycler that reduces residential and small commercial air-conditioning and water heating electricity loads during summer peak hours. While this technology still helps lower peak load demand for electricity, this aging technology will be phased out over time. Vectren's Summer Cycler program has served Vectren and its customers well for more than two decades, but emerging technology is now making the program obsolete.

By installing connected devices in customer homes rather than using one-way signal switches, Vectren will be able to provide its customer base deeper energy savings opportunities and shift future energy focus to customer engagement rather than traditional program goals and rules. The most recent Vectren electric DSM evaluation has demonstrated that smart thermostats outperform standard programmable thermostats and are a practical option to transition into future customer engagement strategies.

Smart thermostat installations are also a feasible solution to multiple utility and customer quandaries. Past Vectren evaluations have discovered that its customers program less than half of all programmable thermostats installed, hindering potential savings and acting a disincentive for customers to become involved in how their home uses energy. This issue is coupled with the uncertainty of whether standard DLC switches in the field are in working order and the fact that the switches cannot record or yield any savings data. With these issues mitigated, utility management burden is reduced, customer engagement and satisfaction is increased, and Vectren will be able to obtain better home usage data for creation and implementation of future DSM programs.

If approved by the Commission, Vectren South anticipates replacing DLC switches with smart thermostats over time, as the benefits associated with this emerging technology far outweigh the benefits associated with DLC switches. In 2018, Vectren South will begin its phase out of the Summer Cycler program by removing approximately 1,000 Sumer Cycler devices and replacing them with Wi-Fi thermostats that utilize demand response technology. Customers will receive a professionally installed Wi-Fi thermostat at no additional cost and a monthly bill credit of $5 during the months of June to September. The current monthly credit for Summer Cycler is also $5; therefore the annual bill credit by customer does not change.

By replacing the Summer Cycler devices, Vectren South will eliminate the annual inspection and maintenance ("I&M costs") for the Summer Cycler program, and thus offer a more reliable DR program. Long-term, Vectren South will almost eliminate the annual ongoing inspection and maintenance cost. By replacing 1,000 switches each year, Vectren continues to have resources to manage peak demand for electricity during the summer months.

Table 22: SmartDLC – Wi-Fi/DLC Switchout Program& Energy Savings Targets

Market	Program	2018	2019	2020	Total Program
Residential	**SmartDLC - Wifi DR/DLC Changeout**				
	Number of Participants	1,000	1,000	1,000	3,000
	Energy Savings kWh	466,690	466,690	466,690	1,400,070
	Peak Demand kW	600.0	600.0	600.0	1,800.0
	Total Program Budget $	517,759	562,148	606,532	1,686,439
	Per Participant Avg Energy Savings (kWh)*				466.7
	Per Participant Avg Demand Savings (kW)*				0.600
	Weighted Avg Measure Life*				15
	Net To Gross Ratio				100%

Eligible Customers

Customers in the Vectren South territory who currently participate in the DLC Summer Cycler program and have access to Wi-Fi.

Marketing Plan

Proposed marketing efforts include utilizing direct mailers, email blasts, Vectren South online audit tools, bill inserts as well as other outreach and education efforts and promotional campaigns throughout the year to ensure participation levels are maintained.

Incentive Strategy

Customers will receive a professionally installed Wi-Fi thermostat at no additional cost and a monthly bill credit of $5 during the months of June to September.

Program Delivery

Vectren South will oversee the program.

Evaluation, Measurement and Verification

A third party evaluator will evaluate the program using standard EM&V protocols.

L. Bring Your Own Thermostat (BYOT)

Program Description

The Bring Your Own Thermostat ("BYOT") program is a further expansion of the residential smart thermostat initiative. BYOT allows customers to purchase their own device from multiple vendors and participate in DR with Vectren South and other load curtailing programs managed through the utility. Taking advantage of two-way communicating smart thermostats, the BYOT program can help reduce acquisition costs for load curtailment programs and improve customer satisfaction.

Table 23: BYOT Program Budget & Energy Savings Targets

Market	Program	2018	2019	2020	Total Program
Residential	**BYOT (Bring Your Own Thermostat)**				
	Number of Participants	400	400	400	1,200
	Energy Savings kWh				
	Peak Demand kW	240.0	240.0	240.0	720.0
	Total Program Budget $	111,036	178,592	146,128	435,756
	Per Participant Avg Energy Savings (kWh)*				0.0
	Per Participant Avg Demand Savings (kW)*				0.600
	Weighted Avg Measure Life*				15
	Net To Gross Ratio				100%

Eligible Customers

Residential single or multi-family customers in the Vectren South territory with access to Wi-Fi and who own a qualifying compatible Wi-Fi thermostat that operates the central air-conditioning cooling system.

Marketing Plan

Proposed marketing efforts include utilizing direct mailers, email blasts, Vectren South online audit tools, bill inserts as well as other outreach and education efforts and promotional campaigns throughout the year to ensure participation levels are maintained.

Incentive Strategy

Customers will receive a one-time enrollment incentive of $75 and a bill credit of $5 during the months of June to September. The enrollment incentive will be provided in the first year to new enrollees only.

Program Delivery

Vectren South will oversee the program.

Evaluation, Measurement and Verification

A third party evaluator will evaluate the program using standard EM&V protocols.

M. Conservation Voltage Reduction - Residential and Commercial and Industrial

Program Description

Conservation Voltage Reduction (CVR) is a technology that reduces energy usage and peak demand through automated monitoring and control of voltage levels provided on distribution circuits. End use customers realize lower energy and demand consumption when CVR is applied to the distribution circuit from which they are served.

A distribution circuit facilitates electric power transfer from an electric substation to utility meters located at electric customer premises. Electric power customers employ end-use electric devices (loads) that consume electrical power. At any point along a single distribution circuit, voltage levels vary based upon several parameters, mainly including, but not exclusive of, the actual electrical conductors that comprise the distribution circuit, the size and location of electric loads along the circuit, the type of end-use loads being served, the distance of loads from the power source, and losses incurred inherent to the distribution circuit itself. All end-use loads require certain voltage levels to operate and standards exist to regulate the levels of voltage delivered by utilities. In Indiana, Vectren South is required to maintain a steady state +/- 5% of the respective baseline level as specified by ANSI C84.1 (120 volt baseline yields acceptable voltage range of 114 volts to 126 volts).

Historically, utilities including Vectren South have set voltage levels near the upper limit at the distribution circuit source (substation) and have applied voltage support devices such as voltage regulators and capacitors along the circuit to assure that all customers are provided voltages within the required range. This basic design economically met the requirements by utilizing the full range (+/- 5%) of allowable voltages while only applying independent voltage support where needed. This basic design has worked well for many years. However, in the 1980's, utilities recognized that loads on the circuits would actually consume less energy if voltages in the lower portion of the acceptable range were provided. In fact, many utilities, including Vectren South, established emergency operating procedures to lower voltage at distribution substations by 5% during power shortage conditions.

The recent focus on EE and the availability of technology that allows monitoring and tighter control of circuit voltage conditions has led to development of automated voltage control schemes which coordinate the operation of voltage support devices and allow more customers on the circuit to be served at voltages in the lower portion of the acceptable range.

Once applied, a step change in energy and demand consumption by customers is realized, dependent upon where customer loads are located within the voltage zones, the load characteristics of the circuit, and how end-use loads respond to the voltage reduction. The resultant energy and demand consumption reduction persist at the new levels as long as tighter voltage bandwidth operation is applied. As a result, ongoing energy and demand savings persists for the duration of the life of the CVR equipment and as long as the equipment is maintained and operated in the voltage bandwidth mode.

With Commission approval, Vectren South will capitalize the costs to implement the CVR program and seek to recover through the annual Demand Side Management Adjustment (DSMA) mechanism the carrying costs and depreciation expense associated with the implementation along with annual, ongoing Operation and Maintenance (O&M) expense, a representative share of Vectren South's DSM support staff and administration costs and related EM&V cost. The budget below is reflective of this request.

Table 21: Conservation Voltage Reduction Energy Savings Targets

Market	Program	2018	2019	2020	Total Program
Residential	**CVR Residential**				
	Number of Participants			5,324	5,324
	Energy Savings kWh			1,461,047	1,461,047
	Peak Demand kW			263	263
	Total Program Budget $	118,786	114,907	230,134	463,827
	Per Participant Avg Energy Savings (kWh)*				274.4
	Per Participant Avg Demand Savings (kW)*				0.049
	Weighted Avg Measure Life*				15
	Net To Gross Ratio				100%

Market	Program	2018	2019	2020	Total Program
Commercial & Industrial	**CVR Commercial**				
	Number of Participants			558	558
	Energy Savings kWh			1,032,655	1,032,655
	Peak Demand kW			185.9	185.9
	Total Program Budget $	108,834	105,297	137,003	351,134
	Per Participant Avg Energy Savings (kWh)*				1850.6
	Per Participant Avg Demand Savings (kW)*				0.333
	Weighted Avg Measure Life*				15
	Net To Gross Ratio				100%

Program Delivery

Vectren South will oversee the program and will partner with an implementer to deliver the program. One unit installation will be completed in 2017, and as an expansion of this program, one additional unit will be installed in 2020.

Eligible Customers

Vectren South has identified substations that will benefit from the CVR program. For this program, one substation will be installed in 2020.

Barriers/Theory

CVR is both a DR and an EE program. First, it seeks to cost effectively deploy new technology to targeted distribution circuits, in part to reduce the peak demand experienced on Vectren South's electrical power supply system. The voltage reduction stemming from the CVR program operates to effectively reduce consumption during the times in which system peaks are set and as a result directly reduces peak demand. CVR also cost effectively reduces the level of ongoing energy consumption by end-use devices located on the customer side of the utility meter as many end-use devices consume less energy with lower voltages consistently applied. Like an equipment maintenance service program, the voltage optimization allows the customer’s equipment to operate at optimum levels which saves energy without requiring direct customer intervention or change.

Initial Measures, Products and Services

Vectren South will install the required communication and control equipment on the appropriate circuits from the substation. No action is required of the customers.

N. Commercial and Industrial Prescriptive

Program Description

The Commercial & Industrial (C&I) Prescriptive Program is designed to provide financial incentives on qualifying products to produce greater energy savings in the C&I market. The rebates are designed to promote lower electric energy consumption, assist customers in managing their energy costs, and build a sustainable market around EE.

Program participation is achieved by offering incentives structured to cover a portion of the customer's incremental cost of installing prescriptive efficiency measures.

Table 24: Commercial & Industrial Prescriptive Budget & Energy Savings Targets

Market	Program	2018	2019	2020	Total Program
Commercial & Industrial	**Commercial Prescriptive**				
	Number of Measures	7,024	5,981	6,856	19,861
	Energy Savings kWh	4,999,125	4,501,186	5,002,621	14,502,932
	Peak Demand kW	378.2	325.4	369.0	1,072.6
	Total Program Budget $	729,398	655,370	731,330	2,116,098
	Per Participant Avg Energy Savings (kWh)*				730.2
	Per Participant Avg Demand Savings (kW)*				0.054
	Weighted Avg Measure Life*				14
	Net To Gross Ratio				87%

Eligible Customers

Any eligible participating commercial or industrial customer receiving Vectren South electric service.

Marketing Plan

Proposed marketing efforts include trade ally outreach, trade ally meetings, direct mail, face-to-face meetings with customers, marketing campaigns and bonuses, web-based marketing, and coordination with key account executives.

Barriers/Theory

Customers often have the barrier of higher first cost for EE measures, which precludes them from purchasing the more expensive EE alternative. They also lack information on high-efficiency alternatives. Trade allies often run into the barrier of not being able to promote more EE alternatives because of first cost or lack of knowledge. Trade allies also gain credibility with customers for their EE claims when a measure is included in a utility prescriptive program. Through the program the Trade allies can promote EE measures directly to their customers encouraging them to purchase more efficient equipment while helping customers get over the initial cost barrier.

Initial Measures, Products and Services

Measures will include high efficient lighting and lighting controls, HVAC equipment including variable frequency drives, commercial kitchen equipment including electronically commutated motors (ECMs), and miscellaneous items including compressed air equipment.

Note that measures included in the program will change over time as baselines change, new technologies become available and customer needs are identified. Detailed measure listings, participation and incentives are in Appendix B.

Implementation & Delivery Strategy

The program will be delivered primarily through the trade allies working with their customers. Vectren South and its implementation partners will work with the trade allies to make them aware of the offerings and help them promote the program to their customers. The implementation partner will provide training and technical support to the trade allies to become familiar with the EE technologies offered through the program. The program will be managed by the same implementation provider as the Commercial & Industrial Custom program so that customers can seamlessly receive assistance and all incentives can be efficiently processed through a single procedure.

Incentive Strategy

Incentives are provided to customers to reduce the difference in first cost between the lower efficient technology and the high efficient option. There is no fixed incentive percentage amount based on the difference in price because some technologies are newer and need higher amounts. Others have been available in the marketplace longer and do not need as much to motivate customers. Incentives will be adjusted to respond to market activity and bonuses may be available for limited time, if required, to meet goals.

Program Delivery

Vectren South will oversee the program partner Nexant to deliver the program.

Evaluation, Measurement and Verification

Site visits will be made on 5% of the installations, as well as all projects receiving incentive greater than $20,000, to verify the correct equipment was installed. Standard EM&V protocols will be used for the third party evaluation of the program.

O. Commercial and Industrial Custom

Program Description

The Commercial & Industrial (C&I) Custom Program promotes the implementation of customized energy saving measures at qualifying customer facilities. Incentives promoted through this program serve to reduce the cost of implementing energy saving projects and upgrading to high-efficiency equipment. Due to the nature of a custom EE program, a wide variety of projects are eligible.

Table 25: Commercial & Industrial Custom Budget & Energy Savings Targets

Market	Program	2018	2019	2020	Total Program
Commercial & Industrial	**Commercial Custom**				
	Number of Measures	50	50	55	155
	Energy Savings kWh	5,000,000	5,000,000	5,500,000	15,500,000
	Peak Demand kW	476.0	476.0	524.0	1,476.0
	Total Program Budget $	1,019,072	1,022,184	1,160,256	3,201,512
	Per Participant Avg Energy Savings (kWh)*				100000.0
	Per Participant Avg Demand Savings (kW)*				9.523
	Weighted Avg Measure Life*				15
	Net To Gross Ratio				100%

Eligible Customers

Any participating commercial or industrial customer receiving electric service from Vectren South.

Marketing Plan

Proposed marketing efforts include coordination with key account representatives to leverage the contacts and relationships they have with the customers. Direct mail, media outreach, trade shows, marketing campaigns and bonuses, trade ally meetings, and educational seminars could also be used to promote the program.

Barriers/Theory

Applications of some specific EE technologies are unique to that customer’s application or process. The energy savings estimates for these measures are highly variable and cannot be assessed without an engineering estimation of that application; however, they offer a large opportunity for energy savings. To promote the installation of these high efficient technologies or measures, the Commercial & Industrial Custom program will provide incentives based on the kWh saved as calculated by the engineering analysis. To assure savings, these projects will require program engineering reviews and pre approvals. The custom energy assessments offered will help remove customer barriers regarding opportunity identification and determining energy savings potential.

Initial Measures, Products and Services

All technologies or measures that save kWh qualify for the program. Facility energy assessments will be offered to customers who are eligible and encouraged to implement multiple EE measures. Detailed measure listings, participation and incentives are in Appendix B.

Implementation & Delivery Strategy

The implementation partner will work collaboratively with Vectren South staff to recruit and screen customers for receiving facility energy assessments. The implementation partner will also provide engineering field support to customers and trade allies to calculate the energy savings. Customers or trade allies with a proposed project will complete an application form with the energy savings calculations for the project. The implementation team will review all calculations and where appropriate complete site visits to assess and document pre-installation conditions. Customers will be informed and funds will be reserved for the project. Implementation engineering staff will review the final project information as installed and verify the energy savings. Incentives are then paid on the verified savings.

The implementation partner will work collaboratively with Vectren South staff to recruit and screen customers for receiving facility energy assessments, technical assistance and energy management education. The program will seek to gain customer commitment towards setting up an energy management process and implementing multiple EE improvements. The implementation partner will help customers achieve agreed upon milestones in support for their commitment.

Incentive Strategy

Incentives will be calculated on a per kWh basis. The initial kWh rate will be $0.12/kWh and is paid based on the first year annual savings reduction. Rates may change over time and vary with some of the special initiatives. Incentives will not pay more than 50% of the project cost nor provide incentives for projects with paybacks less than 12 months. Vectren South will offer a cost share on facility energy assessments that will cover up to 100% of the assessment cost.

Program Delivery

Vectren South will oversee the program partner Nexant to deliver the program.

