IMPACTS OF REGULATIONS ON EMPLOYMENT

Examining EPA's Oft-Repeated Claims that Regulations Create Jobs

U.S. CHAMBER OF COMMERCE

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OVERVIEW

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Over the last four years, the U.S. Environmental Protection Agency (EPA) has often claimed that its new major, economically significant regulations create jobs. As industries have announced job layoffs due to the newly issued regulations and the claims that job creation continued, it became necessary to undertake a study to understand how EPA reached its conclusions as well as the soundness of its findings that its regulations create jobs. To better understand the employment impacts of environmental regulations, the Chamber in 2012 commissioned the economic research firm NERA to undertake a study to review and assess EPA's methods for estimating employment impacts related to air quality regulations.

The Impact of Regulations on Employment

The impact of regulations on jobs has been debated in Congress for more than 45 years. The earliest discussion of the impact of regulations on jobs is found during the congressional debate over the Air Quality Act of 1967. As part of the debate, Congress mandated a comprehensive study of the economic impacts of air quality standards on the nation's industries and communities. A decade later, Congress mandated that the EPA administrator study the potential dislocation of employees due to the implementation of environmental laws. This mandate was codified by Congress in Section 321(a) of the Clean Air Act, which requires EPA to conduct continuing evaluations of potential loss and shifts in employment that may result from the implementation and enforcement of the Clean Air Act. Unfortunately, EPA has ignored this congressional mandate, thus depriving Congress of a significant body of data that would shed light on the impact of regulations on jobs and employment.

In 2001, Justice Scalia, writing for a near unanimous U.S. Supreme Court in *Whitman v. American Trucking Associations*, clearly analyzed the regulations versus employment debate:

> [T]he economic cost of implementing a very stringent standard might produce health losses sufficient to offset the health gains achieved in cleaning the air – for example, by closing down whole industries and thereby impoverishing the workers and consumers dependent upon those industries. That is unquestionably true, and Congress was unquestionably aware of it. Thus, Congress had commissioned in the Air Quality Act of 1967 (1967 Act) 'a detailed estimate of the cost of carrying out the provisions of this Act; a comprehensive study of the economic impact of air quality standards on the Nation's industries, communities and other contributing sources of pollution.' Sec.2, 81 Stat. 505. The 1970 Congress, armed with the results of this study, see The Cost of Clean Air, S. Doc. No. 91 – 40 (1969) not only anticipated compliance costs could injure the public health, but provided for that precise exigency.[1]

[1] *Whitman v. American Trucking Associations,* 531 U.S. 457 (2001) at 466.

Subsequently, when EPA issued a large number of regulations in 2009, six U.S. senators wrote to EPA requesting the results of its Section 321(a) continuing evaluation of potential loss or shifts of employment that would result from those new regulations. On October 26, 2009, EPA responded to the six senators stating "EPA has not interpreted CAA Section 321 to require EPA to conduct employment investigations in taking regulatory actions."

Therefore, an inquiry that started 45 years ago when Congress sought to understand the employment effects of regulations is still unresolved. Congress has been left without the continuing evaluation of job loss and shifts in employment due to regulations. The study is intended to review and assess EPA's methods for evaluating employment impacts from new air quality regulations.

Summary Results of the Study

NERA found that EPA discussed the employment impacts of proposed air quality regulations in only 11 of the 48 rulemakings over the 1995 through 2010 period. After 2010 (since the issuance of Executive Order 13563), EPA discussed employment impacts in 7 of 9 rulemakings. NERA reviewed each regulatory impact analysis to determine the economic methodologies used and evaluated their adequacy.

The study reveals striking omissions and inconsistencies in EPA's analyses. While the study found that many recent EPA regulatory analyses claimed job-creating net benefits for new air quality rules, NERA found that the approach on which EPA based such optimistic forecasts was flawed in several ways:

- EPA's analyses use a jobs impact formula that relies on aggregated data from four individual industries that do not mirror the industries targeted by recent EPA rules and which was derived from 1980s data that are no longer relevant for assessing current impacts.
- The methods used by EPA considered only part of the potential overall employment impacts.
- EPA's partial analysis methods ignored the effects of regulatory compliance costs on prices.

NERA concluded that the correct approach for assessment of the overall economic and employment impacts of rules with large economy wide costs is to model the impact of regulation compliance cost through a whole-economy model. This approach takes into account the cascading effects of a regulatory change across interconnected industries and markets nationwide. NERA found that EPA possesses the capability to perform such whole-economy modeling and had actually done so in connection with two rulemakings in 2005. EPA's failure to use the more comprehensive economic analysis tool in its rulemakings partially accounts for the agency's consistently optimistic estimates of employment impacts in those rulemakings.

NERA applied the whole-economy approach to estimate the impact of EPA's 2011 Utility Mercury and Air Toxics Standard (MATS). EPA's partial-economy analysis showed that regulation would create 46,000 temporary construction jobs and 8,000 net new permanent jobs. By contrast, NERA's whole-economy analysis estimated that the MATS rule would have a negative impact on worker incomes equivalent to 180,000 to 215,000 lost jobs in 2015, and the negative worker income impacts would persist at the level of 50,000 to 85,000 such "job-equivalents" annually thereafter.

NERA also analyzed three other EPA rules using the whole-economy model and found similar results of adverse employment effects:

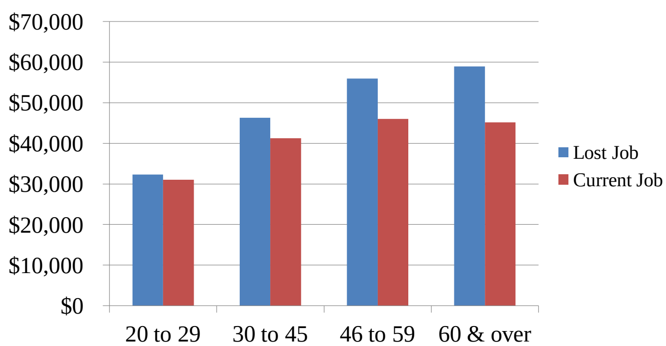
- EPA's Cross State Air Pollution rule would have an impact on worker incomes equivalent to the annual loss of 34,000 jobs from 2013 through 2037, compared with EPA's claim of 700 jobs per year gained.
- EPA's Industrial Boiler Maximum Achievable Technology (MACT) rule would have a negative impact on worker incomes equivalent to 28,000 jobs per year on average from 2013 through 2037, compared to EPA's claim of 2,200 per year gained.
- EPA's planned ozone National Ambient Air Quality Standard (NAAQS) would reduce worker incomes by the equivalent of 609,000 jobs annually on average from 2013 through 2037. EPA has not yet published an employment impact for the ozone NAAQS.

The details of NERA's analyses are contained in the report and appended case study summaries.

The Impacts of Regulations on Displaced Workers

Post-Displacement Jobs Pay Less

Annual earnings before and after job loss, January 2012. Full-time workers who were displaced between 2009–2011.



Regulators typically assume that workers who are displaced from long-held jobs by regulations will find new work quickly. In reality, unemployment often has serious, continuing impacts on workers and their families. In addition to loss of income, many workers never return to full-time work, and those who do return to full-time work often earn less than previous wage levels long after reemployment. The Bureau of Labor Statistics' Displaced Worker Survey in January 2012 found that among the 6.1 million workers who lost long-tenured jobs between 2009 and 2011, 44% were still unemployed up to three years later. Of those who found full-time reemployment, 54% were earning less than their prior jobs had paid, and a full one-third were earning at least 20% less.

Conclusion

The past 40 years have seen significant declines in the copper mining, steel, textile, furniture, coal mining and forest products industries. While a variety of factors have played a role in the decline of these industries, a common thread running through all of them has been the role of regulatory mandates and costs. Even when regulations are not the primary cause of change, regulations imposed on an industry can provide the tipping point that leads to plant closures and adverse economic impacts that otherwise might have been avoided or cushioned over time. While EPA continues to issue regulations to protect the environment, it must also be forthcoming and provide Congress and the American people with methodologically complete estimates of the impact its regulations may have on jobs and communities.

Timeline of Air Regulatory Impact Analyses Found to Contain Employment Impact Estimates

Year of RIAs	EPA Rule
1997	Locomotive Emission Standards
	Ozone and $PM_{2.5}$ NAAQS
	Medical Waste Incinerators NSPS
	Highway Heavy-Duty Engines
	Pulp & Paper NESHAP
1998	NOx SIP Call & Section 126 Petitions
	Non-Road Diesel Engines
	New Fossil-Fuel-Fired Steam Generating Units
	National VOC Standards
1999	Phase 2 Nonroad Non-Handheld SI Engines
	Regional Haze Rule
	Gasoline Sulfur Control Requirements
	Section 126 Petition
2000	Phase 2 Nonroad Handheld SI Engines
	2004+ Model Year Highway Heavy-Duty Engines
	Stratospheric Ozone Reductions
	Heavy-Duty Engine & Fuel Control Requirement
2001	
2002	Nonroad & Recreational Spark-Ignition Engines
2003	PSD & NSR: Routine Maintenance and Repair
2004	**Auto. & Light-Duty Vehicle NESHAP**
	Industrial Boilers & Process Heaters NESHAP
	Stationary Reciprocating IC Engine NESHAP
	Plywood & Composite Wood Products NESHAP
	Nonroad Diesel Rule
2005	**Clean Air Interstate Rule**
	Clean Air Mercury Rule
	Clean Air Visibility Rule/BART Guidelines
2006	Sec 126 Petition NC; Revs to CAIR & Acid Rain Pgm
	Stationary Compression Ignition IC Engine NSPS
	$PM_{2.5}$ NAAQS
2007	Control of HAP from Mobile Sources
	Clean Air Fine Particle Implementation Rule
2008	Ozone NAAQS
	Petroleum Refineries NSPS
	Locomotive & Marine Diesel Engines < 30 L/cyl
	Lead NAAQS
	Nonroad Spark-Ignition Engines and Equipment
2009	Marine CI Engines Emissions Stds >30 L/cyl
	GHG Mandatory Reporting Rule
2010	Ozone NAAQS Reconsideration
	NO_2 NAAQS
	Existing Stationary Comp-Ignit. Engines NESHAP
	Title V Greenhouse Gas Tailoring Rule and GHG PSD
	Light-Duty Vehicle GHG & CAFE Standard
	SO_2 NAAQS
	Existing Stationary Spark-Ignit. Engines NESHAP
	Portland Cement NSPS & NESHAP
2011	Sewage Sludge Incineration NSPS
	Industrial Boiler NESHAP
	Industrial Solid Waste Incinerator NSPS
	Chlor Alkali Plant Hg Emissions NESHAP
	Cross-State Air Pollution Rule
	Oil & Gas Industry NSPS & NESHAP
	Heavy-Duty Vehicle GHG & CAFE Std
	Manganese Ferroalloys RTR
	Utility Mercury and Air Toxics Std

Employment Impact Provided Using Partial Analysis

Employment Impact Provided Using Computable General Equilibrium Analysis

If no green or orange, EPA did not provide an employment impact estimate

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The U.S. Chamber of Commerce is the world’s largest business federation representing the interests of more than 3 million businesses of all sizes, sectors, and regions, as well as state and local chambers and industry associations.