Evaluation, Measurement and Verification

Given the variability and uniqueness of each project, all projects will be pre-approved. Pre and post visits to the site to verify installation and savings will be performed as defined by the program implementation partner. Monitoring and verification may occur on the largest projects. A third party evaluator will be used for this project and use standard EM&V protocols.

P. Small Business Direct Install

Program Description

The Small Business Direct Install Program provides value by directly installing EE products such as high efficiency lighting, pre-rinse sprayers, refrigeration controls, electrically-commutated motors, smart thermostats and vending machine controls. The program helps businesses identify and install cost effective energy saving measures by providing an on-site energy assessment customized for their business.

Table 26: Small Business Direct Install Budget & Energy Savings Targets

Market	Program	2018	2019	2020	Total Program
Commercial & Industrial	**Small Business Direct Install**				
	Number of Projects	146	142	127	415
	Energy Savings kWh	4,032,934	3,905,372	3,900,306	11,838,612
	Peak Demand kW	667.0	645.0	567.0	1,879.0
	Total Program Budget $	1,149,640	1,182,037	1,173,133	3,504,810
	Per Participant Avg Energy Savings (kWh)*				28526.8
	Per Participant Avg Demand Savings (kW)*				4.528
	Weighted Avg Measure Life*				15
	Net To Gross Ratio				95%

Eligible Customers

Any participating Vectren South business customer with a maximum peak energy demand of less than 400 kW.

Marketing Plan

The Small Business Direct Install Program will be marketed primarily through in-network trade ally outreach. The program implementer will provide trade ally-specific marketing collateral to support trade allies as they connect with customers.

The program will provide targeted marketing efforts as needed to individual customer segments (e.g., hospitality, grocery stores, and retail) to increase participation in under-performing segments, including direct customer outreach and enhanced incentive campaigns. Additional program marketing may occur through direct mail, trade associations, local business organizations, marketing campaigns and bonuses, educational seminars, and direct personal communication from Vectren South staff and third-party contractors.

Barriers/Theory

Small business customers generally do not have the knowledge, time or money to invest in EE upgrades. This program assists these small businesses with direct installation and turn-key services to get measures installed at no or low out-of-pocket cost.

There is an implementation contractor in place providing suggested additions and changes to the program based on results and local economics.

Implementation & Delivery Strategy

Trade Ally Network: Trained trade ally energy advisors will provide energy assessments to business customers with less than 400 kW of annual peak demand. The program implementer will issue an annual Request for Qualification (RFQ) to select the trade allies with the best ability to provide high-quality and cost-effective service to small businesses, and provide training to Small Business Energy Solutions trade allies on the program process, with an emphasis on improving energy efficiency sales.

Energy Assessment: Trade allies will walk through small businesses and record site characteristics and energy efficiency opportunities at no cost to the customer. They will provide an energy assessment report that will detail customer-specific opportunities, costs, energy savings, incentives, and simple payback periods. The trade ally will then review the report with the customer, presenting the program benefits and process, while addressing any questions.

Initial Measures, Products and Services

Details of the measures, savings, and incentives can be found in Appendix B. The program will have two types of measures provided. The first are measures that will be installed at no cost to the customer. Some available measures will include, but are not limited to the following:

- LEDs: 8-12W
- LEDs: MR16 track light
- LEDs: > 12 W flood light
- Wifi-enabled thermostats
- Programmable thermostats
- Pre-rinse sprayers
- Faucet aerators

The second types of measures require the customer to pay a portion of the labor and materials. Some available measures will include, but are not limited to the following:

- Interior LED lighting (replacing incandescent, high bays and linear fluorescents)
- High-efficiency linear fluorescent lighting
- Linear fluorescent delamping
- LED exit signs
- Exterior LED lighting
- ECMs in refrigeration equipment

- Anti-sweat heater controls
- LED lighting for display cases

Incentive Strategy

In addition to the no-cost measures identified during the audit, the program will also pay a cash incentive on every recommended improvement identified through the assessment. Incentive rates may change over time and vary with special initiatives.

Program Delivery

Vectren South will oversee the program partner Nexant to deliver the program.

Integration with Vectren South Gas

Vectren South will offer this integrated natural gas and electric EE program in its combined natural gas and electric service territory.

Evaluation, Measurement and Verification

On-site verification will be provided for the first three projects completed by each trade ally, in addition to the program standard 5% of all completed projects and all projects receiving incentives greater than $20,000. These verifications allow the program to validate energy savings, in addition to providing an opportunity to ensure the trade allies are providing high-quality customer services and the incentivized equipment satisfies program requirements. A third party evaluator will evaluate the program using standard EM&V protocols.

Q. Commercial & Industrial New Construction

Program Description

The Commercial and Industrial New Construction Program provides value by promoting EE designs with the goal of developing projects that are more energy efficient than current Indiana building code. This program applies to new construction and major renovation projects. Major renovation is defined as the replacement of at least two systems within an existing space (e.g. lighting, HVAC, controls, building envelope). The program provides incentives as part of the facility design process to explore opportunities in modeling EE options to craft an optimal package of investments. The program also offers customers the opportunity to receive prescriptive or custom rebates toward eligible equipment in order to reduce the higher capital cost for the EE solutions.

Table 27: Commercial & Industrial New Construction Budget & Energy Savings Targets

Market	Program	2018	2019	2020	Total Program
Commercial & Industrial	**Commercial New Construction**				
	Number of Projects	18	20	18	56
	Energy Savings kWh	502,080	1,835,413	502,080	2,839,573
	Peak Demand kW	108.0	120.0	108.0	336.0
	Total Program Budget $	214,536	386,092	222,628	823,256
	Per Participant Avg Energy Savings (kWh)*				50706.7
	Per Participant Avg Demand Savings (kW)*				6.000
	Weighted Avg Measure Life*				10
	Net To Gross Ratio				100%

Eligible Customers

Any commercial or industrial customer who receives or intends to receive electric service from Vectren South.

Marketing Plan

The Commercial & Industrial New Construction Program will be marketed through trade ally meetings, trade association training, marketing campaigns and bonuses, educational seminars, and direct personal communication from Vectren South staff and third party contractors.

Barriers/Theory

There are three primary barriers addressed by the C&I New Construction program. The first is knowledge. For commercial and industrial buildings it is the knowledge and experience of the design team including the owner, architect, lighting and HVAC engineers, general contractor and others. This team may not understand new technologies and EE options that could be considered. The second barrier is cost. There is a cost during the design phase of the project in modeling EE options to see what can cost-effectively work within the building. The program provides design team incentives to help reduce the design cost for the consideration of EE upgrades. The third barrier is the first cost of the high efficiency upgrades in equipment and materials. The program provides prescriptive or custom rebates toward eligible equipment to help reduce this first cost.

Implementation & Delivery Strategy

The new construction program is designed as a proactive, cost-effective way to achieve energy efficiency savings and foster economic growth. Typically, program participants face time and cost constraints throughout the project that make it difficult to invest in sustainable building practices. Participants need streamlined and informed solutions that are specific to their projects and locations. This scenario is particularly true for small to medium-sized new construction projects, where design fees and schedules provide for a very limited window of opportunity.

To help overcome the financial challenge for small-medium size projects, we offer a Standard Energy Design Assistance (EDA). EDA targets buildings that are less than 100,000 square feet, but is also available for larger new buildings that are beyond the schematic design phase or are on an accelerated schedule. Commercial and industrial projects for buildings greater than 100,000 square feet still in the conceptual design phase qualify for Vectren South's Enhanced EDA incentives. The Vectren South implementation partner staff expert will work with the design team through the conceptual design, schematic design and design development processes providing advice and counsel on measures that should be considered and EE modeling issues. Incentives will be paid after the design team submits completed construction documents for review to verify that the facility design reflects the minimum energy savings requirements.

For those projects that are past the phase where EDA can be of benefit, the C&I New Construction program offers the opportunity to receive prescriptive or custom rebates towards eligible equipment.

Incentive Strategy

Incentives are provided to help offset some of the expenses for the design team's participation in the EDA process with the design team incentive. The design team incentive is a fixed amount based on the new/renovated conditioned square footage and is paid when the proposed EE projects associated with the construction documents exceed a minimum energy savings threshold. The program also offers customers the opportunity to receive prescriptive or custom rebates toward eligible equipment in order to reduce the higher capital cost for the EE solutions. Program specific savings and incentive include:

Facility Size – Square Feet	Design Team Incentives	Minimum Savings
Small <25,000	$750	25,000 kWh
Medium 25,000 - 100,000	$2,250	75,000 kWh
Large >100,000	$3,750	150,000 kWh
Enhance Large >100,000	$5,000	10% beyond code

Program Delivery

Vectren South will oversee the program and partner with Nexant to deliver the program.

Integration with Vectren South Gas

Vectren South will offer this integrated natural gas and electric EE program in its combined natural gas and electric service territory. Vectren South has allocated implementation costs based on the net benefits split between natural gas and electric.

Evaluation, Measurement and Verification

All construction documents will be reviewed and archived. A third party evaluator will evaluate the program using standard EM&V protocols.

R. Commercial Building Tune-Up

Program Description

The Building Tune-Up (BTU) program provides a targeted, turnkey, and cost-effective retrocommissioning solution for small- to mid-sized customer facilities.

It is designed as a comprehensive customer solution that will identify, validate, quantify, and encourage the installation of both operational and capital measures. The majority of these measures will be no- or low-cost with low payback periods and will capture energy savings from a previously untapped source: building automation systems.

Table 28: Building Tune-Up Budget & Energy Savings Targets

Market	Program	2018	2019	2020	Total Program
Commercial & Industrial	**Building Tune-up**				
	Number of Projects	10	14	20	44
	Energy Savings kWh	500,000	700,000	1,000,000	2,200,000
	Peak Demand kW	1.0	1.0	1.0	3.0
	Total Program Budget $	130,880	182,074	261,266	574,220
	Per Participant Avg Energy Savings (kWh)*				50000.0
	Per Participant Avg Demand Savings (kW)*				0.068
	Weighted Avg Measure Life*				7
	Net To Gross Ratio				100%

Eligible Customers

Applicants must be both an active Vectren South electric customer on a qualifying commercial rate and an active natural gas General Service customer on Rate 120 or 125. The program will target customers with buildings between 50,000 square feet and 150,000 square feet.

Marketing Plan

The BTU Program will be marketed primarily through in-network service provider outreach and direct personal communication from Vectren South staff and third-party contractors. The program implementer will provide service provider specific-marketing collateral to support these companies as they connect with customers.

The program will provide targeted marketing efforts to recruit quality participants. Additional program marketing may occur through direct mailing, trade associations, marketing campaigns and bonuses, local business organizations, and educational seminars.

Barriers/Theory

The program will typically target customers with buildings between 50,000 square feet and 150,000 square feet. Customers in this size range face unique barriers to energy efficiency. For example, although they are large enough to have a Building Automation System (BAS), they are usually too small to have a dedicated facility manager or staff with experience achieving operational efficiency. Also, most retrocommissioning service companies prefer larger projects and their services often are too expensive for small-to-midsized customers. We have specifically tailored the incentive structure and program design to eliminate these barriers. The BTU program is designed as a comprehensive customer solution that will identify, validate, quantify, and encourage the installation of both operational and capital measures eligible for incentive offerings.

Implementation & Delivery Strategy

The BTU program is designed to encourage high levels of implementation by customers seeking to optimize the operation of their existing HVAC system. Key elements of the program approach are:

- Service Provider Network: Service providers play a key role in program marketing and outreach. Their existing relationships with building owners and knowledge of customer facilities give them an easy starting point to begin program marketing efforts. For this reason, recruiting quality providers, training them on program processes, and making the BTU program profitable for them are key strategies that drive program participation. The program implementer will issue an annual RFQ to select those service providers with the best ability to provide high-quality and cost-effective services.

- Fully Funded Service Offering: The BTU program fully funds the investigation of opportunities by the program implementer and service providers. The program also provides a cash incentive on implemented improvements.

- Customer Commitment: BTU program participants are required to commit to a spending minimum to implement a group, or "bundle," of agreed-upon energy saving measures. This bundle of measures will have a collective estimated simple payback of 1.5 years or less based upon energy savings identified, which ensures that it benefits customers as well as the program.

- Technical Services: The program will provide the following technical services to successfully implement each BTU project:

Application Phase: Each application will be screened to verify that the customer's facility has enough energy savings potential for the BTU study. After being accepted into the program, the customer will sign the Customer Agreement to spend the minimum amount of money on a bundle of measures with a simple payback of 1.5 years or less. This agreement ensures that both the customer and Vectren South will achieve energy savings from the project.

Investigation and Implementation Phase: During the investigation and implementation phase, the program implementer and the customers' preferred in-network service provider will perform a BTU study to identify and install measures for the customer. They will generate a study report to summarize findings from the investigation and present the results to the customer. The customer will select the bundle of measures to install that meet the program minimum and payback requirements, and work with their service provider to install the selected measures.

Verification Phase: The program implementer revisits the customer's facility as needed. If any of the measures were incorrectly installed, the service provider works with the customer to fix it. The implementer and service provider calculate the final estimated energy savings from the BTU project and share those results with both the customer and Vectren South, thus ensuring that the most accurate energy savings estimate is reported.

Initial Measures, Products and Services

The BTU program will specifically target measures that provide no- and low-cost operational savings. Customized measures will be identified for each building, these could include:

- Scheduling air handling units
- Optimizing economizer and outdoor air control
- Reducing/resetting duct static pressure
- Resetting chilled water temperature

Most measures involve optimizing the building automation system (BAS) settings but the program will also investigate related capital measures, like controls, operations, processes, and HVAC.

Incentive Strategy

The BTU program fully funds the investigation of opportunities by the program implementer and service provider. The program also provides a cash incentive on implemented improvements.

Program Delivery

Vectren South will oversee the program and partner with Nexant to deliver the program.

Integration with Vectren South Gas

Vectren South will offer this integrated natural gas and electric EE program in its combined natural gas and electric service territory. Vectren South has allocated implementation costs based on the net benefits split between natural gas and electric.

Evaluation, Measurement and Verification

A third party evaluator will evaluate the program using standard EM&V protocols.

S. Multi-Family Retrofit

Program Description

The Multi-Family Retrofit Program provides value by directly installing EE products such as high efficiency lighting, water-saving measures, thermostats, and vending machine controls into multi-family common areas. The program helps multi-family facilities identify and install cost-effective energy-saving measures by providing an on-site energy assessment customized for their business.

Table 29: Multi-Family Retrofit Budget & Energy Savings Targets

Market	Program	2018	2019	2020	Total Program
Commercial & Industrial	**Multi-Family Retrofit**				
	Number of Projects	4	4	4	12
	Energy Savings kWh	101,590	101,590	115,853	319,033
	Peak Demand kW	18.0	18.0	18.0	54.0
	Total Program Budget $	34,880	35,074	35,266	105,220
	Per Participant Avg Energy Savings (kWh)*				26586.1
	Per Participant Avg Demand Savings (kW)*				4.500
	Weighted Avg Measure Life*				15
	Net To Gross Ratio				100%

Eligible Customers

Applicants must be both an active Vectren South electric customer on a qualifying commercial rate and an active natural gas General Service customer on Rate 120 or 125.

Marketing Plan

The Multi-Family Retrofit Program will be marketed primarily through in-network trade ally outreach. The program implementer will provide trade ally-specific marketing collateral to support trade allies as they connect with customers.

The program will provide targeted marketing efforts as needed to increase participation, including direct customer outreach and enhanced incentive campaigns.

Additional program marketing may occur through direct mail, trade associations, local business organizations, marketing campaigns and bonuses, educational seminars, and direct personal communication from Vectren South staff and third-party contractors.

Barriers/Theory

Multi-family landlords generally do not have the knowledge, time or money to invest in EE upgrades. This program assists these customers with direct installation and turn-key services to get measures installed at no or low out-of-pocket cost.

There is an implementation contractor in place providing suggested additions and changes to the program based on results and local economics.

Implementation & Delivery Strategy

Trade Ally Network: Trained trade ally energy advisors will provide energy assessments to customers. The program implementer will issue an annual RFQ to select the trade allies with the best ability to provide high-quality and cost-effective service to customers, and provide training to trade allies on the program process, with an emphasis on improving energy efficiency sales.

Energy Assessments: Trade allies will walk through the multi-family common areas and record site characteristics and energy efficiency opportunities at no cost to the customer. They will provide an energy assessment report that will detail customer-specific opportunities, costs, energy savings, incentives, and simple payback periods. The trade ally will then review the report with the customer, presenting the program benefits and process, while addressing any questions.

Initial Measures, Products and Services

The program will have two types of measures provided. The first are measures that will be installed at no cost to the customer. They will include but are not limited to the following:

- LEDs: 8-12W
- LEDs: MR16 track light
- LEDs: > 12 W flood light
- Wi-fi enabled thermostats
- Programmable thermostats
- Pre-rinse sprayers
- Faucet aerators

The second types of measures require the customer to pay a portion of the labor and materials. These measures include:

- Interior LED lighting (replacing incandescent, high bays and linear fluorescents)
- High-efficiency linear fluorescent lighting
- Linear fluorescent delamping
- Electronically commutated motors (ECM)
- Anti-sweat heater controls
- LED exit signs
- Exterior LED lighting

Incentive Strategy

In addition to the no-cost measures identified during the audit, the program will also pay a cash incentive for all recommended improvements identified through the assessment.

Program Delivery

Vectren South will oversee the program and will partner with Nexant to deliver the program.

Integration with Vectren South Gas

Vectren South will offer this integrated natural gas and electric EE program in its combined natural gas and electric service territory. Vectren South has allocated implementation costs based on the net benefits split between natural gas and electric.

Evaluation, Measurement and Verification

On-site verification will be provided for the first three projects completed by each trade ally, in addition to the program standard 5% of all completed projects and all projects receiving incentives greater than $20,000. These verifications allow the program to validate energy savings, in addition to providing an opportunity to ensure the trade allies are providing high-quality customer services and the incentivized equipment satisfies program requirements. A third party evaluator will evaluate the program using standard EM&V protocols.

8. Program Administration

As in previous years, Vectren South will continue to serve as the program administrator for the 2018-2020 Plan. Vectren South will utilize third party program implementers to deliver specific programs or program components where specialty expertise is required. Contracting directly with specialty vendors avoids an unnecessary layer of management, oversight and expense that occurs when utilizing a third-party administration approach.

Program administration costs are allocated at the program level and include costs associated with program support and internal labor. Program support includes costs associated with outside consulting and annual license and maintenance fees for DSMore, Data Management, and Esource. Based upon the EE and DR programs proposed in the 2018 - 2020 Plan, Vectren South is proposing to maintain the staffing levels that were previously approved to support the portfolio. The major responsibilities associated with these FTEs are as follows:

- **Portfolio Management and Implementation -** Oversees the overall portfolio and staff necessary to support program administration. Serves as primary contact for regulatory and oversight of programs.
- **Reporting and Analysis -** Responsible for all aspects of program reporting including, budget analysis/reporting, scorecards and filings.
- **Outreach and Education -** Serves as contact to trade allies regarding program awareness. Also serves as point of contact for residential and commercial/industrial customers to assist with responding to program inquiries.
- **Research and Evaluation -** Works with the selected EM&V Administrator and facilitates measurement and verification efforts, assists with program reporting/tracking.

9. Support Services

Support services are considered indirect costs which support the entire portfolio and include: Contact Center, Online Audit, Outreach & Education, and Evaluation, Measurement and Verification (EM&V). These costs are budgeted at the portfolio level.

Table 30: Portfolio Level Costs by Year

Indirect Portfolio Level Costs	2018	2019	2020
Contact Center	$63,000	$63,000	$63,000
Online Audit	$36,444	$39,806	$42,911
Outreach & Education	$410,000	$410,000	$410,000
Evaluation	$427,992	$447,304	$444,314
Total Indirect Portfolio Level Costs	**$937,436**	**$960,110**	**$960,225**

A. Contact Center

The Vectren Contact Center, called the Energy Efficiency Advisory Team, fields referrals from the company's general call center and serves as a resource for interested customers. A toll-free number is provided on all outreach and education materials. Direct calls are initial contacts from customers or market providers coming through the dedicated toll free number printed on all Vectren South's energy efficiency materials. Transferred calls are customers that have spoken with a Vectren Contact Center representative and have either asked or been offered a transfer to an Energy Efficiency Advisor who is trained to respond to energy efficiency questions or conduct the on-line energy audit.

These customer communication channels provide support mechanisms for Vectren South customers to receive the following services:

- Provide general guidance on energy saving behaviors and investments using customer specific billing data via the on-line tool (bill analyzer and energy audit).
- Respond to questions about the residential and general service programs.
- Facilitate the completion of and provide a hard copy report from the online audit tool for customers without internet access or who have difficulty understanding how to use the tool.
- Respond to inquiries about rebate fulfillment status.

B. Online Audit

The Online Energy Audit tool is a customer engagement and messaging tool that uses actual billing data from a customer's energy bills to pinpoint ways to save energy in their home. Data collected drives account messaging through providing tips and rebates relevant to that customer's situation. Additionally, data collected from the online energy audit is used to validate neighbor comparison data, which illustrates how the customer's monthly energy use compares to their neighbors and is designed to inspire customers to try and save more energy than their efficient neighbors. This tool provides the online ability and means to communicate, cross promote, and educate customers about energy efficiency and Vectren's energy efficiency programs. The Online Energy Audit tool provides tools and messaging to educate customers and provide suggestions, tips, and advice on energy usage.

C. Outreach & Education

Vectren South's Customer Outreach and Education program serves to raise awareness and drive customer participation as well as educate customers on how to manage their energy bills. The program includes the following goals as objectives:

- Build awareness;
- Educate consumers on how to conserve energy and reduce demand;
- Educate customers on how to manage their energy costs and reduce their bill;
- Communicate support of customer EE needs; and
- Drive participation in the EE and DR programs.

The marketing approach includes paid media as well as web-based tools to help analyze bills, energy audit tools, EE and DSM program education and information. Informational guides and sales promotion materials for specific programs are included in this budget.

This effort is the key to achieving greater energy savings by convincing the families and businesses making housing/facility, appliance and equipment investments to opt for greater EE. The first step in convincing the public and businesses to invest in EE is to raise their awareness.

It is essential that a broad public education and outreach campaign not only raise awareness of what consumers can do to save energy and control their energy bills, but also prime them for participation in the various EE and DR programs.

Vectren South will oversee outreach and education for the programs and work closely with implementation partners to provide consistent messaging across different program outreach and education efforts. Vectren South will utilize the services of communication and EE experts to deliver the EE and DR message.

The Outreach budget also includes funds for program development and staff training. Examples of these costs include memberships to EE related organizations, outreach for home/trade shows and travel and training related to EE associated staff development.

D. Evaluation

Vectren South will work with an independent third party evaluator, selected by the VOB, to conduct an evaluation of DSM programs approved as part of its 2018-2020 Plan. The evaluation will include standard EM&V analyses, such as a process, impact, and/or market effects evaluation of Vectren South's portfolio of DSM programs. Gas impacts will be calculated for all of Vectren South's integrated gas programs. EM&V costs are based on 5% of the budget and allocated at the portfolio level.

10. Other Costs

Other costs being requested in the 2018-2020 filed plan include a Market Potential Study and funding for Emerging Markets.

Table 31: Other Costs by Year

Other Costs	2018	2019	2020
Emerging Markets	$200,000	$200,000	$200,000
Market Potential Study	$300,000	$0	$0
Total	**$500,000**	**$200,000**	**$200,000**

A. Emerging Markets

The Emerging Markets funding allows Vectren's DSM portfolio to offer leading-edge program designs for next-generation technologies, services, and engagement strategies to growing markets in the Vectren territory. The budget will be $200,000 each year for 2018-2020 and will not be used to support existing programs, but rather support new program development or new measures within an existing program.

Incentives promoted through this program may range from innovative rebate offerings to engineering and trade ally assistance to demand-control services that encourage early adoption of new, efficient technologies in high-impact market sectors. Depending on the development of certain technologies and growth areas in the service territory, a wide variety of projects and services are eligible.

To offset the risks of oversaturation of common prescriptive measures and redefined prescriptive baselines, this program will bring to market next generation technologies and energy-saving strategies that have significant savings and cost-effectiveness potential. As new technologies develop towards lower costs and higher efficiency, their market penetration and energy-savings potential will increase. This program will allow Vectren to be on the forefront of emerging technologies to understand the market disruption a new product may cause, test strategies for capturing their energy-saving opportunities, and plan for future program savings growth. This offering will supplement the other DSM programs that do not easily fit into other program offerings. Additionally, growing segments of Vectren South electric customers may require tailored offerings to accommodate their needs in order to participate.

Because this program will focus on innovative new approaches and leading the DSM market, the exact list of measures cannot be set at this time. However, potential measures and services include: new technologies, such as Advanced Lighting Controls; new strategies for achieving significant energy savings, such as midstream incentives, contractor bids to provide energy efficiency projects, and targeting high-impact market sectors; and integrated DSM (iDSM) approaches, such as demand response, combined energy efficiency and demand response measures, and load shifting.

Emerging technologies and measures will be reviewed and may be offered using this funding as long as they do not fall into a current program offering. Innovative engagement and incentivizing approaches may also be used as a tool to provide reduced costs to new systems, equipment and/or services to help reduce peak demand and electric usage. This program also allows Vectren to take steps toward an integrated Demand Side Management approach to address both energy efficiency and demand response together.

B. Market Potential Study

Vectren South is requesting $300,000 to complete a full blown Market Potential Study (MPS) for the years of 2020 and beyond, which is scheduled for 2018. Vectren will issue a Request for Quote to select a consultant to perform this work.

11. Conclusion

Vectren South has developed a 2018-2020 Electric Energy Efficiency Plan that is aligned with the 2016 Integrated Resource Plan and is reasonably achievable and cost effective. The cost effectiveness analysis was performed for 2018-2020 using the DSMore model – a nationally recognized economic analysis tool that is specifically designed to evaluate the cost effectiveness of implementing energy efficiency and demand response programs.

Program costs were determined by referencing 2016 program delivery costs, based on prior contracts and performance in the field and consultation with the program vendors that will deliver the DSM Plan. Energy and demand savings were primarily determined by using recent EM&V results and the IN TRM version 2.2. For measures that were not addressed in the IN TRM or EM&V, Vectren South used Technical Resource Manual resources from nearby states or vendor input. Vectren South utilized the avoided costs from Figure 10.13 in the 2016 IRP.

Based on this information, Vectren South requests IURC approval of this 2018-2020 DSM Plan as well as the costs associated with Emerging Markets and the Market Potential study for 2020 and beyond.

12. Appendix A: Cost Effectiveness Tests Benefits & Costs Summary

Test	Benefits	Costs
Participant Cost Test	• Incentive payments • Annual bill savings • Applicable tax credits	• Incremental technology/equipment costs • Incremental installation costs
Utility Cost Test (Program Administrator Cost Test)	• Avoided energy costs • Avoided capacity costs	• All program costs (startup, marketing, labor, evaluation, promotion, etc.) • Utility/Administrator incentive costs
Rate Impact Measure Test	• Avoided energy costs • Avoided capacity costs	• All program costs (startup, marketing, labor, evaluation, promotion, etc.) • Utility/Administrator incentive costs • Lost revenue due to reduced energy bills
Total Resource Cost Test	• Avoided energy costs • Avoided capacity costs • Applicable participant tax credits	• All program costs (not including incentive costs) • Incremental technology/equipment costs (whether paid by the participant or the utility)

13. Appendix B: Program Measure Detail

Program	Measure	Measure Life	Average Savings per Unit (kWh)	Demand per Unit (KW)	2018 Participation	2019 Participation	2020 Participation	Avg Incentive Paid Per Unit	Average Incremental Cost	2018 kWh Savings	2019 kWh Savings	2020 kWh Savings
Residential Programs												
Residential Lighting	Standard Units		27.75	0.00	146,465	164,424	80,000		$ 3	4,064,403	4,562,766	2,220,000
Residential Lighting	Specialty Units		44.00	0.01	62,698	67,962	69,716		$ 4	2,758,712	2,990,328	3,067,504
Residential Lighting	LED Fixtures		57.48	0.01	13,700	13,700	13,700		$ 20	787,501	787,501	787,501
Total Residential Lighting					**222,863**	**246,086**	**163,416**			**7,610,617**	**8,340,595**	**6,075,005**
Residential Prescriptive	Air Source Heat Pump 16 SEER	18	1,154.92	0.30	52	52	52	$ 300	$ 870	60,056	60,056	60,056
Residential Prescriptive	Air Source Heat Pump 18 SEER	18	1,625.77	0.35	9	9	9	$ 500	$ 870	14,632	14,632	14,632
Residential Prescriptive	Attic Insulation - Elec Heated	25	3,382.75	0.30	13	13	13	$ 450	$ 500	43,976	43,976	43,976
Residential Prescriptive	Attic Insulation - Gas Heated South (Electric)	25	339.71	0.30	36	36	36	$ 450	$ 500	12,229	12,229	12,229
Residential Prescriptive	Central Air Conditioner 16 SEER	18	294.63	0.35	644	644	644	$ 200	$ 400	189,745	189,745	189,745
Residential Prescriptive	Central Air Conditioner 18 SEER	18	573.88	0.33	76	76	76	$ 400	$ 800	43,615	43,615	43,615
Residential Prescriptive	Dual Fuel Air Source Heat Pump 16 SEER	18	767.06	0.34	0	0	0	$ 300	$ 1,000	0	0	0
Residential Prescriptive	Duct Sealing Electric Heat Pump - South	20	829.21	0.44	7	7	7	$ 350	$ 400	5,804	5,804	5,804
Residential Prescriptive	Duct Sealing Electric Resistive Furnace - South	20	1,351.93	0.40	0	0	0	$ 350	$ 400	0	0	0
Residential Prescriptive	Duct Sealing Gas Heating with A/C - South (Electric)	20	228.61	0.40	77	77	77	$ 175	$ 200	17,603	17,603	17,603
Residential Prescriptive	Ductless Heat Pump 17 SEER 9.5 HSPF	18	3,847.40	0.29	2	2	2	$ 500	$ 1,667	7,695	7,695	7,695
Residential Prescriptive	Ductless Heat Pump 19 SEER 9.5 HSPF	18	3,919.89	0.40	7	7	7	$ 500	$ 2,333	27,439	27,439	27,439
Residential Prescriptive	Ductless Heat Pump 21 SEER 10.0 HSPF	18	3,924.75	0.29	2	2	2	$ 500	$ 2,833	7,850	7,850	7,850
Residential Prescriptive	Ductless Heat Pump 23 SEER 10.0 HSPF	18	4,032.45	0.31	11	11	11	$ 500	$ 3,333	44,357	44,357	44,357
Residential Prescriptive	Duel Fuel Air Source Heat Pump 18 SEER	18	1,498.67	0.13	0	0	0	$ 500	$ 1,667	0	0	0
Residential Prescriptive	ECM HVAC Motor	20	384.72	0.10	1,107	1,107	1,107	$ 100	$ 97	425,884	425,884	425,884
Residential Prescriptive	Heat Pump Water Heater	10	2,291.38	0.31	2	2	2	$ 300	$ 1,000	4,583	4,583	4,583
Residential Prescriptive	Nest On-Line Store (Electric)	15	466.69	0.90	300	350	400	$ 75	$ 39	140,007	163,342	186,676
Residential Prescriptive	Nest On-Line Store (Dual)	15	377.71	0.90	900	1,000	1,100	$ 15	$ 175	339,939	377,710	415,481
Residential Prescriptive	Pool Heater	10	666.87	0.00	1	1	1	$ 1,000	$ 3,333	667	667	667
Residential Prescriptive	Wifi Thermostat - South (Electric)	15	405.09	0.00	264	264	264	$ 10	$ 21	106,944	106,944	106,944
Residential Prescriptive	Smart Programmable Thermostat - South (Electric)	15	412.19	0.00	428	428	428	$ 15	$ 39	176,417	176,417	176,417
Residential Prescriptive	Variable Speed Pool Pump	15	1,173.00	1.72	18	18	18	$ 300	$ 750	21,114	21,114	21,114
Residential Prescriptive	Wall Insulation - Elec Heated	25	1,158.34	0.04	5	5	5	$ 450	$ 500	5,792	5,792	5,792
Residential Prescriptive	Wall Insulation - Gas Heated - South (Electric)	25	60.29	0.04	32	32	32	$ 450	$ 500	1,929	1,929	1,929
Residential Prescriptive	AC Tune Up	5	75.64	0.12	0	644	644	$ 50	$ 64	0	48,710	48,710
Residential Prescriptive	ASHP Tune Up	5	284.99	0.12	0	22	22	$ 50	$ 64	0	6,270	6,270
Residential Prescriptive	Air Purifier	9	492.70	0.06	100	100	100	$ 25	$ 70	49,270	49,270	49,270
Residential Prescriptive	Furnace Tune Up	2	35.51	0.00	0	1,536	1,536	$ -	$ -	0	54,543	54,543
Total Residential Prescriptive					**4,093**	**6,445**	**6,595**			**1,747,547**	**1,918,174**	**1,979,280**
Residential New Construction	Gold Star: HERS Index Score ≤ 65 - EH	25	954.15	0.64	0	0	0	$ 700	$ 2,504	0	0	0
Residential New Construction	Gold Star: HERS Index Score ≤ 65 - Gas Heated	25	954.15	0.64	22	22	22	$ 175	$ 1,573	20,991	20,991	20,991
Residential New Construction	Platinum Star: HERS Index Score ≤ 60 - EH	25	1,419.20	0.89	1	1	1	$ 800	$ 3,079	1,419	1,419	1,419
Residential New Construction	Platinum Star: HERS Index Score ≤ 60-Gas Heated	25	1,419.20	0.89	116	116	116	$ 200	$ 1,778	164,627	164,627	164,627
Total Residential New Construction					**139**	**139**	**139**			**187,038**	**187,038**	**187,038**