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EXECUTIVE SUMMARY

Although employment impacts *per se* are not viewed as either benefits or costs in standard benefit-cost analysis, they are a regulatory impact of substantial interest to policymakers and the public. Employment impacts are also conceptually complex and frequently discussed in oversimplified ways, leading to chronic misunderstanding. Often, analysts simply report an estimate of "jobs lost" or "jobs gained" with little or no explanation of what type of estimate has been performed, or of the limitations of that particular type of estimate. Frequently the reported estimate is based only on a "partial" analysis of the avenues by which employment may be affected. Partial estimates of a regulation's "job impacts" can be either positive or negative, depending on which aspects of the policy's impacts have been omitted from the analysis. Consumers of the policy analyses are left to sort out for themselves why opposing sides of the regulatory debate can come up with directionally inconsistent estimates.

Even if the estimate is based on a comprehensive analysis, policymakers and the public cannot be expected to gain much insight about a regulation's impacts on employment when they are provided only estimates of numbers of "jobs affected." This is a misleadingly simplistic metric that does not begin to reflect the true issues and concerns that regulations pose for employment opportunity. Some of the important concerns that simplistic "jobs affected" estimates fail to address are:

- Whether the impact is to reduce the wage rate that would otherwise be earned by workers, to change the number of hours of work per week, or literally to eliminate job openings.
- Whether the impact will come in the form of layoffs, or via reduced growth in new job positions.
- Whether new employment opportunities created by the regulation will call upon the same sets of skills and education as the employment opportunities ended by the regulation.
- Whether wage rates for lost hours of work are greater or less than wage rates for hours of work gained – in other words, whether lower paying jobs are replaced with higher paying jobs, or vice versa.
- In the case of an economy with current underemployment:
    - Whether the new employment opportunities match the skills and capabilities of those who are in need of work, or simply increase the demand for individuals with skills not greatly affected by the downturn.
    - Whether the change in employment opportunities is expected to occur during or after the anticipated end of the downturn.
- Whether the projected employment impacts would be of short duration (as in the case of transition to a new equilibrium) or permanent (as in the case of reduced productivity of the economy).

This paper reports on a study to review and evaluate the practices of one major U.S. regulatory agency in estimating the employment impacts of its regulations, and in communicating about those impacts to policymakers and the public. The methodologies found are evaluated in their own right, and also in the context of the full set of relevant concerns listed above, to identify areas for improvement. This review focuses on how the U.S. Environmental Protection Agency (EPA) has been estimating the employment impacts of its air regulations in the Regulatory Impact Analyses (RIAs) that EPA must provide to the Office of the President for all of its major regulations.

In this review, we consider the methods EPA has applied dating back to 1997, when the fine particulate matter ($PM_{2.5}$) National Ambient Air Quality Standard (NAAQS) was first promulgated. RIAs extend farther back in time, but the first $PM_{2.5}$ NAAQS rule can be considered a turning point in the magnitude and scope of EPA air regulation. This natural breakpoint, and a desire to avoid reviewing practices that may be obsolete, led us to limit our review of air regulation RIAs to those dating 15 years back.

Our findings regarding EPA's employment impact estimation practices in that fifteen-year record of air RIAs are as follows:

- Until 2011, EPA only intermittently provided employment impact estimates in its RIAs. The shift coincides with an amendment to the Executive Order mandating RIAs that specifically mentions "job creation" as an important concern to address in RIAs. For the years prior to 2011, we could not discern why some RIAs provided employment impact estimates and others did not.
- With only two exceptions (in 2005), EPA's employment impacts estimates have been narrowly limited to job counts, and have been "partial" estimates, meaning none of them have addressed the impact of a regulation's costs on the rest of the economy beyond those sectors directly bearing the compliance costs and their suppliers.[1]
- Although some of the job estimates have shown net job losses, the majority of them have reported net gains. This is traceable to the partial nature of those estimates.
- In some cases, job impact estimates are provided separately for short-term jobs associated with the period in which compliance investments are being made, and longer-term job impacts after the construction demand spike of capital investments for compliance. In other cases, it is unclear exactly what types of job counts have been reported.
- Over the years there has been little attempt in the RIAs to explain or explore the broader set of issues that exist with regard to employment impacts. EPA did not elucidate these issues even in the two RIAs in 2005 that did provide a different type of labor impact estimate than job counts.

[1] The two exceptions were for the Clean Air Interstate Rule (CAIR) and for the Clean Air Visibility Rule and Best Available Retrofit Technology Guidelines (CAVR/BART). Both of these RIAs were released in 2005, and both used a method called Computable General Equilibrium (CGE) modeling, which addresses labor market impacts in the context of the full economy and full employment. CGE models do not directly measure employment impacts in the form of "job counts." More on this point is discussed below.

Below we discuss three overarching conclusions about EPA's employment impact estimation methods and areas for improvement in the future:

(i) EPA makes insufficient use of full-economy models.

(ii) EPA makes excessive and inappropriate use of a 2002 paper by Morgenstern, Pizer, and Shih as a basis for its most recent job impact estimates.

(iii) EPA needs explicit and sound method selection criteria that will be consistently applied in future RIAs.

Insufficient Use of Full-Economy Modeling. A comprehensive assessment of labor impacts across the entire economy requires a full-economy model. This class of model can address how compliance costs that are passed from the regulated businesses to their customers may affect downstream businesses. Economists consider computable general equilibrium (CGE) models as the most appropriate for this task.

EPA has several CGE models available for use in its RIAs, and has used them for two air rules that we reviewed. Those RIAs, both issued in 2005, were for the Clean Air Interstate Rule (CAIR), and for the Clean Air Visibility Rule and Best Available Retrofit Technology Guidelines (CAVR/BART). In both instances, EPA noted that the rule would have effects on energy prices that could impact energy-purchasing companies across the rest of the economy not directly facing compliance obligations under that rule. This is the type of situation in which use of a full-economy modeling approach is important. In both of those RIAs, the net effect of the regulations on labor was reported to be effectively nil.[2] These results stand in contrast to EPA's partial impact analyses in all of the other RIAs (which mostly project positive job impacts).

Despite the two examples of CGE modeling found in the RIA record, EPA has not been consistent in its decision on when it is appropriate to use CGE modeling. EPA appeared to choose the CGE approach for CAIR and CAVR/BART when it concluded that the regulations might have significant costs that could be passed through to other sectors of the economy. Yet, EPA used partial impact analyses for its analyses of two of the most costly air rules covered in this review: the 1997 $PM_{2.5}$ NAAQS rule and the 2011 Utility Mercury and Toxic Substances (MATS) rule. EPA chose not to use a CGE approach for the latter two rules even though it had estimated direct compliance costs for both that were about four times larger than EPA's estimated costs for CAIR or CAVR/BART. As a result of applying only partial analysis methods, EPA reported large positive job impacts for MATS and the 1997 $PM_{2.5}$ NAAQS – the two most expensive of all its air rules. There was no technical reason why EPA could not have performed a CGE-based analysis of its own for all of its large rules, as it had the tools available in-house to do so. In both cases, analyses by outside parties that considered the full-economy impacts of their cost increases found a net negative impact to labor in the U.S. as a whole (see Smith *et al.*, 1997, and Smith *et al.*, 2012). Section V of this report compares the CGE analysis of the MATS rule (Smith *et al.*, 2012) to EPA's partial analysis of MATS.

[2] EPA's CGE analysis results are not internally consistent, however, which raises questions about their quality. This issue is discussed further in the body of this paper.

<u>Excessive Use of Morgenstern, Pizer and Shih (2002).</u> A 2002 paper by Morgenstern, Pizer, and Shih (MPS) applies sophisticated econometric methods to develop an *ex post* empirical estimate of the labor spending impacts of early environmental regulations on four specific sectors of the economy (steel, pulp and paper, plastics, and petroleum). This econometric analysis of past regulations accounts for three different ways that a sector's total labor expenditures could have been affected by the costs of a regulation. MPS's results varied by sector, and the average net effect over all four sectors had a confidence interval spanning from negative to positive, although the central estimate that was slightly positive. MPS concluded that their analysis suggested that past regulations had not caused any significant change in total payments to workers in those affected industries.

Starting in 2010, EPA adopted the slightly positive but statistically-insignificant four-sector average estimate from MPS as a simple multiplier, which EPA then used to generate job impact estimates in its RIAs for a wide range of *different* types of sectors and regulations than those studied by MPS. This "MPS-based" multiplier method is not appropriate for all such applications, and EPA is aware of that. For example, in two of its RIAs released in 2011, EPA chose not to use the MPS-based approach on the sound grounds that the affected sectors were different from the four studied in MPS. However EPA has not been consistent in its decisions about when to apply the MPS-based approach, just as it has not been consistent in when it chooses to apply CGE. EPA has provided an MPS-based estimate of job impacts in several other RIAs in which the regulated sectors also were very different from the four MPS studied. Most salient of these is the RIA for the Utility MATS rule. As explained above, this rule was costly enough to warrant a full-economy analysis based on EPA's own criteria for employing its CGE models; instead EPA used the MPS-based approach for MATS, even though the utility sector affected by MATS is nothing like the four sectors that MPS studied. The result was that EPA reported that the Utility MATS rule would generate a small net job increase over the long-term. Section V demonstrates how a full-economy, CGE approach indicates a much different conclusion.

EPA's recent use of estimates in the MPS paper to extrapolate to sectors and rules far from its empirical base is clearly inappropriate. As a consequence, results for specific RIAs such as the Utility MATS rule are not credible. In any event, the MPS approach is a partial analysis and thus omits impacts that happen beyond the directly affected sector(s). By conducting major analyses that are inconsistent with sound methodology-selection criteria, EPA undercuts the confidence one can place in its RIAs.

<u>A Constructive Path Forward</u>. The path to greater credibility demands that the economics profession articulate explicit model-selection criteria, and that EPA adhere to those criteria. In our opinion, full-economy modeling using CGE methods is always the more credible choice. Discrepancies between full-economy modeling and a partial analysis may be relatively small when the regulation is relatively narrow in scope. However, CGE analyses should be required for any regulation that affects the costs of inputs to large parts of our economy, such as any regulation affecting energy supply. EPA has the relevant tools and know-how to accomplish this.

In addition, RIAs (and all other related regulatory impact analyses within or beyond the Agency) would benefit greatly from more thoughtful discussion of the many important attributes of employment impacts other than a simple "job count." When job counts are provided, an explanation of the range of types of impacts on labor that might be implicit in "a job" should be provided. Any employment impact estimate based on a partial analysis should be explicitly caveated that it counts only direct job gain or losses and that any offsetting effects in the rest of the economy are ignored.

This study's review was limited to EPA's employment impact estimation practices in its RIAs for air rules. To the extent that non-governmental groups have adopted the same methods as those in EPA's air RIAs, points made in this report also may be useful for interpreting those other studies and estimates. Assessments of other methods that were not covered in this study (because EPA has not used them) could be helpful additional research. An even higher priority for further research, however, would be to advance new methods for assessing the range of employment impact attributes listed at the outset of this Executive Summary. Without such research, policy discussions about employment impacts will continue to be anchored to misleading and misunderstood estimates of "job counts."

I. INTRODUCTION

Regulations force a change in the economy by requiring companies to change their practices to meet new guidelines or standards. In theory, a case exists for governments to regulate when there is a clear market failure. An example is when the unconstrained operation of private incentives in a free market leads to detrimental impacts on others that occur outside of market transactions. This phenomenon is called a "negative externality." Properly designed, regulation to address negative externalities or other market failures will balance the incremental costs to the regulated parties with the incremental benefits to individuals across society at large. Benefit-cost analysis (BCA) is the method developed by economists to help guide this balancing act. If this balancing act is accomplished successfully, the overall welfare of the society can be improved relative to the situation with no regulation on the externality.

Even the best designed regulations, however, can have an impact on employment. Although employment impacts *per se* are not viewed as either benefits or costs in standard BCA practice, they are a regulatory impact of substantial interest to policymakers and the public. This category of regulatory impact is also conceptually complex and frequently discussed in oversimplified ways leading to chronic misunderstanding. Often, analysts simply report an estimate of "jobs lost" or "jobs gained" with little or no explanation of what type of estimate has been performed, or of the limitations of that particular type of estimate.

This study was designed to provide a review of the practices of one major U.S. regulatory agency in estimating and communicating the employment impacts of its own regulations. The review focuses on how the U.S. Environmental Protection Agency (EPA) has been estimating the employment impacts of its air regulations. In particular, it seeks to determine whether EPA's assessments of employment impacts have been complete, and, if not, to identify what has been left out.

One of the main avenues where EPA has assessed the employment impacts of its regulations is in regulatory impact assessments (RIAs).[3] RIAs are intended to provide a structured assessment of the costs, benefits, and impacts of individual regulations. In this review, we consider methods EPA has applied in its air RIAs dating back to 1997, when the first $PM_{2.5}$ NAAQS rule was promulgated. RIAs extend back farther in time, but the first $PM_{2.5}$ standard can be considered a turning point in the magnitude and scope of EPA air regulation. This natural breakpoint, in addition to a desire to avoid excessive effort reviewing practices that may be obsolete, caused us to limit our review of air regulation RIAs to those dating 15 years back.

RIAs have evolved over the years; a review of their purpose and history informs their current role in the regulatory process. Federal regulatory agencies are required by Executive Order (EO)

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[3] EPA is also required to consider employment effects as part of the original enabling legislation under the Clean Air Act, but has apparently not done so. 42 USC 85:III § 7621: "(a) **Continuous evaluation of potential loss or shifts of employment -** The Administrator shall conduct continuing evaluations of potential loss or shifts of employment which may result from the administration or enforcement of the provision of this chapter and applicable implementation plans, including where appropriate, investigating threatened plant closures or reductions in employment allegedly resulting from such administration or enforcement."

to submit RIAs for all "significant" regulations to the Office of Management and Budget.[4] (Independent agencies, such as the Securities and Exchange Commission or the Federal Trade Commission, are exempt from the requirement to produce RIAs.) The first formal requirement for RIAs dates back to 1981 when President Ronald Reagan issued EO 12291. EO 12291 required that each new major rule be demonstrated, in an RIA, to provide greater benefits than its costs.[5] Because employment impacts are not viewed as either benefits or costs in standard BCA, and given the original focus of the RIA requirement on BCA specifically, early RIAs did not always make an effort to address employment impacts. This situation largely continued to be the case when President Clinton replaced EO 12291 with EO 12866 in 1993.[6] In 2011, however, President Barack Obama issued EO 13563 to supplement EO 12866. EO 13563 states that "our regulatory system must protect public health, welfare, safety, and our environment while promoting economic growth, innovation, competitiveness, *and job creation*."[7] It was only with this recent amendment that EPA started to *routinely* include estimates of employment impacts in its RIAs.[8]

Given this background information on RIAs, the rest of this paper undertakes a review and comments on how employment impacts have been estimated in EPA's air rule RIAs. Section II provides a brief discussion from an economics perspective of the key concerns and attributes of a comprehensive assessment of employment impacts, to establish some context for understanding the scope of EPA's actual practices. Section III describes a particular estimation method that EPA has been relying on since 2010, based on an empirical analysis by Morgenstern, Pizer, and

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[4] As spelled out in EO 12866, ''Significant regulatory action'' means any regulatory action that is likely to result in a rule that may: (1) Have an annual effect on the economy of $100 million or more or adversely affect in a material way the economy, a sector of the economy, productivity, competition, jobs, the environment, public health or safety, or State, local, or tribal governments or communities; (2) Create a serious inconsistency or otherwise interfere with an action taken or planned by another agency; (3) Materially alter the budgetary impact of entitlements, grants, user fees, or loan programs or the rights and obligations of recipients thereof; or (4) Raise novel legal or policy issues arising out of legal mandates, the President's priorities, or the principles set forth in this Executive order."

[5] Section 2 of EO 12291 specifically required, inter alia, that "(b) Regulatory action shall not be undertaken unless the potential benefits to society for the regulation outweigh the potential costs to society; (c) Regulatory objectives shall be chosen to maximize the net benefits to society; (d) Among alternative approaches to any given regulatory objective, the alternative involving the least net cost to society shall be chosen." These are overtly the requirements of standard BCA-based decision making.

[6] However, EPA's *Statutory and Administrative Requirements for Economic Analysis of Regulations* do indicate an awareness that employment impacts were a relevant consideration in RIAs. EPA's document states: "The first set of impacts to be included in an assessment of a regulation are those specifically cited in EO 12866. Many of these impacts may be addressed in an economic analysis; however, the analyst may find it desirable to address some of these impacts separately, depending on the nature of the regulation under consideration. The impact analysis requirements mentioned in EO 12866 include the impact of the regulation on: the efficient functioning of the economy and private markets, including productivity, employment, and competitiveness; distribution of impacts and equity; and discrimination or bias."

[7] EO 13563, Section 1, emphasis added.

[8] It is important to note that, guidance on the merits and intention of the regulation notwithstanding, the ultimate RIA is at the discretion of the agency. The RIA is not subject to any formal public or peer review process other than review by OMB's Office of Information and Regulatory Affairs (OIRA).

Shih (2002). Section IV then summarizes the trends observed in EPA's methods for estimating employment impacts in air RIAs, and comments on them. Section V illustrates the insufficiency of EPA's "partial analysis" method with a specific example of a more comprehensive analysis for the Utility MATS rule. Section VI concludes with recommendations.

II. WHAT IS AN EMPLOYMENT IMPACT?

An employment impact is a difficult concept to characterize and measure. All relevant measures of economic impact are tied to either a consumer welfare measure or to a distributional impact. From a consumer welfare standpoint (which is the foundation of the benefit-cost paradigm), the most relevant measure for employment impacts is the change in income from employment, or the "payments to labor." This can take many different forms, however, including loss in average wage rates without any actual loss of jobs. However, much of the analysis of regulatory employment impacts emphasizes a different measure: a "number" of jobs lost or gained. Such a metric lacks a recognition that employment impacts emerge in many different forms, such as shifts between higher-paying and lower-paying jobs, between the mix of full-time and part-time jobs, and in the distribution of local employment and its implication for net national changes.

To assess employment impacts with accuracy, one might wish to build a model to account for every business and every market relationship in the economy; but the data necessary for such an undertaking makes it impractical. Instead, economists take two paths in economic impact modeling: a "top-down" approach and a "bottom-up" approach. A top-down approach approximates the relationships between all the activities in the economy, grouped as "sectors," and simulates what happens if something changes (*e.g.*, a new regulation). A bottom-up approach starts with a particular sector of the economy – the industry directly subject to a new regulation – and approximates the links between that sector and other sectors. The bottom-up approach usually ends up limited to a few closely-related sectors, due to the data complexity that it entails, and is thus often characterized as a "partial" market analysis.

There are drawbacks to either approach; their suitability depends on the specific regulation. In the case of a small sector that supplies to narrow niches of the rest of the economy, a partial bottom-up approach might be suitable. An approach that does not account for price-related impacts throughout the economy may be sufficient if those effects are so small as to be immaterial to the economy at large. In contrast, a new regulation affecting the production of electricity or other products consumed by most homes and businesses is more likely to require a model of the entire economy. This is a situation more suitable for a top-down approach.

A. Partial / Direct Approach

A partial approach accounts for only a portion of the economy: typically, the directly-regulated sector and the sectors that supply it. Partial approaches to employment impact estimation include narrow 'compliance cost' accountings, which measure the specific effects directed by the regulation (*e.g.*, the additional personnel to install and maintain required pollution control equipment). They also include input/output models, which assume historic patterns in quantities of inputs per unit of production to estimate labor-input changes expected if a new regulation will affect a sector's output levels. Both of the former methods preclude effects due to changes in prices of goods or services. At a higher level of sophistication within the partial analysis category is a partial equilibrium model. Such a model typically estimates how increased costs affect production processes and market shares, but still only includes a subset of the economy in the analysis.

Partial analysis methods conform readily with the simplest conceptualization of employment impacts, which is that associated with the *direct* impacts of a regulation. The direct impact of the regulation would be the lost productivity resulting from the costs absorbed by those companies or individuals directly subject to a regulation. These include new equipment purchases, more expensive inputs, as well as training, monitoring, and reporting.
However, impacts are not limited to directly affected entities, and a majority of overall economic impacts (including employment impacts) may derive from the *indirect* costs. For example, suppose that a new regulation requires all electricity to be generated with wind. The full impacts of such a regulation would extend beyond the directly affected companies (electricity generators) to include industries that sell products to the regulated industry. Some of the indirect impacts may be positive, as in the case of companies that provide supplies that are needed for compliance (*e.g.*, wind turbine manufacturers); other indirect impacts may be negative, as in the case of companies whose inputs can no longer be purchased (*e.g.*, steam turbine manufacturers, as well as coal or natural gas suppliers, in the example). Partial analyses often address these types of indirect effects too.

Partial analyses may appear to be complete if they report that they have considered both direct and indirect impacts such as those described above. However they still omit certain more indirect types of impacts that may be important in major regulations. For example, if the costs of compliance are passed through into a company's product prices (*e.g.*, an increase in the cost of electricity), the price-mediated impacts on labor income can become larger than the impacts to the more directly affected sectors. When the affected product is widely purchased by other entities throughout the economy (as in the case of most forms of energy), regulatory impacts can be spread across many other sectors of the economy. These *downstream* effects are not among the indirect effects that partial types of employment impact analyses capture. Indirect effects in partial analyses are usually limited to changes in demand *for inputs* for the directly regulated entities, and thus limited to impacts *upstream* of the regulated entities' supply chain.