Program	Measure	Measure Life	Average Savings per Unit (kWh	Demand per Unit (KW)	2018 Participation	2019 Participation	2020 Participation	Avg Incentive Paid Per Unit	Average Incremental Cost	2018 kWh Savings	2019 kWh Savings	2020 kWh Savings
HEA & Weatherization	Water Heater Temperature Setback - Elec DHW	4	86.40	0.01	15	15	15		$ 7	1,296	1,296	1,296
HEA & Weatherization	Wifi Thermostat - South (Electric)	15	405.09	0.00	399	399	399		$ 21	161,631	161,631	161,631
HEA & Weatherization	Exterior LED Lamp	15	91.98	0.00	1,210	1,210	1,210		$ 8	111,296	111,296	111,296
HEA & Weatherization	Duct Sealing Gas Heating with A/C	15	228.61	0.40	64	64	64		$ 200	14,631	14,631	14,631
HEA & Weatherization	Duct Sealing Electric Heat Pump	15	829.21	0.44	8	8	8		$ 400	6,634	6,634	6,634
HEA & Weatherization	Duct Sealing Electric Resistive Furnace	15	1,351.93	0.40	4	4	4		$ 400	5,408	5,408	5,408
HEA & Weatherization	Air Sealing Gas Furnace w/ CAC	15	140.27	0.39	258	258	258		$ 100	36,190	36,190	36,190
HEA & Weatherization	Air Sealing Heat Pump	15	1,501.47	0.28	30	30	30		$ 200	45,044	45,044	45,044
HEA & Weatherization	Air Sealing Electric Furnace w/ CAC	15	4,687.85	0.92	15	15	15		$ 200	70,318	70,318	70,318
HEA & Weatherization	AC Tune Up	5	75.64	0.12	0	0	0		$ 175	0	0	0
HEA & Weatherization	ASHP Tune Up	5	284.99	0.12	0	0	0		$ 350	0	0	0
HEA & Weatherization	Furnace Tune Up	2	35.51	0.00	0	0	0		$ -	0	0	0
Total HEA & Weatherization					**15,158**	**15,158**	**15,158**			**863,991**	**863,991**	**863,991**
	Number of Homes				1,210	1,210	1,210					
Income Qualified Weatherization	Water Heater Temperature Setback - Gas DHW	4	-34.20	0.00	0	0	0		$ 7	0	0	0
Income Qualified Weatherization	Attic Insulation - Electric Resistance Heated	25	828.28	0.03	24	25	26		$ 1,413	19,879	20,707	21,535
Income Qualified Weatherization	Attic Insulation - Gas Heated (Electric)	25	138.64	0.14	238	250	263		$ 706	32,997	34,661	36,463
Income Qualified Weatherization	Audit Recommendations - dual (Electric)	1	67.87	0.01	475	500	525		$ 26	32,239	33,936	35,633
Income Qualified Weatherization	Audit Recommendations - Electric Only	1	67.87	0.01	0	0	0		$ 106	0	0	0
Income Qualified Weatherization	Bathroom Aerator 1.0 gpm - Elec DHW	10	12.03	0.00	145	153	160		$ 1	1,744	1,841	1,925
Income Qualified Weatherization	9W LED	15	18.66	0.00	2,170	2,284	2,399		$ 3	40,501	42,628	44,775
Income Qualified Weatherization	LED 5W Globe	15	10.37	0.00	93	98	102		$ 9	964	1,016	1,058
Income Qualified Weatherization	LED R30 Dimmable	15	52.98	0.01	365	385	404		$ 12	19,337	20,396	21,403
Income Qualified Weatherization	Exterior LED Lamps	15	91.98	0.00	285	300	315		$ 7	26,214	27,594	28,974
Income Qualified Weatherization	Filter Whistle	15	54.72	0.00	190	200	210		$ 2	10,397	10,944	11,491
Income Qualified Weatherization	Kitchen Flip Aerator 1.5 gpm - Elec DHW	10	120.03	0.01	42	44	47		$ 1	5,041	5,281	5,641
Income Qualified Weatherization	LED Nightlight	16	13.64	0.00	887	933	980		$ 3	12,095	12,723	13,364
Income Qualified Weatherization	Low Flow Showerhead 1.5 gpm - Elec DHW	5	299.86	0.01	89	93	98		$ 3	26,688	27,887	29,386
Income Qualified Weatherization	Pipe Wrap - Elec DHW (per home)	15	148.16	0.02	42	44	47		$ 2	6,223	6,519	6,964
Income Qualified Weatherization	Wifi Thermostat - South (Electric)	15	405.19	0.00	262	276	290		$ 25	106,160	111,832	117,505
Income Qualified Weatherization	Refrigerator Replacement	8	441.56	0.07	63	67	70		$ 580	27,818	29,584	30,909
Income Qualified Weatherization	Smart Power Strips	4	23.00	0.00	570	600	630		$ 35	13,110	13,800	14,490
Income Qualified Weatherization	Smart Thermostat (Electric)	15	412.19	0.00	47	49	52		$ 125	19,373	20,197	21,434
Income Qualified Weatherization	Water Heater Temperature Setback - Elec DHW	4	86.40	0.01	135	142	150		$ 7	11,664	12,269	12,960
Income Qualified Weatherization	Duct Sealing Gas Heating with A/C	15	228.61	0.40	303	319	335		$ 225	69,270	72,928	76,585
Income Qualified Weatherization	Duct Sealing Electric Heat Pump	15	829.21	0.44	36	38	39		$ 450	29,852	31,510	32,339
Income Qualified Weatherization	Duct Sealing Electric Resistive Furnace	15	1,351.93	0.40	18	19	20		$ 450	24,335	25,687	27,039
Income Qualified Weatherization	Air Sealing Gas Furnace w/ CAC	15	140.27	0.39	303	319	335		$ 100	42,502	44,746	46,990
Income Qualified Weatherization	Air Sealing Heat Pump	15	1,501.47	0.28	36	38	39		$ 200	54,053	57,056	58,557
Income Qualified Weatherization	Air Sealing Electric Furnace w/ CAC	15	4,687.85	0.92	18	19	20		$ 200	84,381	89,069	93,757
Income Qualified Weatherization	AC Tune Up	5	75.64	0.12	0	0	0		$ 200	0	0	0
Income Qualified Weatherization	ASHP Tune Up	5	284.99	0.12	0	0	0		$ 400	0	0	0
Income Qualified Weatherization	9W LED	15	18.66	0.00	766	919	1,072		$ 3	14,297	17,152	20,008
Income Qualified Weatherization	LED 5W Globe	15	10.37	0.00	45	54	64		$ 9	467	560	664
Income Qualified Weatherization	LED R30 Dimmable	15	52.98	0.01	179	215	251		$ 12	9,483	11,390	13,297
Income Qualified Weatherization	Wifi Thermostat - South (Electric)	15	405.19	0.00	29	35	40		$ 25	11,751	14,182	16,208
Income Qualified Weatherization	Site Visit and DI - dual (Electric)	1	0.00	0.00	100	120	140		$ 23	0	0	0
Income Qualified Weatherization	9W LED	15	18.66	0.00	1,250	1,500	1,750		$ 3	23,330	27,996	32,662
Income Qualified Weatherization	LED 5W Globe	15	10.37	0.00	114	136	159		$ 9	1,182	1,410	1,649
Income Qualified Weatherization	LED R30 Dimmable	15	52.98	0.01	250	300	350		$ 12	13,244	15,893	18,542
Income Qualified Weatherization	Bathroom Aerator 1.0 gpm - Electric DHW	10	12.03	0.00	23	28	32		$ 1	277	337	385
Income Qualified Weatherization	Kitchen Flip Aerator 1.5 gpm - Electric DHW	10	120.03	0.01	11	13	15		$ 1	1,320	1,560	1,800
Income Qualified Weatherization	Low Flow Showerhead 1.5 gpm - Electric DHW	5	299.86	0.01	29	35	40		$ 3	8,696	10,495	11,994
Income Qualified Weatherization	Wifi Thermostat - South (Electric)	15	405.19	0.00	72	87	101		$ 25	29,174	35,252	40,924
Income Qualified Weatherization	Duct Sealing Gas Heating with A/C	15	114.31	0.20	213	255	298		$ 225	24,347	29,148	34,063
Income Qualified Weatherization	Duct Sealing Electric Heat Pump	15	414.61	0.22	13	15	18		$ 450	5,390	6,219	7,463
Income Qualified Weatherization	Duct Sealing Electric Resistive Furnace	15	675.96	0.20	25	30	35		$ 450	16,899	20,279	23,659
Income Qualified Weatherization	Air Sealing Gas Furnace w/ CAC	15	70.14	0.19	213	255	298		$ 100	14,939	17,884	20,900

Program	Measure	Measure Life	Average Savings per Unit (kWh)	Demand per Unit (KW)	2018 Participation	2019 Participation	2020 Participation	Avg Incentive Paid Per Unit	Average Incremental Cost	2018 kWh Savings	2019 kWh Savings	2020 kWh Savings
Income Qualified Weatherization	Air Sealing Heat Pump	15	1,501.47	0.28	36	38	39		$ 200	54,053	57,056	58,557
Income Qualified Weatherization	Air Sealing Electric Furnace w/ CAC	15	4,687.85	0.92	18	19	20		$ 200	84,381	89,069	93,757
Income Qualified Weatherization	AC Tune Up	5	75.64	0.12	0	0	0		$ 200	0	0	0
Income Qualified Weatherization	ASHP Tune Up	5	284.99	0.12	0	0	0		$ 400	0	0	0
Income Qualified Weatherization	9W LED	15	18.66	0.00	766	919	1,072		$ 3	14,297	17,152	20,008
Income Qualified Weatherization	LED 5W Globe	15	10.37	0.00	45	54	64		$ 9	467	560	664
Income Qualified Weatherization	LED R30 Dimmable	15	52.98	0.01	179	215	251		$ 12	9,483	11,390	13,297
Income Qualified Weatherization	Wifi Thermostat - South (Electric)	15	405.19	0.00	29	35	40		$ 25	11,751	14,182	16,208
Income Qualified Weatherization	Site Visit and DI - dual (Electric)	1	0.00	0.00	100	120	140		$ 23	0	0	0
Income Qualified Weatherization	9W LED	15	18.66	0.00	1,250	1,500	1,750		$ 3	23,330	27,996	32,662
Income Qualified Weatherization	LED 5W Globe	15	10.37	0.00	114	136	159		$ 9	1,182	1,410	1,649
Income Qualified Weatherization	LED R30 Dimmable	15	52.98	0.01	250	300	350		$ 12	13,244	15,893	18,542
Income Qualified Weatherization	Bathroom Aerator 1.0 gpm - Electric DHW	10	12.03	0.00	23	28	32		$ 1	277	337	385
Income Qualified Weatherization	Kitchen Flip Aerator 1.5 gpm - Electric DHW	10	120.03	0.01	11	13	15		$ 1	1,320	1,560	1,800
Income Qualified Weatherization	Low Flow Showerhead 1.5 gpm - Electric DHW	5	299.86	0.01	29	35	40		$ 3	8,696	10,495	11,994
Income Qualified Weatherization	Wifi Thermostat - South (Electric)	15	405.19	0.00	72	87	101		$ 25	29,174	35,252	40,924
Income Qualified Weatherization	Duct Sealing Gas Heating with A/C	15	114.31	0.20	213	255	298		$ 225	24,347	29,148	34,063
Income Qualified Weatherization	Duct Sealing Electric Heat Pump	15	414.61	0.22	13	15	18		$ 450	5,390	6,219	7,463
Income Qualified Weatherization	Duct Sealing Electric Resistive Furnace	15	675.96	0.20	25	30	35		$ 450	16,899	20,279	23,659
Income Qualified Weatherization	Air Sealing Gas Furnace w/ CAC	15	70.14	0.19	213	255	298		$ 100	14,939	17,884	20,900
Income Qualified Weatherization	Air Sealing Heat Pump	15	750.74	0.14	13	15	18		$ 200	9,760	11,261	13,513
Income Qualified Weatherization	Air Sealing Electric Furnace w/ CAC	15	2,343.93	0.46	25	30	35		$ 200	58,598	70,318	82,037
Income Qualified Weatherization	Mobile Home Audit (Dual)	1	0.00	0.00	213	255	298		$ 26	0	0	0
Income Qualified Weatherization	Mobile Home Audit (Electric)	1	0.00	0.00	38	45	53		$ 106	0	0	0
Total Income Qualified Weatherization					**10,457**	**11,537**	**12,623**			**959,988**	**1,046,148**	**1,130,945**
	Number of Homes				475	500	525					
Foodbank	**9W LED**	**15**	**27.75**	**0.00**	**50,496**	**50,496**	**0**		**$ 3**	**1,401,264**	**1,401,264**	**0**
Energy Efficient Schools	15-watt LED x1	15	39.33		2,400	2,500				94,403	98,336	0
Energy Efficient Schools	11-watt LED	15	43.69		2,400	2,500				104,863	109,232	0
Energy Efficient Schools	11-watt LED	15	43.69		2,400	2,500				104,863	109,232	0
Energy Efficient Schools	Showerheads	5	122.64		2,400	2,500	2,600			294,330	306,594	318,864
Energy Efficient Schools	Kitchen aerators	10	55.83		2,400	2,500	2,600			133,987	139,569	145,152
Energy Efficient Schools	Bathroom aerators	10	20.04		2,400	2,500	2,600			48,094	50,098	52,102
Energy Efficient Schools	Bathroom aerators	10	20.04		2,400	2,500	2,600			48,094	50,098	52,102
Energy Efficient Schools	Filter Whistle	5	22.60		2,400	2,500	2,600			54,240	56,500	58,760
Energy Efficient Schools	LED Night Light	16	7.01		2,400	2,500	2,600			16,833	17,534	18,236
Total Energy Efficient Schools					**2,400**	**2,500**	**2,600**			**899,706**	**937,194**	**645,216**
Residential Behavorial Savings		**1**	**157.08**		**41,348**	**38,203**	**35,298**			**6,470,000**	**5,970,000**	**5,600,000**
Appliance Recycling	Refrigerator Recycling	8	1,000.09	0.14	760	744	736	$ 50		760,068	744,067	736,066
Appliance Recycling	Freezer Recycling	8	808.96	0.10	190	186	184	$ 50		153,702	150,467	148,849
Total Appliance Recycling					**950**	**930**	**920**			**913,771**	**894,534**	**884,915**
Smart Thermostat Program (Incentive)		15			2,000	2,000	2,000	$ 20				
												Savings
Conservation Voltage Reduction - Residential		**15**										**1,461,047**
Smart DLC - Wifi DR/DLC Changeout		**15**	**466.69**	**0.90**	**1,000**	**1,000**		**$ 20**		**466,690**	**466,690**	**466,690**
BYOT (Bring Your Own Thermostat)		**15**		**0.90**	**300**	**300**	**300**	**$ 20**				
Sub-Total Residential										**21,520,612**	**22,025,627**	**19,294,126**