More sophisticated economic analyses are needed to address *changes in prices* by the regulated entities, which affect the businesses downstream of the regulated entity. Thus, when downstream price-related effects are ignored, the analysis can be characterized as "partial," and it will not address all of the ways a regulation can affect employment opportunities throughout the economy. [9]

B. Full-Economy Approach

A CGE model simulates the full-economy implications of price effects of regulation simultaneously with indirect impacts from changes in input demands, essentially accounting for all the ways the affected sector's costs migrate throughout the rest of the economy. In contrast to partial analysis models, CGE models can produce estimates of macroeconomic impacts. This "top-down" type of approach is especially important to consider using in the case of high-cost regulations of sectors that produce broadly-consumed goods (e.g., energy).

[9] In a similar point, two seminal papers (Jorgenson and Goettle, 1993, and Hazilla and Kopp, 1990) have demonstrated that the overall economic costs from environmental regulation may be much larger (*e.g.*, up to 30% larger) than an accounting of their aggregate compliance costs. However, the focus in this discussion is on assessment of employment-related impacts specifically, rather than overall welfare or GDP impacts.

Very briefly, a CGE model solves a series of equations of supply and demand for all the goods in the economy to establish market equilibrium. Changes in this equilibrium (for example, due to a policy change) are then used to estimate direct and indirect demand-related and price-related policy impacts. Appendix A provides a more detailed description of the key elements of a CGE approach, while the focus here will remain on how employment impacts are represented.

With respect to employment impacts, CGE models are typically "full employment" models, in which all inputs are fully used, including the labor supply available at the prevailing wage. The employment-relevant outputs of a CGE model are changes in real wages and in total willingness to work (labor supply) at those wages, not numbers of jobs.[10] A CGE model solves for labor supply changes in response to policy changes. For example, a hypothetical policy may impose pollution controls on power production. The costs of compliance with the policy can drive down the productivity of labor and with it the equilibrium real wage rate. That can result in less labor supplied, and thus less total worker income. Offsetting that effect, as power prices rise, firms may substitute into relatively less expensive inputs, which may lead to a rise in demand for labor, and offsetting real wage increases. Yet other effects will be set into motion within the model. The resulting net impacts of the policy will be a mix of shifts in labor among sectors, changes in total hours supplied, and in real wages earned per hour worked. These are the various forms of employment impacts produced by the typical CGE model. They account for impacts in all sectors of the economy, even those not directly linked to the regulated sector.

A full accounting of employment impacts also considers the hidden costs to the economy. While a dollar spent on regulation may spur some additional employment activity (*e.g.*, in the example, wind turbine manufacturers may hire additional staff to meet the surge in orders), more money is being absorbed to produce every unit of the same commodity (*i.e.*, electricity in this example). That leaves less money available to invest in equipment or workers that would generate more real output for the economy. The long-term effect of these hidden costs can be reduced economic growth, and reduced prospects for worker income levels on a widespread and permanent basis. Thus, accounting for the inter-related economic impacts of regulation is difficult. Some, but not all, CGE models are able to address such productivity impacts on economic growth.

In theory, an approach based upon CGE modeling captures all effects of the regulation on the economy (including employment). However, much depends on the exact parameterization of the model, and on the scenario assumptions underlying the analysis. It is time-consuming to construct a CGE model with detailed specifications, and it requires knowledge to understand impact channels and interpret the results. Sometimes, the scope of a regulation is small enough to reasonably employ a partial equilibrium approach instead. However, EPA employed a CGE

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[10] Labor supply is represented by hours available to work, not persons available to work. Because a "job" is usually thought of as pertaining to a person, there is a natural disconnect between the CGE structure and the concept of "positions" to be filled by individuals. Thus, the closest CGE metrics to impacts on jobs are change in labor supply (%) and change in payments to workers ($). The latter is sometimes expressed, for context, as an equivalent number of jobs at the average wage ("job-equivalents"), by dividing it by the average annual worker pay. It is important to note, however, that the change in numbers of people employed may be unchanged, while all of the change may come from changes in the wage earned by workers, consistent with the concept of full-employment.

model on just two of the 18 occasions in which its air RIAs offered any employment impact estimates. As we will argue later in this paper, two was too few.

C. A Need for Broader Assessment of Employment Impacts

Policymakers and the public cannot be expected to gain much insight about a regulation's impacts on employment when they are provided only estimates of numbers of "jobs." Even if estimated in a comprehensive manner, this is a misleading metric that does not begin to reflect the true issues and concerns that regulations pose for employment opportunity. In fact (as discussed above), full-economy CGE models naturally produce a more textured representation of employment impacts than counts of job positions, but that also is less than is needed. Some of the important attributes of employment-relative impacts that simplistic "jobs" estimates fail to address include:

- Whether the impact is to reduce the wage rate that would otherwise be earned by workers, to change the number of hours of work per week, or literally to eliminate job openings.
- Whether the impact will come in the form of layoffs, or via reduced growth in new job positions.
- Whether any new employment opportunities created by the regulation will call upon the same sets of skills and education as the employment opportunities ended by the regulation.
- Whether wage rates for lost hours of work are greater or less than wage rates for hours of work gained – in other words, whether higher paying jobs are replaced with lower paying jobs or vice versa.
- In the case of an economy with current underemployment:
    - Whether the new employment opportunities match the skills and capabilities of those who are in need of work, or simply increase the demand for individuals with skills not greatly affected by the downturn.
    - Whether the change in employment opportunities is expected to occur during or after the anticipated end of the downturn.
- Whether the larger concern for employment impacts is tied to the transitional impacts of a regulation, which will be a one-time cost, or to reduced productivity of the economy, which will translate into less growth in worker income levels over the long term.

The difference between long-run and transitional employment impacts deserves special discussion. New regulatory requirements typically also have transitional employment impacts such as decreases in jobs of one form offset by increases in jobs of another form. The new jobs may require a different set of skills than the declining jobs, and they may be in different locations. These types of short-term changes may sum to a net zero job impact, yet still result in a short-term increase in unemployment (*e.g.*, individuals facing lay-offs may not be able to immediately reconfigure their skill sets and locations).

For the individual employees who are laid off as the result of new regulation, informational barriers may impede their ability to find one of the new job openings even if they are qualified; "matching" the available worker supply to the new worker demands may be slow. Thus, involuntary unemployment can be a real economic cost, as well as a drain on individual well-being (emotional as well as financial) during a transitional period.[10]

Transitional employment impacts are difficult to quantify and measure. Conceptually, transition costs are often treated as a distributional impact rather than a true economic impact of lasting duration. Yet, if these transition impacts occur during a period of macroeconomic decline (*e.g.*, currently), and if the jobs are substantially different in skills and locations from the types of jobs being lost, some of the displaced workers may find themselves placed in a position that they could only view as long-term unemployment. This suggests a real loss of economic productivity rather than just a distributional impact.

Estimating these transitional impacts requires different types of modeling approaches than are most commonly used in current regulatory policy impact analyses. For example, CGE models usually project only long-run conditions after return of the economy to equilibrium. Such models thus may not be able to estimate any aspect of transitional employment impacts, even while they are helpful for understanding the long-run impacts to the full economy. Thus, even comprehensive models may need to be supplemented with models that are suited to projecting short-run market outcomes, such as short-term econometric models used to analyze business-cycle effects.[11]

Thus, a thorough understanding of employment impacts will require use of multiple different types of models. Some of the dimensions of impact above are not even amenable to current modeling methods, and may merit empirical research. Ideally, in time multiple approaches will come to be used in combination, to assess the multiple dimensions of employment impacts. For any of this to be fruitful, however, policy makers also will need to develop a greater appreciation for the multiple relevant dimensions of employment impacts.

[10] Livermore *et al.,* 2012 also make this point.

[11] Additionally, it might be feasible to use bottom-up studies to estimate direct spending on labor in detail, then transfer those costs to a full-economy model as changes in labor productivity, energy cost per unit of output, or changes in capital or factor productivity. Sector-specific transitional labor costs may be possible estimated in this fashion.

III. THE MORGENSTERN, PIZER, AND SHIH PAPER

MPS refers to a paper that examines the relationship between past environmental regulations and past changes in employment in four specific U.S. sectors. It is described in some detail in this section because our review found that EPA has begun to rely on estimates from this paper for a majority of its recent air RIA employment impacts estimates. The contents of the MPS paper, and how EPA is using its results in its RIAs, therefore merit explanation before Section IV describes the results of our review of all of EPA's employment impact estimation methods.

A. What the MPS Paper Does

The MPS paper considers direct employment changes in four different industries: pulp and paper, plastics, petroleum, and steel.[12] The analysis covers the years 1979-1981, 1985, 1988, and 1991. MPS splits the effect of regulation on industry labor demand into three elements and estimates them all econometrically. The elements are changes in payments to labor due to (i) change in the quantity of output demanded ("the demand effect"), (ii) change in the cost of inputs, holding output and technology fixed ("the cost effect"), and (iii) change in the mix of factors, such as shifting from a dirty to a clean fuel ("the factor-shift effect"). Each of these effects is explained below.

<u>(i) The demand effect.</u> In economics, the "law of demand" holds that as a product costs more, people buy less of it. This explains why consumers go to the movies less as ticket prices go up, or make shorter phone calls if they are in a roaming area. This inverse relationship between price and quantity holds for almost all goods, and a summary of its steepness is the *elasticity of demand*. If compliance costs lead to reduced demand for a sector's products, then less will be produced, and so, *ceteris paribus*, there will be less demand for labor to help make those products. MPS uses historical data to estimate the demand elasticity for output for each of the four industries.[13] It estimates, consistent with theory, that the demand effect of compliance spending was negative in each sector studied.

<u>(ii) The cost effect.</u> The cost effect addresses the following question: if a company is to keep producing the same amount, with the same ratio of ingredients, but with additional spending per unit of output for compliance, how much labor spending will arise? As long as there are any labor costs associated with production, then this will be a positive effect, *ceteris paribus*. For example, if regulation is projected to cost an additional 2% to the industry, and labor accounts for 50% of the added costs, the industry will spend 1% more on its labor inputs as it complies, so the cost effect would be 1% of the industry labor force. Another way to consider the cost effect in terms of employment would be: how many people does a company have to hire to comply with the new regulation? MPS estimates, consistent with expectations, that this effect was positive in each of the four sectors studied.

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[12] No theoretical justification for the selection of these industries is given (or for the absence of other industries): the authors classify them as 'heavily-polluting', but the choice seemingly is based upon the data that they had available.

[13] MPS define labor productivity as the log difference between annual input price and output price. They use productivity changes to map the industry-specific demand curves (and thus, to identify the demand elasticity).

(iii) The factor shift effect. The final effect estimated in MPS is the "factor-shift." Instead of holding the proportions of inputs per unit of production fixed, response to the regulatory requirement may also cause a shift in the input mix per unit of production. This could result in an decrease in labor demand, *ceteris paribus*, if the new, compliant production process is less labor-intensive than the pre-regulatory processes. For example, if new regulation prompted a company to replace a production worker with a new machine, this would be a 'factor shift.' The likely direction of the factor shift effect was not anticipated *a priori*. MPS estimates it was positive in three of the four sectors studied, and close to zero in the fourth. This essentially implies that regulatory compliance in those sectors was more labor-intensive than the original production processes themselves.

The MPS paper also provides an aggregate estimate of the combined effect of these three market/production phenomena. MPS estimates that in these four sectors, compliance with the regulations implemented in the 1980s did have an incremental negative effect on labor payments as product demand decreased, but this was largely offset by greater use of labor inputs for compliance. The positive labor-implication of spending on compliance appears to have been reinforced by those compliance-related activities being more labor-intensive than the sectors' original productive processes. Net effects on labor spending were found to be positive in three sectors (plastics, petroleum, and steel) and negative in one (pulp and paper).

It is important to point out that the entire theoretical formulation and associated econometric analysis in MPS is based on payments to labor reported by these sectors. No measure of "job counts" enters the analysis until all of the estimation has been completed. At that stage alone, MPS aggregates the annual expenditures, including depreciation for pollution-abatement capital, and divides them by the sample mean to construct industry-specific normalized costs. MPS assumes one "job" is implied by a change in labor spending of $35,000 ($1987). They thus normalize their results to allow comparison across industries by expressing results as changes in "jobs" per million dollars in environmental spending. The paper's econometric methods are complex and sophisticated, but this summary result (*i.e.*, change in jobs per $ million compliance spending) can be a misleading way of summarizing for those who have not read the details behind it.[14]

This summary result varies from -1.13 to 6.90 "jobs" per million dollars of compliance spending across the four sectors.[15] MPS also calculates an "average" effect, by weighting the four sectors' impacts based on the amount each sector was spending on compliance in the sample period (1979-1991). The appropriateness of this single average estimate is questionable, but at best it is an average over the four sectors and not an economy-wide average. It is 1.55 "jobs" per million dollars of compliance spending, and is not statistically significant. Even if the simplistic summaries have some use for purposes of discussion, it should be kept in mind that these are estimates of the net labor effects that occurred in the past, and only reveal that total spending on workers in those four sectors did not decline when those sectors spent their way to environmental compliance.

[14] This conversion in MPS from labor payments (the data analyzed) to "jobs" for a summary metric also means that any estimates based on that summary metric are actually "job-equivalents."

[15] Morgenstern, Pizer and Shih (2002), Table III, p. 427.

MPS does not present these findings as evidence that environmental regulations increase employment in the economy. If anything, MPS itself describes the estimated change in labor income as an "insignificant change."[16] This appears to refer to the weak statistical significance of many of the paper's estimates more than to the small quantitative magnitude of the average estimate net effect.

Possibly lost from view to the reader is that this econometrically-sophisticated method is nevertheless a partial-equilibrium analysis. The analysis considers only the net labor spending impacts in the directly regulated sectors. There is no consideration in MPS of indirect impacts to upstream industries (*e.g.*, coal mining supplying power plants that were forced to retire). There also is no consideration in MPS of downstream effects on businesses that must pay for higher costs of products from the regulated firms. It is a partial equilibrium analysis.

B. How EPA Uses the MPS Estimates in its RIAs

EPA's MPS-based approach to estimating job impacts in its RIAs is far from sophisticated. EPA does not use the statistical methods of MPS to re-estimate the likely impacts in each sector subject to a new regulation. Rather, EPA treats the average four-sector statistically-insignificant parameter reported in the MPS paper as a fixed multiplier, and uses it to extrapolate from the MPS analysis to new regulations in other sectors. In other words, EPA does no more than take an RIA's estimate of the compliance cost of that regulation, state that cost as millions of 1987 dollars, and multiply that number by 1.55. In this manner, all sectors and all regulations are being assumed to have the same overall employment response per dollar spent. Clearly, the result is always going to be a positive impact on jobs, no matter what the regulation's actual cost or modes by which those costs filter into the economy.

It merits repeating that EPA's multiplication represents an extrapolation of job impacts that occurred in regulations that were imposed 20 to 30 years ago. The extrapolation is across decades of economic and regulatory change, and into entirely different sectors. These labor impact estimates are also only reflective of partial, *direct sector-only* impacts, even if applied to only the four sectors that were originally studied

As complex as the MPS paper is itself, EPA's use of MPS to generate employment impact estimates in its RIAs for new regulations is not credible. EPA's approach sidesteps any consideration of actual effects of the regulation in question by borrowing a single parameter estimated in MPS and using it as one-size-fits-all assumption. Readers of EPA's RIAs should not infer that EPA's new MPS-based approach is a step forward in its employment impacts estimation methods just because it cites a sophisticated econometric analysis as the source of that assumption. EPA's MPS-based multiplier is not a credible analytical substitute even for a partial analysis of a new regulation affecting different sectors. It is no substitute at all for regulations warranting an economy-wide employment impacts modeling approach.

[16] Morgenstern, Pizer, and Shih (2002), p. 429.

IV. REVIEW OF EMPLOYMENT IMPACTS ESTIMATION METHODS IN EPA AIR RIAS

A. Summary of Findings

Like other federal agencies, EPA is required to produce RIAs of all of its major regulations. Over the past 15 years, EPA has used a variety of approaches to estimate employment impacts.[17] Of the 57 separate air rule RIAs that NERA reviewed (Figure 1), only about 23% of the pre-2011 RIAs (11 of 48) contained any discussion of employment impacts. In contrast, 78% of RIAs from the year 2011 (*i.e.*, after EO 13563 was issued) estimated employment impacts. EO 13563 clearly affected the willingness of EPA to prepare estimates of employment impacts in its RIAs. We have discerned no pattern to explain why some of the pre-2011 RIAs did include estimates of employment impacts, while most did not. Figure 2 (three pages hence) presents a timeline showing the years when certain RIAs did provide employment impact estimates, which reveals the apparent randomness of employment impact estimates prior to the surge in 2011.

Of the 18 RIAs with an employment impact estimate, all but two provided a simple "job count" rather than estimating the broad and varied ways that employment opportunities might be affected by a regulation. All but four suggested that the employment impact of regulation was either positive or negligible. We therefore explored whether certain methods of estimation led to positive or negative estimated job impacts.

Among the RIAs reviewed, two distinct alternatives emerge in how EPA estimates employment impacts (see Figure 3, four pages hence). One approach takes an economy-wide view of the impacts of regulation, and uses CGE models to estimate the direct, upstream demand-related, and downstream price-related effects of the policy on employment. The second category of approach encompasses a variety of partial analysis methods. As described in Section II, all of these different methods assess only direct effects of the regulation and (in some cases) the upstream impacts on jobs in sectors supplying the directly regulated businesses. As explained below and shown in Figure 4 (four pages hence), we found that EPA has favored partial approaches.

In our review of the RIAs, we found no formal description by EPA of criteria for deciding which type of approach it would use under different regulatory circumstances. The clear evidence that EPA has used several different types of models and analyses for seemingly similar situations suggests no formal criteria exist. Moreover, as we will discuss further below, while EPA has made *ad hoc* statements in some RIAs suggesting the appropriateness or inappropriateness of certain methods, EPA has failed to use the same reasoning when warranted in other RIAs.

[17] As part of Executive Order 12866, EPA is instructed to consider the impact of regulation on small businesses. Generally, EPA expresses the impact in terms of compliance costs borne by small businesses (as a fraction of the total burden), and also includes projected closures and operational changes. EPA uses employment in these analyses to gauge whether the entity is question is, in fact, a small business, and to inform the calculation of regulatory burden. This sometimes, but not always, includes an estimate of employment impact from the regulation. Thus, the discussion of direct compliance (within-industry) impacts also pertains generally to EPA's consideration of small business impacts.

Figure 1: EPA Regulatory Impact Assessments Reviewed for this Study

Year	Regulation	Job Estimate?
1997	Highway Heavy-Duty Engines and Diesel Engines	
	Medical Waste Incinerators NSPS and EG (HMIWI)	
	Locomotive Emission Standards	
	Ozone and $PM_{2.5}$ NAAQS	√
	Pulp & Paper NESHAP	√
1998	National VOC Standards for Architectural Coatings	√
	Non-Road Diesel Engines (Tier 2 and Tier 3)	
	NOx SIP Call & Section 126 Petitions	
	New Fossil-Fuel-Fired Steam Generating Units	
1999	Final Section 126 Petition Rule	√
	Gasoline Sulfur Control Requirements	
	Phase 2 Non-road Non-handheld Spark Ignition Engines	
	Regional Haze Rule	
2000	2004+ Model Year Highway Heavy-Duty Engines	
	Heavy-Duty Engine & Fuel Sulfur Control Requirement	
	Phase 2 Non-road Handheld Spark Ignition Engines	
	Protection of Stratospheric Ozone Reductions	
2002	Non-road & Recreational Spark-Ignition Engines	
2003	PSD & NSR: Routine Maintenance and Repair	
2004	Automobile & Light-Duty Vehicle NESHAP	√
	Industrial Boilers & Process Heaters NESHAP	√
	Non-Road Diesel Engines (Tier 4)	
	Plywood & Composite Wood Products NESHAP	√
	Stationary Reciprocating Internal Combustion Engine NESHAP	√
2005	Clean Air Interstate Rule	√
	Clean Air Mercury Rule	
	Clean Air Visibility Rule/BART Guidelines	√
2006	Inclusion of Delaware and New Jersey in CAIR	
	$PM_{2.5}$ NAAQS	
	Sec 126 NC; Revisions to CAIR & Acid Rain	
	Stationary Compression Ignition Internal Combustion Engine NSPS	
2007	Clean Air Fine Particle Implementation Rule	
	Control of HAP from mobile sources	

Year	Regulation	Job Estimate?
2008	Lead (Pb) NAAQS	
	Locomotives & Marine Diesel Engines <30 L per Cylinder	
	Non-road Spark-Ignition Engines & Equipment	
	Ozone NAAQS	
	Petroleum Refineries NSPS	
2009	GHG Mandatory Reporting Rule	
	New Marine Compression Engines >30 L per Cylinder	
2010	EPA/NHTSA Joint Light-Duty GHG & CAFES	
	Existing Stationary Compression Ignition Engines NESHAP	
	Greenhouse Gases PSD and Tailoring Rule	
	NO_2 NAAQS	
	Ozone Reconsideration NAAQS	
	Portland Cement NSPS & NESHAP Amendment	√
	Existing Stationary Spark Ignition Engines NESHAP	
	SO_2 NAAQS	
2011	Industrial Solid Waste Incineration Units NSPS	√
	GHG from Medium & Heavy-Duty Vehicles	√
	Cross State Air Pollution Rule (CSAPR)	√
	Industrial, Commercial, and Institutional Boilers NESHAP	√
	Manganese Ferroalloys RTR	√
	Chlor Alkali Plant Mercury Emissions NESHAP	
	Oil & Gas Industry NSPS & NESHAP Amendment	√
	Sewage Sludge Incineration NSPS	
	Utility MATS Rule	√