Program	Measure	Measure Life	Average Savings per Unit (kWh)	Demand per Unit (KW)	2018 Participation	2019 Participation	2020 Participation	Avg Incentive Paid Per Unit	Average Incremental Cost	2018 kWh Savings	2019 kWh Savings	2020 kWh Savings
C&I Prescriptive	Lighting Power Density Reduction	15	0.9	0.0002	4	3	4	15754.5	-	4	3	4
C&I Prescriptive	LED Decoratives	10	147.0	0.0460	2231	1892	2170	10	20.62	327,957	278,124	318,990
C&I Prescriptive	T12/T8 4 Lamp 4' To LED Panel	15	288.0	0.0755	1069	907	1040	40	91.64	307,872	261,216	299,520
C&I Prescriptive	T12/T8 3 Lamp 4' To LED Panel	15	261.0	0.0485	578	491	563	40	81.80	150,858	128,151	146,943
C&I Prescriptive	T12/T8 2 Lamp 4' To LED Panel	15	226.0	0.0350	513	435	499	40	37.41	115,938	98,310	112,774
C&I Prescriptive	T12/T8 Lamp 4' to LED Tube (includes U-tube)	15	105.0	0.0174	398	338	388	5	22.85	41,790	35,490	40,740
C&I Prescriptive	Fixture Mounted Occupancy Sensor	8	150.1	0.0182	360	305	350	15	125.00	54,035	45,780	52,534
C&I Prescriptive	High Bay HID to LED 175W+	16	780.2	0.2351	293	249	285	90	340.61	228,610	194,279	222,368
C&I Prescriptive	Bonus Incentive - Electric	0	-	-	259	750	0	50	-	-	-	-
C&I Prescriptive	1000W HID to Exterior LED	15	3,143.7	-	250	212	244	200	330.07	785,916	666,457	767,054
C&I Prescriptive	T12/T8 48” 1 Lamp To Delamp (includes U-tubes)	11	116.0	0.0460	202	171	196	5	15.02	23,439	19,842	22,743
C&I Prescriptive	251-400W Post Fixture LED	15	1,122.0	-	148	126	144	120	543.96	166,063	141,378	161,574
C&I Prescriptive	<= 175W Parking Garage or Canopy Fixture to LED	15	524.6	0.0194	94	80	91	50	240.34	49,314	41,970	47,740
C&I Prescriptive	251-400W Parking Garage or Canopy Fixture to LED	15	1,360.7	0.0693	90	76	87	120	257.23	122,466	103,416	118,384
C&I Prescriptive	<= 175W Wallpack to LED	15	583.4	0.0148	86	73	84	50	227.82	50,170	42,586	49,004
C&I Prescriptive	176-250W Wallpack to LED	15	873.6	-	67	57	65	65	316.05	58,534	49,798	56,787
C&I Prescriptive	Occupancy Sensor - Wall Mounted <500W	8	420.4	0.0114	65	55	63	20	42.00	27,324	23,120	26,483
C&I Prescriptive	251-400W Wallpack to LED 75W+	15	1,438.2	-	56	48	55	120	354.13	80,538	69,033	79,100
C&I Prescriptive	T12 or T8 2-Lamp 8-Foot to LED Panel or Kit	15	217.5	0.0457	46	39	45	40	175.56	10,005	8,483	9,788
C&I Prescriptive	T12 96" 4 Lamp To T8 96" 4 Lamp	15	348.4	0.1018	34	29	33	12	202.04	11,846	10,104	11,497
C&I Prescriptive	<= 175W Post Fixture LED	16	556.7	-	33	28	32	50	278.89	18,371	15,588	17,814
C&I Prescriptive	2 Lamp 4ft T12 to 2 Lamp 4ft HPT8	15	46.1	0.0228	28	24	28	6	47.68	1,290	1,105	1,290
C&I Prescriptive	176-250W Post Fixture LED	15	988.8	-	28	24	27	65	398.61	27,686	23,731	26,697
C&I Prescriptive	T12 6' To Refrigerated Display Case Lighting 6' LED - Cooler	8.1	496.9	0.0494	27	23	26	30	137.14	13,418	11,430	12,921
C&I Prescriptive	Fluorescent Exit Sign To LED Exit Sign	16	92.3	0.0106	23	19	22	30	24.91	2,124	1,754	2,031
C&I Prescriptive	176-250W Parking Garage or Canopy Fixture to LED	15	916.1	-	19	16	19	65	295.80	17,405	14,657	17,405
C&I Prescriptive	T8 5' To Refrigerated Display Case Lighting 5' LED - Cooler	8.1	332.5	0.0500	17	15	17	15	150.00	5,652	4,987	5,652
C&I Prescriptive	Cooler - Walk-In Electronically Commutated (EC) Motor	15	357.0	0.0500	13	11	13	35	50.00	4,641	3,927	4,641
C&I Prescriptive	Occupancy Sensor - Ceiling Mounted <500w	8	604.2	0.0144	10	8	9	20	66.00	6,042	4,834	5,438
C&I Prescriptive	Split System Unitary Air Conditioner <65,000 BtuH	15	638.9	0.0682	10	8	9	120	282.11	6,389	5,111	5,750
C&I Prescriptive	T12/T8 U-Tube 2 Lamp 2' To LED Panel	15	185.0	0.0267	8	7	8	30	179.14	1,480	1,295	1,480
C&I Prescriptive	T12 48" 4 Lamp To T8 48" 28W 4 Lamp	15	240.1	0.0440	8	7	8	14	36.19	1,921	1,681	1,921
C&I Prescriptive	Wifi Thermostat - Electric Only	15	4,720.3	-	8	7	16	100	200.00	37,763	33,042	75,526
C&I Prescriptive	Programmable Thermostat - Electric Only	15	4,720.3	-	8	7	16	100	200.00	37,763	33,042	75,526
C&I Prescriptive	Occupancy Sensor - Ceiling Mounted 500W+	8	176.7	0.0617	7	6	7	40	66.00	1,237	1,060	1,237
C&I Prescriptive	T12/T8 1 Lamp 4' To LED Panel	15	129.4	0.0436	7	6	7	30	83.42	906	776	906
C&I Prescriptive	2 Lamp 8ft T12 to 4 Lamp 4ft HPT8	15	41.1	0.0110	7	6	7	25	132.19	288	247	288
C&I Prescriptive	ENERGY STAR Commercial Ice Machine < 500 lb/day harvest rate	9	230.4	0.0338	5	5	5	100	296.00	1,152	1,152	1,152
C&I Prescriptive	Delamp 2' T12	11	36.4	0.0200	5	4	5	2.5	-	182	146	182
C&I Prescriptive	VFD Supply Fan <100hp	15	35,640.0	0.0149	4	3	4	900	10,915.00	142,560	106,920	142,560
C&I Prescriptive	Interior 1000W HID to LED	16	898.6	0.0199	4	3	4	110	-	3,594	2,696	3,594
C&I Prescriptive	2x2 Panel	15	144.0	0.0377	4	3	4	20	45.82	576	432	576
C&I Prescriptive	Split System Unitary Air Conditioner 65,000-135,000 BtuH	15	1,689.3	0.0424	3	2	3	240	666.67	5,068	3,379	5,068
C&I Prescriptive	ENERGY STAR Commercial Hot Holding Cabinets Full Size	12	5,256.0	0.8100	3	2	3	420	1,110.00	15,768	10,512	15,768
C&I Prescriptive	Split System Unitary Air Conditioner 135,000-240,000 BtuH	15	4,865.3	0.0442	2	2	2	600	1,100.00	9,731	9,731	9,731
C&I Prescriptive	ENERGY STAR CEE Tier 2 Window\Sleeve\Room AC < 14,000 BTUH	15	232.2	0.2248	1	1	1	20	-	232	232	232
C&I Prescriptive	ENERGY STAR CEE Tier 2 Window\Sleeve\Room AC >= 14,000 BTUH	15	363.3	0.4430	1	1	1	22	-	363	363	363
C&I Prescriptive	Split System Unitary Air Conditioner 240,000-760,000 BtuH	15	27,827.4	0.2015	1	1	1	1200	2,000.00	27,827	27,827	27,827
C&I Prescriptive	Split System Unitary Air Conditioner >760,000 BtuH	15	81,970.0	2.8190	1	1	1	1050	-	81,970	81,970	81,970
C&I Prescriptive	ENERGY STAR Window\Sleeve\Room AC < 14,000 BTUH	15	189.8	0.1628	1	1	1	12	-	190	190	190
C&I Prescriptive	ENERGY STAR Window\Sleeve\Room AC >= 14,000 BTUH	15	293.3	0.3208	1	1	1	14	-	293	293	293
C&I Prescriptive	ENERGY STAR CEE Tier 1 Window\Sleeve\Room AC < 14,000 BTUH	15	189.8	0.1135	1	1	1	16	-	190	190	190
C&I Prescriptive	ENERGY STAR CEE Tier 1 Window\Sleeve\Room AC >= 14,000 BTUH	15	293.3	0.2237	1	1	1	18	-	293	293	293
C&I Prescriptive	Electric Chiller - Air cooled, with condenser	20	9,606.6	0.0031	1	1	1	1500	-	9,607	9,607	9,607
C&I Prescriptive	Electric Chiller Tune-up - Air cooled, without condenser	5	8,153.0	0.0013	1	1	1	400	-	8,153	8,153	8,153

Program	Measure	Measure Life	Average Savings per Unit (kWh	Demand per Unit (KW)	2018 Participation	2019 Participation	2020 Participation	Avg Incentive Paid Per Unit	Average Incremental Cost	2018 kWh Savings	2019 kWh Savings	2020 kWh Savings
C&I Prescriptive	Electric Chiller Tune-up - Water Cooled, Centrifugal	5	21,430.9	0.0002	1	1	1	1600	-	21,431	21,431	21,431
C&I Prescriptive	Electric Chiller Tune-up - Water Cooled, Rotary Screw	5	5,073.1	0.0425	1	1	1	1600	1,790.00	5,073	5,073	5,073
C&I Prescriptive	Chilled Water Reset Control	10	173.0	0.0133	1	1	1	1.5	-	173	173	173
C&I Prescriptive	Electric Chiller - Air cooled, without condenser	20	2,923.7	0.0013	1	1	1	500	-	2,924	2,924	2,924
C&I Prescriptive	Electric Chiller - Water Cooled, Rotary Screw <150 tons	20	5,814.1	0.0011	1	1	1	1500	-	5,814	5,814	5,814
C&I Prescriptive	Electric Chiller - Water Cooled, Rotary Screw 150-300 tons	20	17,632.9	0.0000	1	1	1	4500	-	17,633	17,633	17,633
C&I Prescriptive	Electric Chiller - Water Cooled, Rotary Screw >300 tons	20	33,449.4	0.0003	1	1	1	9000	-	33,449	33,449	33,449
C&I Prescriptive	Electric Chiller - Water Cooled, Centrifugal <150 tons	20	6,969.9	0.0033	1	1	1	1500	-	6,970	6,970	6,970
C&I Prescriptive	Electric Chiller - Water Cooled, Centrifugal 150-300 tons	20	17,438.9	0.0006	1	1	1	4500	-	17,439	17,439	17,439
C&I Prescriptive	Electric Chiller - Water Cooled, Centrifugal >300 tons	20	18,656.4	0.0416	1	1	1	9000	13,833.00	18,656	18,656	18,656
C&I Prescriptive	Electric Chiller Tune-up - Air cooled, with condenser	5	9,222.3	0.0015	1	1	1	400	-	9,222	9,222	9,222
C&I Prescriptive	Central Lighting Control	8	224.7	0.0270	1	1	1	30	-	225	225	225
C&I Prescriptive	Daylight Dimming Control <500w	8	337.1	0.0135	1	1	1	20	-	337	337	337
C&I Prescriptive	Occupancy Sensor - Wall Mounted 500W+	8	344.9	0.0270	1	1	1	40	-	345	345	345
C&I Prescriptive	Daylight Dimming Control 500W+	8	674.2	0.0270	1	1	1	40	-	674	674	674
C&I Prescriptive	Fixture Mounted daylight dimming control	8	168.6	0.0068	1	1	1	15	-	169	169	169
C&I Prescriptive	Switching Control for Multi-Level Lighting 500W+	8	168.6	0.0068	1	1	1	30	-	169	169	169
C&I Prescriptive	ENERGY STAR Griddles	12	6,995.7	1.3416	1	1	1	550	-	6,996	6,996	6,996
C&I Prescriptive	ENERGY STAR Combination Oven	12	18,431.7	3.5348	1	1	1	1000	-	18,432	18,432	18,432
C&I Prescriptive	ENERGY STAR Convection Oven	12	3,234.8	0.6204	1	1	1	350	-	3,235	3,235	3,235
C&I Prescriptive	ENERGY STAR Commercial Dishwasher - Door Type, High Temp	15	14,143.0	0.6889	1	1	1	1100	-	14,143	14,143	14,143
C&I Prescriptive	ENERGY STAR Commercial Dishwasher - Door Type, Low Temp	15	12,135.0	0.5911	1	1	1	1000	-	12,135	12,135	12,135
C&I Prescriptive	ENERGY STAR Commercial Dishwasher - Multi-Tank Conveyor, High Temp	20	34,153.0	1.6635	1	1	1	2700	-	34,153	34,153	34,153
C&I Prescriptive	ENERGY STAR Commercial Dishwasher - Multi-Tank Conveyor, Low Temp	20	17,465.0	0.8507	1	1	1	1400	-	17,465	17,465	17,465
C&I Prescriptive	ENERGY STAR Commercial Dishwasher - Single Tank Conveyor, High Temp	20	19,235.0	0.9369	1	1	1	1500	-	19,235	19,235	19,235
C&I Prescriptive	ENERGY STAR Commercial Ice Machine >=500 and <1000 lb/day harvest rate	9	702.4	0.1100	1	1	1	175	1,485.00	702	702	702
C&I Prescriptive	ENERGY STAR Commercial Dishwasher - Single Tank Conveyor, Low Temp	20	11,384.0	0.5545	1	1	1	900	-	11,384	11,384	11,384
C&I Prescriptive	ENERGY STAR Commercial Dishwasher - Under Counter, High Temp	10	7,471.0	0.3639	1	1	1	600	-	7,471	7,471	7,471
C&I Prescriptive	ENERGY STAR Commercial Dishwasher - Under Counter, Low Temp	10	1,213.0	0.0591	1	1	1	100	-	1,213	1,213	1,213
C&I Prescriptive	ENERGY STAR Commercial Ice Machine >=1000 lb/day harvest rate	9	1,227.5	0.1898	1	1	1	250	-	1,227	1,227	1,227
C&I Prescriptive	ENERGY STAR Commercial Hot Holding Cabinets Half Size	12	1,795.8	0.2755	1	1	1	150	-	1,796	1,796	1,796
C&I Prescriptive	ENERGY STAR Commercial Hot Holding Cabinets Three Quarter Size	12	2,825.1	0.4334	1	1	1	230	-	2,825	2,825	2,825
C&I Prescriptive	ENERGY STAR Commercial Fryer	12	1,526.2	0.2195	1	1	1	80	-	1,526	1,526	1,526
C&I Prescriptive	ENERGY STAR Commercial Steam Cookers	12	2,200.0	0.4400	1	1	1	200	-	2,200	2,200	2,200
C&I Prescriptive	Air Source Heat Pump <65,000 BtuH	15	555.3	0.0136	1	1	1	120	221.67	555	555	555
C&I Prescriptive	Air Source Heat Pump≥65,000 Btu/h and <135,000 Btu/h	15	492.0	-	1	1	1	240	-	492	492	492
C&I Prescriptive	Air Source Heat Pump≥135,000 Btu/h and <240,000 Btu/h	15	1,350.0	-	1	1	1	600	-	1,350	1,350	1,350
C&I Prescriptive	Air Source Heat Pump≥240,000 Btu/h and <760,000 Btu/h	15	6,949.0	-	1	1	1	1200	-	6,949	6,949	6,949
C&I Prescriptive	Water Source Heat Pump <17,000Btu/hr	15	160.0	0.0500	1	1	1	30	-	160	160	160
C&I Prescriptive	Water Source Heat Pump >=17,000Btu/hr - 65,000Btu/hr	15	596.6	0.0475	1	1	1	120	-	597	597	597
C&I Prescriptive	Water Source Heat Pump >65,000Btu/hr and <135,000Btu/hr	15	1,193.2	0.0463	1	1	1	240	-	1,193	1,193	1,193
C&I Prescriptive	Ground Source Heat Pump <135,000 Btu/hr	15	1,322.4	-	1	1	1	30	-	1,322	1,322	1,322
C&I Prescriptive	Ground Water Source Heat Pump <135,000 Btu/hr	15	41,712.0	0.0350	1	1	1	240	-	41,712	41,712	41,712
C&I Prescriptive	High Bay HID to LED <175W	16	303.5	0.0067	1	1	1	35	-	303	303	303
C&I Prescriptive	T12 or T8 1-Lamp 8-Foot to LED Panel or Kit	15	118.0	0.0228	1	1	1	40	-	118	118	118
C&I Prescriptive	T12/T8 Lamp 8' to LED Tube	15	210.0	-	1	1	1	10	-	210	210	210
C&I Prescriptive	Clothes Washer ENERGY STAR/CEE Tier 1	11	541.5	-	1	1	1	50	-	542	542	542
C&I Prescriptive	Pellet Dryers duct insulation	5	297.7	0.0450	1	1	1	30	-	298	298	298
C&I Prescriptive	Clothes Washer CEE Tier 2	11	541.5	-	1	1	1	60	-	542	542	542
C&I Prescriptive	Clothes Washer CEE Tier 3	11	541.5	-	1	1	1	70	-	542	542	542
C&I Prescriptive	Smart Strip Plug Outlet	8	23.6	-	1	1	1	8	-	24	24	24
C&I Prescriptive	Plug Load Occupancy sensor with Smart Strip	8	169.0	-	1	1	1	20	-	169	169	169
C&I Prescriptive	Compressed Air Engineered Nozzles (1/8")	15	429.8	0.1631	1	1	1	5	-	430	430	430
C&I Prescriptive	Compressed Air Engineered Nozzles (1/4")	15	1,346.6	0.5111	1	1	1	8	-	1,347	1,347	1,347
C&I Prescriptive	VFD compressor	15	31,875.0	0.0011	1	1	1	5625	-	31,875	31,875	31,875
C&I Prescriptive	Barrel Wraps (Inj Mold Only)	5	983.3	0.0306	1	1	1	30	-	983	983	983

Program	Measure	Measure Life	Average Savings per Unit (kWh	Demand per Unit (KW)	2018 Participation	2019 Participation	2020 Participation	Avg Incentive Paid Per Unit	Average Incremental Cost	2018 kWh Savings	2019 kWh Savings	2020 kWh Savings
C&I Prescriptive	Electric Chiller Tune-up - Water Cooled, Centrifugal	5	21,430.9	0.0002	1	1	1	1600	-	21,431	21,431	21,431
C&I Prescriptive	T12/T8 96" 1 Lamp To Delamp	11	157.2	0.0684	1	1	1	10	-	157	157	157
C&I Prescriptive	Incandescent Traffic Signal To LED Traffic Signal Round 8" Red	10	298.7	0.0341	1	1	1	30	-	299	299	299
C&I Prescriptive	Incandescent Traffic Signal To LED Traffic Signal Pedestrian 12"	10	946.1	0.1080	1	1	1	50	-	946	946	946
C&I Prescriptive	Packaged Terminal Air Conditioner (PTAC) <7000 BtuH	15	138.0	0.2284	1	1	1	35	-	138	138	138
C&I Prescriptive	Packaged Terminal Air Conditioner (PTAC) 7,000-15,000 BtuH	15	1,702.4	0.9600	1	1	1	70	35.00	1,702	1,702	1,702
C&I Prescriptive	Packaged Terminal Air Conditioner (PTAC) >15,000 BtuH	15	506.0	0.7715	1	1	1	105	-	506	506	506
C&I Prescriptive	Packaged Terminal Heat Pump (PTHP) <7,000 BtuH	15	395.4	0.3945	1	1	1	35	48.97	395	395	395
C&I Prescriptive	Packaged Terminal Heat Pump (PTHP) 7,000 - 15,000 BtuH	15	385.0	0.1000	1	1	1	70	-	385	385	385
C&I Prescriptive	Packaged Terminal Heat Pump (PTHP) > 15,000 BtuH	15	639.8	0.1133	1	1	1	105	-	640	640	640
C&I Prescriptive	Cooler <15 vol	12	3,671.3	0.0593	1	1	1	375	-	3,671	3,671	3,671
C&I Prescriptive	T12 6' To Refrigerated Display Case Lighting 6' LED - Cooler With Connected Motion Sensor	8.1	825.7	0.0856	1	1	1	45	-	826	826	826
C&I Prescriptive	T12 6' To Refrigerated Display Case Lighting 6' LED - Freezer	8.1	622.5	0.0923	1	1	1	30	-	622	622	622
C&I Prescriptive	T12 6' To Refrigerated Display Case Lighting 6' LED - Freezer With Connected Motion Sensor	8.1	890.2	0.0923	1	1	1	45	-	890	890	890
C&I Prescriptive	T8 5' To Refrigerated Display Case Lighting 5' LED - Cooler With Connected Motion Sensor	8.1	475.4	0.0493	1	1	1	25	-	475	475	475
C&I Prescriptive	T8 5' To Refrigerated Display Case Lighting 5' LED - Freezer	8.1	358.4	0.0531	1	1	1	15	-	358	358	358
C&I Prescriptive	T8 5' To Refrigerated Display Case Lighting 5' LED - Freezer With Connected Motion Sensor	8.1	512.5	0.0531	1	1	1	25	-	513	513	513
C&I Prescriptive	Cooler - Reach-In Electronically Commutated (EC) Motor	15	328.0	0.0330	1	1	1	35	-	328	328	328
C&I Prescriptive	Freezer - Reach-In Electronically Commutated (EC) Motor	15	411.0	0.0350	1	1	1	45	-	411	411	411
C&I Prescriptive	Cooler 15-30 vol	12	14,411.1	0.0500	1	1	1	1650	164.00	14,411	14,411	14,411
C&I Prescriptive	Freezer - Walk-In Electronically Commutated (EC) Motor	15	532.0	0.0360	1	1	1	45	-	532	532	532
C&I Prescriptive	Cooler Anti-Sweat Heater Controls	12	614.5	-	1	1	1	50	-	615	615	615
C&I Prescriptive	Freezer Anti-Sweat Heater Controls	12	1,302.5	-	1	1	1	100	-	1,303	1,303	1,303
C&I Prescriptive	Refrigerated Case Covers	5	157.5	-	1	1	1	10	-	158	158	158
C&I Prescriptive	Cooler - Glass Door 30-50 vol	12	38,943.5	0.0800	1	1	1	3000	164.00	38,944	38,944	38,944
C&I Prescriptive	Cooler - Glass Door >50 vol	12	91,487.5	0.1000	1	1	1	7000	249.00	91,488	91,488	91,488
C&I Prescriptive	Freezer - Glass Door <15 vol	12	5,837.7	0.0800	1	1	1	750	142.00	5,838	5,838	5,838
C&I Prescriptive	Freezer - Glass Door 15-30 vol	12	26,061.0	0.0900	1	1	1	4500	166.00	26,061	26,061	26,061
C&I Prescriptive	Freezer - Glass Door 30-50 vol	12	164,834.0	0.4400	1	1	1	8000	166.00	164,834	164,834	164,834
C&I Prescriptive	Freezer - Glass Door >50 vol	12	715,400.0	0.7667	1	1	1	35000	407.00	715,400	715,400	715,400
C&I Prescriptive	T12 48" 1 Lamp To T5 46" 1 Lamp	15	25.3	0.0100	1	1	1	4	-	25	25	25
C&I Prescriptive	175 - 250W HID To T5 46" 2 Lamp HO	15	377.7	0.1049	1	1	1	45	-	378	378	378
C&I Prescriptive	175 - 250W HID To T5 46" 3 Lamp HO	15	167.5	0.0465	1	1	1	40	-	168	168	168
C&I Prescriptive	400W HID To T5 46" 4 Lamp HO	15	702.9	0.1952	1	1	1	85	-	703	703	703
C&I Prescriptive	400W HID To T5 46" 6 Lamp HO	15	318.6	0.0885	1	1	1	50	-	319	319	319
C&I Prescriptive	1000W HID To T5 46" 10 Lamp HO	15	1,652.2	0.4587	1	1	1	115	-	1,652	1,652	1,652
C&I Prescriptive	1000W HID To T5 46" 12 Lamp HO	15	1,215.3	0.3374	1	1	1	105	-	1,215	1,215	1,215
C&I Prescriptive	T12 48" 2 Lamp To T5 46" 2 Lamp	15	18.4	0.0073	1	1	1	6	-	18	18	18
C&I Prescriptive	T12 48" 3 Lamp To T5 46" 3 Lamp	15	43.7	0.0173	1	1	1	8	-	44	44	44
C&I Prescriptive	T12 48" 4 Lamp To T5 46" 4 Lamp	15	36.8	0.0146	1	1	1	12	-	37	37	37
C&I Prescriptive	HID 75W-100W To T5 Garage 1 Lamp	15	301.7	0.1104	1	1	1	8	-	302	302	302
C&I Prescriptive	HID 101W-175W To T5 Garage 2 Lamp	15	275.4	0.1008	1	1	1	12	-	275	275	275
C&I Prescriptive	HID 176W+ To T5 Garage 3 Lamp	15	367.2	0.1344	1	1	1	16	-	367	367	367
C&I Prescriptive	Up to 175W HID To T5 46" 2 Lamp HO	15	239.8	0.0666	1	1	1	35	-	240	240	240
C&I Prescriptive	Up to 175W HID To T5 46" 3 Lamp HO	15	88.7	0.0246	1	1	1	30	-	89	89	89
C&I Prescriptive	Up to 175W HID to T8VHO 48" 3 Lamp	15	197.1	0.0547	1	1	1	35	-	197	197	197
C&I Prescriptive	T12 48" 1 Lamp To T8 48" 25W 1 Lamp	15	48.3	0.0192	1	1	1	8	-	48	48	48
C&I Prescriptive	T12 48" 2 Lamp To T8 48" 25W 2 Lamp	15	71.3	0.0283	1	1	1	10	-	71	71	71
C&I Prescriptive	T12 48" 3 Lamp To T8 48" 25W 3 Lamp	15	123.5	0.0490	1	1	1	12	-	123	123	123
C&I Prescriptive	T12 48" 4 Lamp To T8 48" 25W 4 Lamp	15	146.0	0.0579	1	1	1	16	-	146	146	146
C&I Prescriptive	1 Lamp 4ft T12 to 1 Lamp 4ft HPT8	15	41.4	0.0164	1	1	1	4	-	41	41	41
C&I Prescriptive	3 Lamp 4ft T12 to 3 Lamp 4ft HPT8	15	96.6	0.0383	1	1	1	8	-	97	97	97
C&I Prescriptive	4 Lamp 4ft T12 to 4 Lamp 4ft HPT8	15	110.4	0.0438	1	1	1	12	-	110	110	110
C&I Prescriptive	T12 96" 1 Lamp To T8 96" 1 Lamp	15	39.1	0.0155	1	1	1	6	-	39	39	39
C&I Prescriptive	T12 96" 2 Lamp To T8 96" 2 Lamp	15	32.2	0.0128	1	1	1	8	-	32	32	32
C&I Prescriptive	176-250W HID to T8VHO 48" 4 Lamp	15	266.1	0.0739	1	1	1	50	-	266	266	266
C&I Prescriptive	1 Lamp 8ft T12 to 2 Lamp 4ft HPT8	15	62.1	0.0246	1	1	1	20	-	62	62	62

Program	Measure	Measure Life	Average Savings per Unit (kWh)	Demand per Unit (KW)	2018 Participation	2019 Participation	2020 Participation	Avg Incentive Paid Per Unit	Average Incremental Cost	2018 kWh Savings	2019 kWh Savings	2020 kWh Savings
C&I Prescriptive	Electric Chiller Tune-up - Water Cooled, Centrifugal	5	21,430.9	0.0002	1	1	1	1600	-	21,431	21,431	21,431
C&I Prescriptive	T12/T8 96” 1 Lamp To Delamp	11	157.2	0.0684	1	1	1	10	-	157	157	157
C&I Prescriptive	400W HID to T8VHO 4ft 6 Lamp	15	762.0	0.2116	1	1	1	85	-	762	762	762
C&I Prescriptive	400W HID to T8VHO 4ft 8 Lamp	15	558.4	0.1550	1	1	1	60	-	558	558	558
C&I Prescriptive	MH 1000W To T8VHO 48" 8 Lamp (2 fixtures)	15	1,655.5	0.4596	1	1	1	125	-	1,655	1,655	1,655
C&I Prescriptive	T12 48" 1 Lamp To T8 48" 28W 1 Lamp	15	45.3	0.0180	1	1	1	6	-	45	45	45
C&I Prescriptive	T12 48" 2 Lamp To T8 48" 28W 2 Lamp	15	57.5	0.0228	1	1	1	8	-	57	57	57
C&I Prescriptive	T12 48" 3 Lamp To T8 48" 28W 3 Lamp	15	103.7	0.0411	1	1	1	10	-	104	104	104
C&I Prescriptive	Vending Machine Occ Sensor - Refrigerated Beverage	5	1,611.8	-	1	1	1	50	-	1,612	1,612	1,612
C&I Prescriptive	Snack Machine Controller (Non-refrigerated vending)	5	342.5	-	1	1	1	25	-	343	343	343
C&I Prescriptive	Vending Machine Occ Sensor - Refrigerated Glass Front Cooler	5	1,208.9	-	1	1	1	50	-	1,209	1,209	1,209
C&I Prescriptive	VFD Return Fan <100hp	15	60,000.0	-	1	1	1	900	-	60,000	60,000	60,000
C&I Prescriptive	VFD Tower Fan <100hp	15	19,220.0	-	1	1	1	900	-	19,220	19,220	19,220
C&I Prescriptive	VFD CW Pump <100hp	15	26,800.0	-	1	1	1	900	-	26,800	26,800	26,800
C&I Prescriptive	VFD HW Pump <100hp	15	88,620.0	0.9790	1	1	1	900	-	88,620	88,620	88,620
C&I Prescriptive	VFD CHW Pump <100hp	15	74,020.0	0.3900	1	1	1	900	-	74,020	74,020	74,020
C&I Prescriptive	Heat Pump Water Heater 10-50 MBH	10	3,534.0	0.5000	1	1	1	500	-	3,534	3,534	3,534
C&I Prescriptive	Window Film	10	3.7	0.0010	1	1	1	1	-	4	4	4
C&I Prescriptive	Pre-Rinse Sprayer - Electric	5	3,727.2	-	1	1	1	50	-	3,727	3,727	3,727
C&I Prescriptive	Livestock Waterer	10	266.1	0.5250	1	1	1	110	787.50	266	266	266
C&I Prescriptive	Agriculture - Poultry Farm LED Lighting	7	292.0	0.0500	1	1	1	10	30.00	292	292	292
C&I Prescriptive	VSD Milk Pump	15	33.9	0.0116	1	1	1	5	4,000.00	34	34	34
C&I Prescriptive	High Volume Low Speed Fans	10	8,543.0	3.1000	1	1	1	1000	4,180.00	8,543	8,543	8,543
C&I Prescriptive	High Speed Fans (Ventilation and Ciculation)	7	625.0	0.1980	1	1	1	50	150.00	625	625	625
C&I Prescriptive	Dairy Plate Cooler	15	76.2	0.0163	1	1	1	8	-	76	76	76
C&I Prescriptive	Heat Mat (Single, ~14x60")	5	657.0	-	1	1	1	65	225.00	657	657	657
C&I Prescriptive	Automatic Milker Take Off	15	556.0	0.1165	1	1	1	5	-	556	556	556
C&I Prescriptive	HE Diary Scroll Compressor	12	279.5	0.0689	1	1	1	250	-	279	279	279
C&I Prescriptive	Heat Reclaimer (No Precooler Installed)	14	152.7	-	1	1	1	5	-	153	153	153
C&I Prescriptive	Prescriptive Other	15								132,109	99,082	132,110
Total C&I Prescriptive					**7,024**	**5,981**	**6,856**			**4,999,125**	**4,501,186**	**5,002,621**
Small Business Direct Install (SBDI)	Lamp & Ballast Retrofit: 1-Lamp 4' T12 to HP, 28W or 25W T8	15	64.0	0.0171	80	77	68	12	51	5,122	4,930	4,353
Small Business Direct Install (SBDI)	Lamp & Ballast Retrofit: 2-Lamp 4' T12 to HP, 28W or 25W T8	15	85.4	0.0228	119	116	102	15	56	10,158	9,902	8,707
Small Business Direct Install (SBDI)	Lamp & Ballast Retrofit: 3-Lamp 4' T12 to HP, 28W or 25W T8	15	104.1	0.0383	2	2	1	20	70	208	208	104
Small Business Direct Install (SBDI)	Lamp & Ballast Retrofit: 4-Lamp 4' T12 to HP, 28W or 25W T8	15	116.5	0.0390	159	154	136	24	78	18,523	17,940	15,843
Small Business Direct Install (SBDI)	Lamp & Ballast Retrofit: 1-Lamp 8' T12 to 2-Lamp 4' or 1-Lamp 8' HP, 28W or 25W T8 w/ reflector	15	153.9	0.0246	2	2	1	20	93	308	308	154
Small Business Direct Install (SBDI)	Lamp & Ballast Retrofit: 2-Lamp 8' T12 to 4-Lamp 4' or 2-Lamp 8' HP, 28W or 25W T8 w/ reflector	15	59.3	0.0230	192	185	164	25	108	11,381	10,966	9,721
Small Business Direct Install (SBDI)	Lamp & Ballast Retrofit: 1-Lamp 8' T12 to 2-Lamp 4' or 1-Lamp 8' HP, 28W or 25W T8	15	110.7	0.0246	2	2	1	22	88	221	221	111
Small Business Direct Install (SBDI)	Lamp & Ballast Retrofit: 2-Lamp 8' T12 to 4-Lamp 4' or 2-Lamp 8' HP, 28W or 25W T8	15	41.6	0.0208	256	248	218	27	103	10,653	10,320	9,072
Small Business Direct Install (SBDI)	400W HID to High Bay Fluorescent 6-Lamp 4' HP, 28W or 25W T8	7	703.4	0.2116	2	2	1	125	300	1,407	1,407	703
Small Business Direct Install (SBDI)	250W HID to High Bay Fluorescent 4-Lamp 4' HP, 28W or 25W T8	7	519.9	0.1778	2	2	1	90	255	1,040	1,040	520
Small Business Direct Install (SBDI)	Delamping with Lamp & Ballast Retrofit: 4-Lamp 4' T12 to 3-Lamp 4' HP, 28W or 25W T8	15	211.2	0.0648	2	2	1	35	75	422	422	211
Small Business Direct Install (SBDI)	Delamping with Lamp & Ballast Retrofit: 4-Lamp 4' T12 to 2-Lamp 4' HP, 28W or 25W T8	15	264.9	0.0876	2	2	1	45	75	530	530	265
Small Business Direct Install (SBDI)	Delamping with Lamp & Ballast Retrofit: 3-Lamp 4' T12 to 2-Lamp 4' HP, 28W or 25W T8	15	199.8	0.0611	2	2	1	35	57	400	400	200
Small Business Direct Install (SBDI)	Delamping with Lamp & Ballast Retrofit: 2-Lamp 4' T12 to 1-Lamp 4' HP, 28W or 25W T8	15	137.3	0.0246	2	2	1	25	50	275	275	137
Small Business Direct Install (SBDI)	Delamping with Lamp & Ballast Retrofit: 4-Lamp 8' T12 to 4-Lamp 4' or 2-Lamp 8' HP, 28W or 25W T8	15	360.0	0.1368	2	2	1	60	105	720	720	360
Small Business Direct Install (SBDI)	Delamping with Lamp & Ballast Retrofit w/Reflector: 4-Lamp 4' T12 to 3-Lamp 4' HP, 28W or 25W T8	15	247.1	0.0716	2	2	1	35	90	494	494	247
Small Business Direct Install (SBDI)	Delamping with Lamp & Ballast Retrofit w/Reflector: 4-Lamp 4' T12 to 2-Lamp 4' HP, 28W or 25W T8	15	341.5	0.0910	1152	1115	984	60	58.51	393,353	380,719	335,989
Small Business Direct Install (SBDI)	Delamping with Lamp & Ballast Retrofit w/Reflector: 3-Lamp 4' T12 to 2-Lamp 4' HP, 28W or 25W T8	15	225.7	0.0675	2	2	1	40	88	451	451	226
Small Business Direct Install (SBDI)	Delamping with Lamp & Ballast Retrofit w/Reflector: 2-Lamp 4' T12 to 1-Lamp 4' HP, 28W or 25W T8	15	149.2	0.0404	2	2	1	25	57	298	298	149
Small Business Direct Install (SBDI)	Delamping with Lamp & Ballast Retrofit w/Reflector: 2-Lamp 8' T12 to 2-Lamp 4' or 1-Lamp 8' HP, 28W or 25W T8	15	275.9	0.0631	2	2	1	50	110	552	552	276
Small Business Direct Install (SBDI)	Delamping with Lamp & Ballast Retrofit w/Reflector: 4-Lamp 8' T12 to 4-Lamp 4' or 2-Lamp 8' HP, 28W or 25W T8	15	505.3	0.1368	2	2	1	90	140	1,011	1,011	505
Small Business Direct Install (SBDI)	Lamp & Ballast Retrofit: 1-Lamp 4' T12/T8 to 4' LED Tube	15	112.9	0.0232	80	77	68	18	80	9,036	8,697	7,680
Small Business Direct Install (SBDI)	Lamp & Ballast Retrofit: 2-Lamp 4' T12/T8 to 4' LED Tube	15	74.4	-	2	2	1	25	100	149	149	74
Small Business Direct Install (SBDI)	Lamp & Ballast Retrofit: 3-Lamp 4' T12/T8 to 4' LED Tube	15	81.8	-	2	2	1	25	120	164	164	82
Small Business Direct Install (SBDI)	Lamp & Ballast Retrofit: 4-Lamp 4' T12/T8 to 4' LED Tube	15	314.3	0.0645	437	423	374	50	140	137,340	132,940	117,541
Small Business Direct Install (SBDI)	Lamp & Ballast Retrofit: 1-Lamp 8' T12/T8 to 2-Lamp 4' or 1-Lamp 8' LED Tube	15	171.9	0.0353	675	654	577	30	132	116,013	112,404	99,170
Small Business Direct Install (SBDI)	Lamp & Ballast Retrofit: 2-Lamp 8' T12/T8 to 4-Lamp 4' or 2-Lamp 8' LED Tube	15	214.5	0.0433	40	39	34	40	175	8,580	8,366	7,293