Figure 2: Timing of Air RIAs Found to Contain Employment Impact Estimates

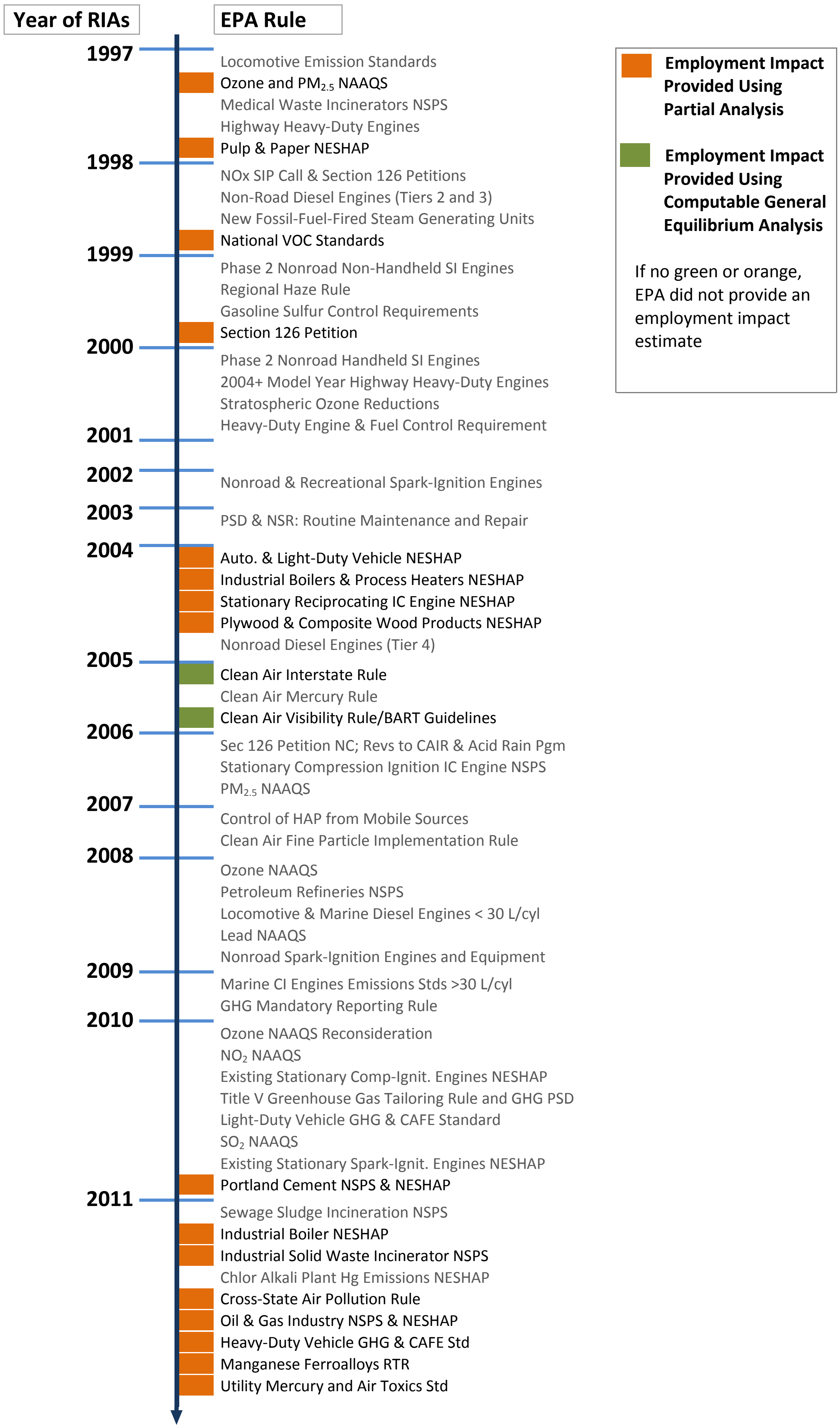


Figure 3: Employment Impact Estimation Methodologies Found in Air RIAs

Approach	Segment
CGE	Full Economy
Input/Output Table	Partial
Direct Compliance Costs	Partial
Partial Equilibrium	Partial
Morgenstern, Pizer, Shih (MPS) extrapolation	Partial

Figure 4: Summary of Employment Impact Estimates Found in Air RIAs

Year	Regulation	Approach**	RIA Estimate of Jobs Impacted	RIA Est. of Rule's Cost* (mil. 2010$)
1997	Ozone and PM2.5 NAAQS	**Partial**	6140	$13,855
1997	Pulp & Paper NESHAP	**I/O**	-4300 to -11200	$170
1998	National VOC st'ds for architectural coatings	**Partial**	-7 to -40	$29.6
1999	Final Section 126 Petition Rule	**Partial**	764	$1533
2004	Automobile & Light-Duty Vehicle NESHAP	**Partial**	-37	$176
2004	Industrial Boilers & Process Heaters NESHAP	**Partial**	(negligible)	$1,101
2004	Plywood & Composite Wood Products NESHAP	**Partial**	-225	$164
2004	Stationary Recip IC Engine NESHAP	**Partial**	(negligible)	$321
2005	Clean Air Interstate Rule	**CGE**	(+0.005% Δ)	$4,082
2005	Clean Air Visibility Rule/BART Guidelines	**CGE**	(+0.001% Δ)	$656
2010	Portland Cement NSPS & NESHAP Amendment	**MPS** **Direct**	+300 (-600 to 1,300) -1,500	$516
2011	Industrial Solid Waste Incineration Units NSPS	**MPS**	+700 (-1,400 to +2,800)	$285
2011	GHG from Medium & Heavy-Duty Vehicles	**MPS**	(negligible)	$8,177
2011	Cross State Air Pollution Rule (CSAPR)	**MPS** **Direct**	+1,000 (-1,000 to +3,000) +2,230	$833
2011	Ind., Comm. & Inst. Boilers NESHAP	**MPS**	+2,200 (-4,100 to +8,500)	$1,426
2011	Manganese Ferroalloys RTR	**Partial**	+4 FTE	$4
2011	Oil & Gas Industry NSPS & NESHAP Amendment	**Partial**	+101.6 FTE	$754
2011	2011 MATS Rule	**MPS** **Direct**	+8,000 (-15,000 to 30,000) +46,000	$9,994

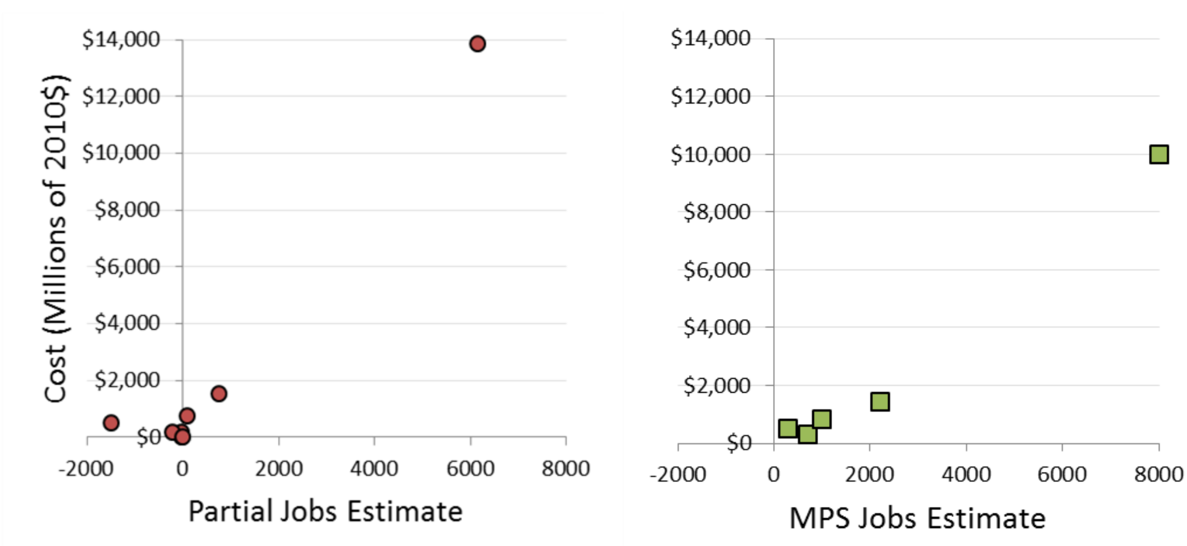
* If a range of economic costs is given, the midpoint is stated. **When RIAs make two types of estimates, both listed.

B. Graphical Analysis of EPA's Estimates

When one graphs the employment impact estimates in Figure 4, patterns begin to emerge. Figure 5 plots EPA's compliance cost estimate for each rule against its employment impact estimate. The right panel does this for the RIAs that used the MPS-based multiplier approach and the left panel does this for all other RIAs listed in Figure 4 as having used some other partial methodology. First, Figure 5 shows that most of the estimates are positive (*i.e.*, job gains are usually projected). Second, the amount of projected gain in jobs is correlated with the size of the cost of the rule. The similarity of the MPS-based relationship to that for the other partial approaches is unsurprising because it is just another partial approach, as Section III explained. However, the fact that *all* of the MPS-based estimates are positive is symptomatic of the more simplistic nature of the MPS-based multiplier approach compared to even many of EPA's other partial approach estimates.

Clearly, regulations cannot perpetually generate positive impacts on jobs in the economy, with ever greater job increases as the regulation becomes more costly. This illogical pattern in EPA's partial-analysis job impacts estimates reflects the clear limitations of using partial analyses. Partial analyses focus on select industries, usually those directly affected and/or those directly supplying them. This results in a greater chance of omitting some of the relevant detrimental impacts, particularly downstream. The MPS-based multiplier approach, however, *guarantees* a positive employment impact, because it simply multiplies a positive 1.55 jobs per million dollars (1987$) of compliance cost against the compliance cost estimate of the rule in question. Simply put, i*f the MPS-based approach is applied, higher costs of compliance will always be projected to generate larger numbers of jobs.* This is, quite clearly, not credible.

Figure 5: Relationship between EPA's Estimates of a Rule's Compliance Costs and its Job Impacts
MPS-Based Estimates (right panel); All Other Partial-Analysis Estimates (left panel)



The high-cost "outlier" cases (with large costs and large positive job impacts) in each panel of Figure 5 deserve further mention. Those two cases turn out to be rules for which no partial analysis method should ever have been applied. The outlier on the left chart comes from the 1997 $PM_{2.5}$ and Ozone NAAQS RIA, while the outlier on the right chart comes from the 2011 Utility MATS rule RIA. Both rules had substantial impacts on the electricity sector, were very costly, and were expected to generate electricity price increases that would filter through the rest of the economy. These rules were prime candidates for application of full-economy modeling, and a partial approach guaranteed an understatement of any negative employment impacts by omitting consideration of the potentially widespread price-related effects on the economy that they would engender.

C. Evaluation of Estimation Practices in EPA's RIAs

1. Insufficient Use of CGE Modeling

As Section II explained, a comprehensive assessment of labor impacts across the entire economy requires a full-economy model. This class of model can address how compliance costs that are passed from the regulated businesses to their customers may affect downstream businesses. Economists consider CGE models as the most appropriate for this task.

As Figure 4 showed, EPA employed a CGE model in its air RIAs on two occasions: for the CAIR rule and the CAVR/BART rule, both in 2005. In those cases, EPA purportedly used the CGE approach due to the high estimated cost of those rules, and the potential for price pass through in a widely used commodity. Notably, however, those two rules had smaller estimated costs than either the 1997 $PM_{2.5}$ and ozone rule RIA, or the 2011 Utility MATS rule RIA (compare their costs in Figure 4), both of which EPA elected to analyze partially instead. Lack of access to a CGE model could not have been an excuse: at the time of the 1997 RIA EPA was actively using a CGE model in another major economic impact analysis.[18] Similarly, in 2011 it had – on the shelf – an enhanced and fully peer-reviewed version of the EMPAX-CGE model that it had used in the two 2005 RIAs.[19] Thus, EPA has been inconsistent in its decisions to use CGE modeling, and has not used CGE modeling to a sufficient degree.

In the two 2005 RIAs where a CGE approach was used, EPA did not make much effort to elucidate the meaning of the rather different labor impact measures that those analyses produced. CGE models assume the economy will always find its way to full-employment, thus, "job counts," if they could be predicted, would simply be equal to the number of people wanting a job. Instead, CGE models represent impacts on labor as changes in leisure and in wage rates (which combine to cause changes in household labor income). In both these RIAs, the net effect of the regulations on labor was reported to be a negligible change in employment. However, the RIAs provided no useful explanation to readers about what these results meant other than to suggest that they were too small to be a concern.

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[18] EPA was using a CGE model in its Section 812 *Retrospective Analysis of the Costs and Benefits of the Clean Air Act 1970-1990* (EPA, 1997) during the years the $PM_{2.5}$ and ozone RIAs were in process.

[19] See, for example, the EMPAX-CGE documentation (RTI International, 2008).

These two RIAs were also unforthcoming about inconsistencies in their CGE results, as well as an unusual finding reported in one. For example, in the analysis of CAIR, EPA used two models (IGEM and EMPAX) to project employment impacts from the rule. The IGEM model projected an increase in real wages and an increase in labor, while the EMPAX model projected a decrease in wages and a decrease in labor. The reasons for these conflicting results were not discussed and should have been to make the analysis useful to readers. Meanwhile, the EMPAX analysis for CAVR/BART projected a decrease in real wages, but an increase in labor. The latter effect is only expected to occur when a policy is so costly that the effect of the rule on income levels overwhelms the underlying preference to work fewer hours when wage rates are lower.[20] The RIA did not even mention that this was an unusual finding or attempt to explain it. This unusual finding deserved discussion in its own right, but the inconsistency between the apparent impacts of the CAVR/BART rule and the CAIR rule when using the same model also deserved discussion that was not provided.

Thus, even when EPA has used CGE models, it has reported without comment both contrary and counterintuitive results. The job impact sections have made little attempt to explain the meaning of the different types of job estimates, and merely reported the technical fact that those models' outputs reflect changes in hours of labor supplied. In addition, those RIAs did not report change in labor income, which would reflect the true net effect on workers, and is the most basic of a CGE model's outputs with respect to labor.

More important than those shortcomings in the two extant CGE-based RIAs, EPA has not been consistent in its decisions on when it should use CGE. As noted above, there were at least two other, larger rules that also should have been addressed using CGE, but were not. Section V demonstrates how directionally incorrect estimates can result from applying the MPS-based approach to a regulation that has significant costs and downstream price impacts.

2. Excessive Use of MPS-Based Approach

Recently, EPA has adopted an MPS-based approach, relying upon results in a paper by Morgenstern, Pizer, and Shih, (2002) that was described in Section III. The original paper finds a statistically insignificant estimate of 1.55 jobs created per $1 million ($1987) in expenditure on regulatory cost. EPA, for its new RIAs, treats this estimate of labor change per unit of cost as a simple multiplier. EPA multiplies this value against its estimates for cost of compliance with different environmental regulations, in a more recent time period, and in different sectors to project the job impacts in its new RIAs.

Section III explained the shortcomings of EPA's MPS-based approach. Despite these shortcomings, as Figure 4 shows, EPA has adopted MPS in nearly all of its RIAs since 2010. Interesting, however, is the case of the two 2011 RIAs in which EPA refrained from using the MPS approach (*i.e.*, for the Ferroalloys and the Oil and Gas NESHAPs). In the Ferroalloys RIA, EPA expressed concern that the industry was too different, and the affected sector too small, to

[20] This is called a backward-bending labor supply condition.

be comparable to the MPS analysis.[21] Similar concerns about MPS's transferability to the Oil and Gas industry were raised in the NESHAP RIA.[22] Yet among the RIAs that did use the MPS-based approach, just one (the industrial boiler MACT) directly affects the specific industries that MPS analyzed. It is not obvious that the other sectors (Portland Cement, Waste Incinerators, Heavy Duty Vehicles, and Utilities) are closer to those industries examined in MPS than the two that were excluded. By inconsistently applying MPS, EPA raises the question of *which* criteria it used to evaluate the suitability of the industry to MPS, and whether those criteria were uniformly followed, or appropriate.

We conclude that EPA's recent use of the MPS study to extrapolate to sectors and rules far from its base is inappropriate. Results for specific RIAs, such as the Utility MATS rule, are, as a consequence, not credible. In any event, the MPS approach is a partial analysis and thus omits impacts that happen beyond the directly affected sector(s). Section V provides a case study of the bias that EPA's MPS-based approach has created in its application to the Utility MATS rule. In that section the MPS-based estimates in the Utility MATS rule are contrasted to the estimates that emerge from a more appropriate CGE-based analysis of the same rule's costs. By conducting major analyses that are inconsistent with sound methodology-selection criteria, EPA undercuts the confidence one can place in any of its RIAs.

[21] "While the steel industry is one of the industries studied by Morgenstern *et al.*, and ferroalloys is an important input to steel production, the differences in the two industries are significant enough to lead to questions about how applicable are the parameters in Morgenstern *et al.* in this analysis." Ferroalloys RIA (EPA 2011b), p. 5-11.

[22] "Because of the likelihood of negative compliance costs for the proposed NSPS and the segments of the oil and natural gas industry affected by the proposals are not examined by Morgenstern *et al.*, we decided not to use the parameters estimated by Morgenstern *et al*. to estimate within-industry employment effects for the proposed oil and natural gas NESHAP amendments and NSPS." Oil and Gas NESHAP RIA (EPA 2011a), p. 7-28.

V. CASE STUDY: EMPLOYMENT IMPACTS OF THE 2011 UTILITY MATS RULE BASED ON A CGE ANALYSIS

Prior sections of this report have explained why a credible analysis of the economic (and employment) impacts of the Utility MATS rule requires a CGE approach. Restated briefly, it is that the rule is very costly (approximately $10 billion per year after annualization of capital costs), and it affects electricity generation, which is used by virtually all sectors and individuals of the U.S. economy. This creates the groundwork for impacts in many sectors other than the directly regulated electricity generation sector and its key suppliers. Its large requirement for upfront capital to construct lower-emitting generation technologies also indicates a significant potential for detrimental economic impacts from crowding out of capital. Despite this, EPA applied a simple extrapolation of partial impact estimates from the MPS study.

In 2012, NERA used its N_{ew}ERA CGE model of the U.S. to analyze the impacts of the Utility MATS rule on a full-economy basis. It projected large and negative employment impacts, in contrast to the rosy picture of net positive job impacts that EPA had reported. This section briefly summarizes the two sets of results. A more detailed description of the CGE analysis by NERA is available in a separate report (Smith *et al.*, 2012).

A. EPA's Approach

In the RIA for the Utility MATS rule, EPA uses a combination of two approaches to produce their employment impact estimate: a short-term, compliance-based method of employment impact based engineering cost estimates, and an approach based upon MPS. Admittedly, EPA introduces several caveats in the discussion of the scope of the analysis in the RIA. EPA states it did not estimate any of the following:

- *Changes resulting from labor needed to operate the needed pollution controls, increased demand for materials used in pollution control operation, shifts in demand for fuel in response to the rule, changes in employment resulting from additional coal retirements, and changes in other industries due to changes in the price of electricity and natural gas.*
- *Impacts on employment as a result of the increase in electricity and other energy prices in the economy.*
- *Other employment changes in industries that support and supply the pollution control industry.*
- *Employment impacts beyond the pollution control and regulated sectors.*
- *Impacts due to an increase labor productivity by improving health.*[23]

In other words, EPA acknowledges that its RIA estimates direct impacts from the regulation, and is a partial representation of the full economic impacts. Nevertheless, EPA adopts, without further question, the MPS jobs-per-dollar multiplier to generate a MATS-rule employment impact: a net of 8,000 new "jobs" over the long term. (EPA also used engineering cost estimates to estimate a short-term employment impact of 46,000 jobs during the implementation phase of the policy.) Such a partial approach, while failing to consider indirect impacts, also inadequately considers the direct impacts: labor is a scarce resource, and the supply of labor has

[23] Utility MATS RIA (EPA, 2011c), p. 6-11.

to be accounted for – employing 46,000 people, even for a short period, deprives other businesses that utilize the same labor pool, and raises their costs. This impacts the rest of the economy.

As explained in Section III, MPS provides an econometric, partial equilibrium approach based on the 20 to 30-years prior experience of four sectors in the economy. While more robust partial approaches may be suitable to apply to a small fragment of the economy, it is problematic to extrapolate the statistics from MPS to a larger part of the economy because the approach does not take into account interdependence between sectors, nor does it extend to ensure that all markets clear and budget constraint is satisfied for the economy. A more extensive discussion of the differences between general equilibrium models and MPS is included in Appendix A to this report.

B. A CGE-Based Estimate

In a separate analysis, NERA used N_{ew}ERA, a macroeconomic, economy-wide CGE model to estimate the economic impacts of the MATS rule.[24] NERA's approach included inter-industry links, production functions with substitutability among factors of inputs (*e.g.*, labor, capital, and energy), economy-wide supply and demand, and consumer choices on how much labor to supply. The N_{ew}ERA model also contains a detailed, bottom-up representation of all the generating units serving U.S. electricity load, in regional electricity markets. This model is ideally suited to assess the direct costs of air regulations affecting the utility sector and to simultaneously assess the general economic impacts to the U.S. economy when such regulatory costs may be absorbed by electricity generators.

NERA's analysis of the Utility MATS rule assessed the cost of complying with the MATS Rule relative to a Baseline with CAIR, and relative to a Baseline with Cross-State Air Pollution Rule (CSAPR). The inclusion of CSAPR had little effect on the results. NERA's analysis relied on the same compliance cost assumptions that EPA used in its RIA's cost analysis. Unsurprisingly, the NERA analysis derived very similar estimates of the direct costs of compliance. Figure 6 compares EPA's annualized compliance cost estimates (developed with the IPM model) to those estimated with the N_{ew}ERA model.

Because the N_{ew}ERA model is an integrated model of the entire economy, we are able to identify the economic impacts outside of the electric sector, which EPA did not. These macroeconomic impacts included declines in the rate of growth of the U.S. economy as measured by GDP and declines in consumption, or household disposable income. All of these impacts are inconsistent with EPA's statement, based on its partial analysis, that the Utility MATS rule would increase net jobs.