Program	Measure	Measure Life	Average Savings per Unit (kWh)	Demand per Unit (KW)	2018 Participation	2019 Participation	2020 Participation	Avg Incentive Paid Per Unit	Average Incremental Cost	2018 kWh Savings	2019 kWh Savings	2020 kWh Savings
Small Business Direct Install (SBDI)	Delamping with Lamp & Ballast Retrofit: 4-Lamp 4' T12/T8 to 3-Lamp 4' LED Tube	15	190.4	-	2	2	1	30	130	381	381	190
Small Business Direct Install (SBDI)	Delamping with Lamp & Ballast Retrofit: 4-Lamp 4' T12/T8 to 2-Lamp 4' LED Tube	15	353.6	0.0726	80	77	68	60	120	28,285	27,225	24,042
Small Business Direct Install (SBDI)	Delamping with Lamp & Ballast Retrofit: 3-Lamp 4' T12/T8 to 2-Lamp 4' LED Tube	15	158.1	-	2	2	1	30	100	316	316	158
Small Business Direct Install (SBDI)	Delamping with Lamp & Ballast Retrofit: 2-Lamp 4' T12/T8 to 1-Lamp 4' LED Tube	15	213.5	-	2	2	1	40	75	427	427	214
Small Business Direct Install (SBDI)	Delamping with Lamp & Ballast Retrofit: 4-Lamp 8' T12/T8 to 4-Lamp 4' or 2-Lamp 8' LED Tube	15	364.8	-	2	2	1	65	250	730	730	365
Small Business Direct Install (SBDI)	Delamping with Lamp & Ballast Retrofit w/Reflector: 2-Lamp 2' T12 U-tube to 2-Lamp 2' HP, 28W or 25W T8	15	108.0	0.0329	2	2	1	19	89	216	216	108
Small Business Direct Install (SBDI)	400W HID to High Bay LED ≤250W	15	589.9	0.1797	172	166	147	220	480	101,461	97,921	86,714
Small Business Direct Install (SBDI)	250W HID to High Bay LED ≤100W	15	716.6	0.1778	2	2	1	160	460	1,433	1,433	717
Small Business Direct Install (SBDI)	LED Exit Sign Fixture with Battery Backup	16	87.2	0.0077	641	621	548	60	88	55,923	54,178	47,810
Small Business Direct Install (SBDI)	4-Lamp 4' T12/T8 to LED Panel	15	286.6	-	2	2	1	50	155	573	573	287
Small Business Direct Install (SBDI)	3-Lamp 4' T12/T8 to LED Panel	15	214.9	-	2	2	1	40	145	430	430	215
Small Business Direct Install (SBDI)	2-Lamp 4' T12/T8 to LED Panel	15	93.3	-	2	2	1	40	135	187	187	93
Small Business Direct Install (SBDI)	ENERGY STAR® LED lamps 40W Equivalent	15	64.3	0.0293	279	270	238	12	33	17,951	17,372	15,313
Small Business Direct Install (SBDI)	ENERGY STAR® LED lamps 60W Equivalent	15	120.8	0.0337	913	884	780	22	7.38	110,272	106,769	94,208
Small Business Direct Install (SBDI)	ENERGY STAR® LED lamps 75W+ Equivalent	15	179.2	0.0536	2	2	1	32	35	358	358	179
Small Business Direct Install (SBDI)	ENERGY STAR® LED downlights - 40W Equivalent	15	94.3	0.0285	2	2	1	18	52	189	189	94
Small Business Direct Install (SBDI)	ENERGY STAR® LED downlights - 60W Equivalent	15	132.3	0.0371	5	5	4	27	57	661	661	529
Small Business Direct Install (SBDI)	ENERGY STAR® LED downlights - 75W+ Equivalent	15	205.3	0.0412	398	385	340	35	39	81,698	79,029	69,792
Small Business Direct Install (SBDI)	Delamp 1 lamp 8ft T12 lamp and ballast	10	278.1	-	2	2	1	50	34	556	556	278
Small Business Direct Install (SBDI)	Delamp 2 lamp 8ft T12 lamp and ballast	10	417.2	-	2	2	1	75	36	834	834	417
Small Business Direct Install (SBDI)	Delamp 4 lamp 8ft T12 lamp and ballast	10	834.3	-	2	2	1	75	38	1,669	1,669	834
Small Business Direct Install (SBDI)	Vending Machine Occ Sensor - Refrigerated Glass Front Cooler	5	1,208.9	-	2	2	1	200	178	2,418	2,418	1,209
Small Business Direct Install (SBDI)	Vending Machine Occ Sensor - Refrigerated Beverage	5	1,602.5	-	2	2	1	250	208	3,205	3,205	1,602
Small Business Direct Install (SBDI)	Occupancy Sensors - Ceiling Mount (must control 350 watts)	8	299.3	0.0630	5	5	4	60	170	1,496	1,496	1,197
Small Business Direct Install (SBDI)	Occupancy Sensors - Wall Mount (must control at least 200 watts)	8	250.2	0.0108	2	2	1	40	115	500	500	250
Small Business Direct Install (SBDI)	Occupancy Sensors - Fixture Mount (must control at least 100 watts)	8	154.6	0.0054	2	2	1	25	37	309	309	155
Small Business Direct Install (SBDI)	Exterior Wallpack: 175W HID to LED	15	470.4	0.0251	972	941	830	100	225.5	457,246	442,663	390,447
Small Business Direct Install (SBDI)	Exterior Wallpack: 176 W-250 W HID to LED	15	639.2	0.1236	172	166	147	115	310	109,946	106,111	93,965
Small Business Direct Install (SBDI)	Exterior Wallpack: 251 W-400 W HID to LED	15	1,066.7	0.0900	2	2	1	185	600	2,133	2,133	1,067
Small Business Direct Install (SBDI)	Exterior Canopy: less than 175W HID to LED	15	470.4	0.0251	632	612	540	100	190.4	297,304	287,896	254,025
Small Business Direct Install (SBDI)	Exterior Canopy: 176 W-250 W HID to LED	15	639.2	0.1236	132	128	113	115	272	84,377	81,820	72,232
Small Business Direct Install (SBDI)	Exterior Canopy: 251 W-400 W HID to LED	15	1,066.7	0.0900	2	2	1	185	600	2,133	2,133	1,067
Small Business Direct Install (SBDI)	Exterior Flood: less than 175W HID to LED	15	470.4	0.0251	778	753	664	100	188.33	365,985	354,224	312,357
Small Business Direct Install (SBDI)	Exterior Flood: 176 W-250 W HID to LED	15	639.2	0.1236	146	141	125	115	310	93,326	90,130	79,903
Small Business Direct Install (SBDI)	Exterior Flood: 251 W-400 W HID to LED	15	1,066.7	0.0900	2	2	1	185	600	2,133	2,133	1,067
Small Business Direct Install (SBDI)	Exterior Pole Mount: less than 175W HID to LED	15	470.4	0.0251	680	658	581	100	187.5	319,884	309,535	273,313
Small Business Direct Install (SBDI)	Exterior Pole Mount: 176 W-250 W HID to LED	15	639.2	0.1236	146	141	125	115	310	93,326	90,130	79,903
Small Business Direct Install (SBDI)	Exterior Pole Mount: 251 W-400 W HID to LED	15	1,066.7	0.0900	2	2	1	185	600	2,133	2,133	1,067
Small Business Direct Install (SBDI)	Exterior Pole Mount: 1000W HID to LED	15	3,536.6	0.6745	2	2	1	500	615	7,073	7,073	3,537
Small Business Direct Install (SBDI)	Exterior Other: less than 175W HID to LED	15	470.4	0.0251	534	517	456	100	63.75	251,203	243,206	214,510
Small Business Direct Install (SBDI)	Exterior Other: 176 W-250 W HID to LED	15	639.2	0.1236	119	116	102	115	140	76,067	74,150	65,200
Small Business Direct Install (SBDI)	Exterior Other: 251 W-400 W HID to LED	15	1,066.7	0.0900	2	2	1	185	600	2,133	2,133	1,067
Small Business Direct Install (SBDI)	EC (electronically commutated) Motor, Reach-in Refrigerator	15	325.0	0.0320	2	2	1	70	159	650	650	325
Small Business Direct Install (SBDI)	EC (electronically commutated) Motor, Reach-in Freezer	15	409.0	0.0340	2	2	1	90	159	818	818	409
Small Business Direct Install (SBDI)	EC (electronically commutated) Motor, Walk-in Refrigerator	15	354.0	0.0486	355	343	303	70	137	125,670	121,422	107,262
Small Business Direct Install (SBDI)	EC (electronically commutated) Motor, Walk-in Freezer	15	528.0	0.0560	4	4	3	90	180	2,112	2,112	1,584
Small Business Direct Install (SBDI)	Anti-Sweat Heater Controls - Refrigerator	12	540.0	-	2	2	1	110	300	1,080	1,080	540
Small Business Direct Install (SBDI)	Anti-Sweat Heater Controls - Freezer	12	1,277.0	-	2	2	1	220	360	2,554	2,554	1,277
Small Business Direct Install (SBDI)	Strip Curtain - Walk in Refrigerator	6	13.2	0.0500	35	34	30	2.25	14.5	462	448	396
Small Business Direct Install (SBDI)	Strip Curtain - Walk in Freezer	6	92.9	0.3400	35	34	30	15	14.5	3,253	3,160	2,788
Small Business Direct Install (SBDI)	Refrigerated Display Case Lighting 5' T12/T8 to LED - Refrigerator	8.1	332.0	0.0493	2	2	1	55	180	664	664	332
Small Business Direct Install (SBDI)	Refrigerated Display Case Lighting 5' T12/T8 to LED - Freezer	8.1	358.0	0.0856	2	2	1	55	180	716	716	358
Small Business Direct Install (SBDI)	Refrigerated Display Case Lighting 6' T12/T8 to LED - Refrigerator	8.1	450.0	0.0531	2	2	1	70	200	900	900	450
Small Business Direct Install (SBDI)	Refrigerated Display Case Lighting 6' T12/T8 to LED - Freezer	8.1	498.0	0.0923	2	2	1	70	200	996	996	498
Small Business Direct Install (SBDI)	Programmable Thermostat - Single Point - Electric Only	15	2,037.5	-	272	263	464	250	5	554,200	535,863	945,400
Small Business Direct Install (SBDI)	Programmable Thermostat - Multi Point - Electric Only	15	4,658.0	-	2	2	2	325	10	9,316	9,316	9,316
Small Business Direct Install (SBDI)	"Smart" Wi-Fi Thermostat - Single Point - Electric Only	15	2,037.5	-	2	2	2	400	50	4,075	4,075	4,075
Small Business Direct Install (SBDI)	"Smart" Wi-Fi Programmable Thermostat - Multi Point - Electric Only	15	4,658.0	-	2	2	2	450	100	9,316	9,316	9,316
Small Business Direct Install (SBDI)	Pre-Rinse Sprayer - Electric	5	3,727.2	-	2	2	1	100	0	7,454	7,454	3,727
Small Business Direct Install (SBDI)	Faucet Aerator - Electric	10	391.0	-	0	0	0	50	0	-	-	-
Small Business Direct Install (SBDI)	2x2 Fluorescent Fixture to LED Panel	15	144.0	0.0377	7	7	6	20	45.82	1,008	1,008	864
Total SBDI					**10,808**	**10,465**	**9,429**			**4,032,934**	**3,905,372**	**3,900,306**

Program	Measure	Measure Life	Average Savings per Unit (kWh)	Demand per Unit (KW)	2018 Participation	2019 Participation	2020 Participation	Avg Incentive Paid Per Unit	Average Incremental Cost	2018 kWh Savings	2019 kWh Savings	2020 kWh Savings
Multifamily Retrofit	Pre-Rinse Sprayer - Electric	5	3,727.2	-	0	0	0	100	0	-	-	-
Multifamily Retrofit	Faucet Aerator - Electric	10	391.0	-	1	1	1	50	0	391	391	391
Multifamily Retrofit	Exterior Pole Mount: 1000W HID to LED	15	3,536.6	0.6745	1	1	1	500	615	3,537	3,537	3,537
Multifamily Retrofit	Exterior Wallpack: 251 W-400 W HID to LED	15	1,066.7	0.0900	1	1	1	185	600	1,067	1,067	1,067
Multifamily Retrofit	Exterior Canopy: 251 W-400 W HID to LED	15	1,066.7	0.0900	1	1	1	185	600	1,067	1,067	1,067
Multifamily Retrofit	Exterior Flood: 251 W-400 W HID to LED	15	1,066.7	0.0900	1	1	1	185	600	1,067	1,067	1,067
Multifamily Retrofit	Exterior Pole Mount: 251 W-400 W HID to LED	15	1,066.7	0.0900	1	1	1	185	600	1,067	1,067	1,067
Multifamily Retrofit	Exterior Other: 251 W-400 W HID to LED	15	1,066.7	0.0900	1	1	1	185	600	1,067	1,067	1,067
Multifamily Retrofit	400W HID to High Bay LED ≤250W	15	589.9	0.1797	1	1	1	220	480	590	590	590
Multifamily Retrofit	250W HID to High Bay LED ≤100W	15	716.6	0.1778	0	0	0	160	460	-	-	-
Multifamily Retrofit	Exterior Wallpack: 176 W-250 W HID to LED	15	639.2	0.1236	4	4	4	115	310	2,557	2,557	2,557
Multifamily Retrofit	Exterior Canopy: 176 W-250 W HID to LED	15	639.2	0.1236	4	4	4	115	272	2,557	2,557	2,557
Multifamily Retrofit	Exterior Flood: 176 W-250 W HID to LED	15	639.2	0.1236	4	4	4	115	310	2,557	2,557	2,557
Multifamily Retrofit	Exterior Pole Mount: 176 W-250 W HID to LED	15	639.2	0.1236	4	4	4	115	310	2,557	2,557	2,557
Multifamily Retrofit	Exterior Other: 176 W-250 W HID to LED	15	639.2	0.1236	4	4	4	115	140	2,557	2,557	2,557
Multifamily Retrofit	Anti-Sweat Heater Controls - Freezer	12	1,277.0	-	0	0	0	220	360	-	-	-
Multifamily Retrofit	Exterior Wallpack: 175W HID to LED	15	470.4	0.0251	14	14	14	100	225.5	6,586	6,586	6,586
Multifamily Retrofit	Exterior Canopy: less than 175W HID to LED	15	470.4	0.0251	14	14	14	100	190.4	6,586	6,586	6,586
Multifamily Retrofit	Exterior Flood: less than 175W HID to LED	15	470.4	0.0251	14	14	14	100	188.33	6,586	6,586	6,586
Multifamily Retrofit	Exterior Pole Mount: less than 175W HID to LED	15	470.4	0.0251	14	14	14	100	187.5	6,586	6,586	6,586
Multifamily Retrofit	Exterior Other: less than 175W HID to LED	15	470.4	0.0251	14	14	14	100	63.75	6,586	6,586	6,586
Multifamily Retrofit	400W HID to High Bay Fluorescent 6-Lamp 4' HP, 28W or 25W T8	7	703.4	0.2116	1	1	1	125	300	703	703	703
Multifamily Retrofit	Anti-Sweat Heater Controls - Refrigerator	12	540.0	-	0	0	0	110	300	-	-	-
Multifamily Retrofit	250W HID to High Bay Fluorescent 4-Lamp 4' HP, 28W or 25W T8	7	519.9	0.1778	0	0	0	90	255	-	-	-
Multifamily Retrofit	Delamping with Lamp & Ballast Retrofit: 4-Lamp 8' T12/T8 to 4-Lamp 4' or 2-Lamp 8' LED Tube	15	364.8	-	0	0	0	65	250	-	-	-
Multifamily Retrofit	Vending Machine Occ Sensor - Refrigerated Beverage	5	1,602.5	-	0	0	0	250	208	-	-	-
Multifamily Retrofit	Refrigerated Display Case Lighting 6' T12/T8 to LED - Refrigerator	8.1	450.0	0.0531	0	0	0	70	200	-	-	-
Multifamily Retrofit	Refrigerated Display Case Lighting 6' T12/T8 to LED - Freezer	8.1	498.0	0.0923	0	0	0	70	200	-	-	-
Multifamily Retrofit	EC (electronically commutated) Motor, Walk-in Refrigerator	15	354.0	0.0486	0	0	0	70	137	-	-	-
Multifamily Retrofit	EC (electronically commutated) Motor, Walk-in Freezer	15	528.0	0.0560	0	0	0	90	180	-	-	-
Multifamily Retrofit	Refrigerated Display Case Lighting 5' T12/T8 to LED - Refrigerator	8.1	332.0	0.0493	0	0	0	55	180	-	-	-
Multifamily Retrofit	Refrigerated Display Case Lighting 5' T12/T8 to LED - Freezer	8.1	358.0	0.0856	0	0	0	55	180	-	-	-
Multifamily Retrofit	Vending Machine Occ Sensor - Refrigerated Glass Front Cooler	5	1,208.9	-	0	0	0	200	178	-	-	-
Multifamily Retrofit	Lamp & Ballast Retrofit: 2-Lamp 8' T12/T8 to 4-Lamp 4' or 2-Lamp 8' LED Tube	15	214.5	0.0433	2	2	2	40	175	429	429	429
Multifamily Retrofit	Occupancy Sensors - Ceiling Mount (must control 350 watts)	8	299.3	0.0630	1	1	1	60	170	299	299	299
Multifamily Retrofit	EC (electronically commutated) Motor, Reach-in Refrigerator	15	325.0	0.0320	0	0	0	70	159	-	-	-
Multifamily Retrofit	EC (electronically commutated) Motor, Reach-in Freezer	15	409.0	0.0340	0	0	0	90	159	-	-	-
Multifamily Retrofit	4-Lamp 4' T12/T8 to LED Panel	15	286.6	-	0	0	0	50	155	-	-	-
Multifamily Retrofit	Lamp & Ballast Retrofit: 1-Lamp 8' T12/T8 to 2-Lamp 4' or 1-Lamp 8' LED Tube	15	171.9	0.0353	21	21	21	30	132	3,609	3,609	3,609
Multifamily Retrofit	3-Lamp 4' T12/T8 to LED Panel	15	214.9	-	0	0	0	40	145	-	-	-
Multifamily Retrofit	Delamping with Lamp & Ballast Retrofit w/Reflector: 4-Lamp 8' T12 to 4-Lamp 4' or 2-Lamp 8' HP, 28W or 25W T8	15	505.3	0.1368	0	0	0	90	140	-	-	-
Multifamily Retrofit	Lamp & Ballast Retrofit: 4-Lamp 4' T12/T8 to 4' LED Tube	15	314.3	0.0645	14	14	14	50	140	4,400	4,400	4,400
Multifamily Retrofit	2-Lamp 4' T12/T8 to LED Panel	15	93.3	-	0	0	0	40	135	-	-	-
Multifamily Retrofit	Delamping with Lamp & Ballast Retrofit: 4-Lamp 4' T12/T8 to 3-Lamp 4' LED Tube	15	190.4	-	0	0	0	30	130	-	-	-
Multifamily Retrofit	Lamp & Ballast Retrofit: 3-Lamp 4' T12/T8 to 4' LED Tube	15	81.8	-	0	0	0	25	120	-	-	-
Multifamily Retrofit	Delamping with Lamp & Ballast Retrofit: 4-Lamp 4' T12/T8 to 2-Lamp 4' LED Tube	15	353.6	0.0726	3	3	3	60	120	1,061	1,061	1,061
Multifamily Retrofit	Occupancy Sensors - Wall Mount (must control at least 200 watts)	8	250.2	0.0108	0	0	0	40	115	-	-	-
Multifamily Retrofit	Delamping with Lamp & Ballast Retrofit w/Reflector: 2-Lamp 8' T12 to 2-Lamp 4' or 1-Lamp 8' HP, 28W or 25W T8	15	275.9	0.0631	1	1	1	50	110	276	276	276
Multifamily Retrofit	Lamp & Ballast Retrofit: 2-Lamp 8' T12 to 4-Lamp 4' or 2-Lamp 8' HP, 28W or 25W T8 w/ reflector	15	59.3	0.0230	1	1	1	25	108	59	59	59
Multifamily Retrofit	Delamping with Lamp & Ballast Retrofit: 4-Lamp 8' T12 to 4-Lamp 4' or 2-Lamp 8' HP, 28W or 25W T8	15	360.0	0.1368	0	0	0	60	105	-	-	-
Multifamily Retrofit	Lamp & Ballast Retrofit: 2-Lamp 8' T12 to 4-Lamp 4' or 2-Lamp 8' HP, 28W or 25W T8	15	41.6	0.0208	1	1	1	27	103	42	42	42
Multifamily Retrofit	Delamping with Lamp & Ballast Retrofit w/Reflector: 4-Lamp 4' T12 to 2-Lamp 4' HP, 28W or 25W T8	15	341.5	0.0910	35	35	35	60	58.51	11,951	11,951	11,951
Multifamily Retrofit	Lamp & Ballast Retrofit: 2-Lamp 4' T12/T8 to 4' LED Tube	15	74.4	-	0	0	0	25	100	-	-	-
Multifamily Retrofit	Delamping with Lamp & Ballast Retrofit: 3-Lamp 4' T12/T8 to 2-Lamp 4' LED Tube	15	158.1	-	0	0	0	30	100	-	-	-
Multifamily Retrofit	"Smart" Wi-Fi Programmable Thermostat - Multi Point - Electric Only	15	4,658.0	-	0	0	0	450	100	-	-	-

Program	Measure	Measure Life	Average Savings per Unit (kWh)	Demand per Unit (KW)	2018 Participation	2019 Participation	2020 Participation	Avg Incentive Paid Per Unit	Average Incremental Cost	2018 kWh Savings	2019 kWh Savings	2020 kWh Savings
Multifamily Retrofit	Lamp & Ballast Retrofit: 1-Lamp 8' T12 to 2-Lamp 4' or 1-Lamp 8' HP, 28W or 25W T8 w/ reflector	15	153.9	0.0246	1	1	1	20	93	154	154	154
Multifamily Retrofit	Delamping with Lamp & Ballast Retrofit w/Reflector: 4-Lamp 4' T12 to 3-Lamp 4' HP, 28W or 25W T8	15	247.1	0.0716	1	1	1	35	90	247	247	247
Multifamily Retrofit	Delamping with Lamp & Ballast Retrofit w/Reflector: 2-Lamp 2' T12 U-tube to 2-Lamp 2' HP, 28W or 25W T8	15	108.0	0.0329	1	1	1	19	89	108	108	108
Multifamily Retrofit	Lamp & Ballast Retrofit: 1-Lamp 8' T12 to 2-Lamp 4' or 1-Lamp 8' HP, 28W or 25W T8	15	110.7	0.0246	0	0	0	22	88	-	-	-
Multifamily Retrofit	Delamping with Lamp & Ballast Retrofit w/Reflector: 3-Lamp 4' T12 to 2-Lamp 4' HP, 28W or 25W T8	15	225.7	0.0675	1	1	1	40	88	226	226	226
Multifamily Retrofit	LED Exit Sign Fixture with Battery Backup	16	87.2	0.0077	1	1	1	60	88	87	87	87
Multifamily Retrofit	Lamp & Ballast Retrofit: 1-Lamp 4' T12/T8 to 4' LED Tube	15	112.9	0.0232	3	3	3	18	80	339	339	339
Multifamily Retrofit	Lamp & Ballast Retrofit: 4-Lamp 4' T12 to HP, 28W or 25W T8	15	116.5	0.0390	1	1	1	24	78	116	116	116
Multifamily Retrofit	Delamping with Lamp & Ballast Retrofit: 4-Lamp 4' T12 to 3-Lamp 4' HP, 28W or 25W T8	15	211.2	0.0648	0	0	0	35	75	-	-	-
Multifamily Retrofit	Delamping with Lamp & Ballast Retrofit: 4-Lamp 4' T12 to 2-Lamp 4' HP, 28W or 25W T8	15	264.9	0.0876	0	0	0	45	75	-	-	-
Multifamily Retrofit	Delamping with Lamp & Ballast Retrofit: 2-Lamp 4' T12/T8 to 1-Lamp 4' LED Tube	15	213.5	-	0	0	0	40	75	-	-	-
Multifamily Retrofit	Lamp & Ballast Retrofit: 3-Lamp 4' T12 to HP, 28W or 25W T8	15	104.1	0.0383	0	0	0	20	70	-	-	-
Multifamily Retrofit	Delamping with Lamp & Ballast Retrofit: 3-Lamp 4' T12 to 2-Lamp 4' HP, 28W or 25W T8	15	199.8	0.0611	0	0	0	35	57	-	-	-
Multifamily Retrofit	Delamping with Lamp & Ballast Retrofit w/Reflector: 2-Lamp 4' T12 to 1-Lamp 4' HP, 28W or 25W T8	15	149.2	0.0404	1	1	1	25	57	149	149	149
Multifamily Retrofit	ENERGY STAR® LED downlights - 60W Equivalent	15	132.3	0.0371	1	1	1	27	57	132	132	132
Multifamily Retrofit	ENERGY STAR® LED downlights - 75W+ Equivalent	15	205.3	0.0412	12	12	12	35	39	2,463	2,463	2,463
Multifamily Retrofit	Lamp & Ballast Retrofit: 2-Lamp 4' T12 to HP, 28W or 25W T8	15	85.4	0.0228	4	4	4	15	56	341	341	341
Multifamily Retrofit	ENERGY STAR® LED downlights - 40W Equivalent	15	94.3	0.0285	1	1	1	18	52	94	94	94
Multifamily Retrofit	Lamp & Ballast Retrofit: 1-Lamp 4' T12 to HP, 28W or 25W T8	15	64.0	0.0171	3	3	3	12	51	192	192	192
Multifamily Retrofit	Delamping with Lamp & Ballast Retrofit: 2-Lamp 4' T12 to 1-Lamp 4' HP, 28W or 25W T8	15	137.3	0.0246	0	0	0	25	50	-	-	-
Multifamily Retrofit	"Smart" Wi-Fi Thermostat - Single Point - Electric Only	15	2,037.5	-	0	0	0	400	50	-	-	-
Multifamily Retrofit	2x2 Fluorescent Fixture to LED Panel	15	144.0	0.0377	1	1	1	20	45.82	144	144	144
Multifamily Retrofit	Delamp 4 lamp 8ft T12 lamp and ballast	10	834.3	-	0	0	0	75	38	-	-	-
Multifamily Retrofit	Occupancy Sensors - Fixture Mount (must control at least 100 watts)	8	154.6	0.0054	0	0	0	25	37	-	-	-
Multifamily Retrofit	Delamp 2 lamp 8ft T12 lamp and ballast	10	417.2	-	0	0	0	75	36	-	-	-
Multifamily Retrofit	ENERGY STAR® LED lamps 60W Equivalent	15	120.8	0.0337	28	28	28	22	7.38	3,382	3,382	3,382
Multifamily Retrofit	ENERGY STAR® LED lamps 75W+ Equivalent	15	179.2	0.0536	1	1	1	32	35	179	179	179
Multifamily Retrofit	Delamp 1 lamp 8ft T12 lamp and ballast	10	278.1	-	0	0	0	50	34	-	-	-
Multifamily Retrofit	ENERGY STAR® LED lamps 40W Equivalent	15	64.3	0.0293	9	9	9	12	33	579	579	579
Multifamily Retrofit	Strip Curtain - Walk in Refrigerator	6	13.2	0.0500	0	0	0	2.25	14.5	-	-	-
Multifamily Retrofit	Strip Curtain - Walk in Freezer	6	92.9	0.3400	0	0	0	15	14.5	-	-	-
Multifamily Retrofit	Programmable Thermostat - Multi Point - Electric Only	15	4,658.0	-	0	0	0	325	10	-	-	-
Multifamily Retrofit	Programmable Thermostat - Single Point - Electric Only	15	2,037.5	-	7	7	14	250	5	14,263	14,261.50	28,525
Total Multifamily Retrofit					**255**	**255**	**262**			**101,590**	**101,589**	**115,853**
CVR Commercial		**15**	**1,850.6**	**0.3330**			**558**					**1,032,656**
Total C&I										**15,135,729**	**16,043,561**	**17,053,516**
Portfolio Total										**36,656,341**	**38,069,187**	**36,347,642**