[24] The N_{ew}ERA model is an economy-wide economic model that includes a detailed representation of the electric sector. It has been designed to assess, on an integrated basis, system costs to the power sector to meet any specified policy scenario as well as the overall macroeconomic impacts of that policy scenario. For additional technical details on the N_{ew}ERA model see Appendix B of this report or http://www.nera.com/67_7607.htm.

Figure 6: Compliance Costs of EPA and NERA Approaches

Annualized and Present Value Incremental Compliance Costs (Billions of 2010$)				
	2015	2020	2030	PV(2014-2034)
EPA (IPM)	$9.7	$8.0	$7.7	$89.9
NERA (N_{ew}ERA)	$10.4	$10.8	$11.9	$94.8

Like other CGE models that EPA has used, N_{ew}ERA assumes full-employment and long-run equilibrium occurs immediately. It thus does not find any literal change in the ability of workers to be employed after a transition phase that attends all regulatory changes. Further, a CGE model finds impacts to workers in a more general manner than "job counts." It assesses changes in the real wages paid to workers per hour worked, and changes in hours of work that households are prepared to supply at those wages. This is also reported as a change in total labor income to households. These estimates are always *inclusive* of all the increases in labor demand from compliance spending. Although it is not possible to predict how much of the projected labor income reduction would come in the form of reduced hours per job, shifts in the mix of full-time vs. part-time jobs, or simply reduced average payments per hour worked, it is possible to describe the magnitude of the loss in worker income in terms of the number of "job-equivalents" that would produce that income loss.

The CGE-based analysis of the Utility MATS rule using N_{ew}ERA projected a net negative impact to labor income (*inclusive* of labor increases associated with installing retrofits and building new power plants). In 2015, the projected loss was equivalent *to* 180,000 jobs, compared to the CSAPR baseline. The reduction in 2015 labor income was projected to be equivalent in magnitude to 215,000 jobs if compared to a baseline with only CAIR in effect. While the largest labor income losses are in 2015, there are enduring labor income losses over time as the economy shrinks due to higher energy costs. The specific results are shown in Figure 7 (on the next page) and contrasted to those in EPA's RIA based on the MPS extrapolation.[25] This comparison reveals the significant biases that can come from using the simplistic MPS-based approach to assess significant and costly energy sector regulations.

The results in Figure 6 indicate that the fundamental source of the difference in these two estimates of the overall impact of the rule on the economy is *not* differences in the respective analysts' estimates of the cost of complying with the MATS rule. The fundamental cause of the difference is the fact that EPA only considers the impacts of the policy on the electric sector; they do not consider the broader economic effects of the rule on the full economy. In short, EPA adopted a partial approach, which underestimates the impact of the regulation in a high-cost rule such as utility MATS. By examining only directly affected sectors (electric utilities) and ignoring indirect impacts of the MATS rule (*e.g.*, rising electricity prices), EPA's analysis omits the majority of the economic impact of the rule – both in terms of employment impacts and in other broader measures of economic impact, such as household spending power and GDP.

[25] Although EPA's RIA describes its estimates as "jobs," that estimate also is in "job-equivalents." (See discussion in Section III for more details.)

Figure 7: Utility MATS Rule Labor Impact Estimates: Comparison of EPA's MPS-Based Analysis to a CGE-Based Analysis

Net Employment Change (Job-equivalents)				
EPA (using MPS-based multiplier)	**Annual**			
MATS (relative to CSAPR)	8,000 (95% CI: -15,000 to 30,000)			
NERA (N_{ew}ERA)	**2015**	**2018**	**2021**	**2024**
MATS (relative to CSAPR)	-180,000	5,000	-60,000	-50,000
MATS (relative to CAIR)	-215,000	-15,000	-75,000	-85,000

VI. CONCLUSIONS

In this review, we examined EPA air rule RIAs dating back to 1997 to document their employment impact methodologies. Our findings regarding EPA's general practices are as follows:

- Until 2011, EPA only intermittently provided employment impact estimates in its RIAs. The shift coincides with an amendment to the Executive Order that specifically mentions "job creation" as an important concern to address in RIAs. For the years prior to 2011, we could not discern why some RIAs provided employment impact estimates and others did not.
- With only two exceptions in 2005, EPA's employment impacts estimates have been narrowly limited to assessing "job counts,"[26] and have been "partial" estimates, meaning none of them have addressed the impact of a regulation's costs on the rest of the economy beyond those sectors directly bearing the compliance costs and their suppliers.
- Although some of the job estimates have shown net job losses, the majority of them have reported net gains. This is traceable to the partial nature of those estimates.
- In some cases, job impact estimates are provided separately for short-term jobs associated with the period in which compliance investments are being made, and longer-term job impacts after the construction demand spike of capital investments for compliance. In other cases, it is unclear exactly what types of job counts have been reported.
- Over the years there has been little attempt in the RIAs to explain or explore the broader set of issues that exist with regard to "employment impacts." EPA did not elucidate these issues even in the two RIAs in 2005 where it did report a different type of labor impact estimate than "job counts."

More broadly, we conclude that EPA has made insufficient and inconsistent use of full-economy models. We also conclude that EPA has made excessive use of a 2002 paper by Morgenstern, Pizer, and Shih as a basis for most of its post-2011 job estimates. The combined effect of these two problematic aspects of EPA's employment impacts estimation practice has resulted in biased estimates of impacts for one of the largest air rules in the record, the 2011 Utility MATS rule. EPA's inappropriate use of its partial MPS-based approach indicates positive job increase while a more appropriate full-economy analysis of the same compliance spending indicates negative overall impacts to worker income.

By conducting major analyses that are inconsistent with sound methodology-selection criteria, EPA undercuts the confidence one can place in any of its RIAs. The path to a more credible set of employment impact estimates will first require that the economics profession articulate clear model-selection criteria, and then that EPA adhere explicitly to those criteria. In our opinion,

[26] The exceptions were for the Clean Air Interstate Rule (CAIR) and for the Clean Air Visibility Rule and Best Available Retrofit Technology Guidelines (CAVR/BART). Both of these RIAs were released in 2005, and both used a method called Computable General Equilibrium (CGE) modeling, which addresses labor market impacts in the context of the full economy and full employment. CGE models do not directly measure employment impacts in the form of "jobs." More on this point is discussed below.

full-economy modeling using CGE methods is always the more credible choice. Discrepancies between full-economy modeling and a partial analysis may be relatively small when the regulation is relatively narrow in scope. However, CGE analyses should be required for any regulation that affects the costs of inputs to large parts of our economy, such as any regulation affecting energy supply. EPA has the relevant tools and know-how to accomplish this.

In addition, RIAs (and all other related regulatory impact analyses within or beyond the Agency) would benefit greatly from more thoughtful discussion of the many important attributes of employment impacts other than a simple "job count." When job counts are provided, an explanation of the range of types of impacts on labor that might be implicit in "a job" should be provided. Any partial analysis should be explicitly caveated that it counts only direct job gain or losses and that any offsetting effects in the rest of the economy are ignored.

This study's review was limited to EPA's employment impact estimation practices in its RIAs for air rules. To the extent that non-governmental groups have adopted the same methods as those in EPA's air RIAs, points made in this report also may be useful for interpreting those other studies and estimates. Assessments of other methods that were not covered in this study (because EPA has not used them) could be helpful additional research. An even higher priority for further research, however, would be to advance new methods for assessing the range of employment impact attributes listed in section II. Without such research, policy discussions about employment impacts will continue to be anchored to misleading and misunderstood estimates of "job counts."

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APPENDIX A – KEY CGE MODEL FEATURES COMPARED TO THE MPS APPROACH

A. General Approach

A Computable General Equilibrium (CGE) approach solves a system of equations and inequalities that represent all sectors in the economy simultaneously. The economic equilibrium conditions in the CGE framework include a profit condition that associates the output level with profit, a market clearance condition that associates market price with demand and supply dynamics, and an income balance that ensures all factor earnings, tax payments and transfers are fully exhausted by consumption and savings for future investment.

A CGE approach connects households and firms through goods and factor markets. Goods markets are interdependent as output of one sector can be consumed by another sector as an intermediate input. Conventional CGE modeling assumes full employment of resources (capital, labor, natural resources), and variations can be introduced to capture the frictions in the reality. Government can also be explicitly represented by its function to collect taxes, make public investment and redistribute the wealth.

Production functions in CGE are generally formulated at an aggregate level for computational tractability. Some observers critique CGE for its limitation in capturing the rigidity, frictions, and imperfections that can be fully accounted in a bottom-up model. A hybrid model can integrate a micro model of certain sectors of interest into CGE macro framework, adding a bottom-up representation to fill in the need for more concrete sector formulation, all done still satisfying market clearance and income balance conditions. NERA's N_{ew}ERA model uses such a construction (See Appendix B).

Environmental regulations impose on firms additional costs when diverting resources from production to environmental compliance. These resources include not only capital investment but also goods and services, and labor input. As a result, more inputs are required to produce the same amount of output, leading to higher prices for goods under regulation as well as goods consumed for compliance purposes. Conceptually embedded in the CGE framework, such a circular flow does not exist in partial types of analysis.

This has several implications for modeling the labor market. First, analogous to how reallocated capital investment for abatement technologies may deprive productive R&D, labor diverted to compliance activity could have otherwise been used in productive activities somewhere else. Thus, jobs 'created' as a result of environmental regulation in certain sectors destroy jobs in other sectors. Second, higher prices due to regulation increase the cost of living, and thus reduce real wage income. A net gain of jobs does not consider the price of higher cost of production caused by the regulation. Finally, lower factor productivity and reduction in investment in non-compliance production slows down economic growth, thus growth prospective of labor income. A short-term net gain may impact long-term growth.

B. Impact Mechanism

The econometric analysis in the MPS paper decomposes the impact of environmental regulation into cost effect, factor shift effect, and a demand effect. A CGE approach accounts for all these effects. Moreover, CGE considers what is lacking the MPS econometric analysis: interaction across sectors, a budget constraint for every period, and intertemporal optimization. Specifically:

a) **Interaction across sectors**: MPS estimates four sectors in isolation. Applying the same approach for each and every sector does not reflect the spillover effect along the interaction between markets; as a consequence, it does not guarantee all markets clear. For example, sectors compete for the same type of labor (*e.g.* construction) for regulation purposes. Labor supply may not be sufficiently elastic to meet the rising demand at a given wage rate. In contrast, CGE takes into account both demand and supply in the labor market and thus produces a consistent set of results in price, demand and supply. Finally, missing interactions in goods and services market and in capital market lead to inconsistent estimates that have indirect impact on labor demand.

b) **Budget constraint:** A dollar invested in environment production has an opportunity cost: foregone value in either non-compliance production or final consumption. This is missing from the MPS approach, as their scope is only a fragment of the economy. Applying their approach without considering the budget constraint facing the entire economy is not a valid assessment. An analogous fallacy would be to suppose that a nation can get rich by borrowing.

c) **Intertemporal optimization:** A CGE approach usually establishes a model horizon long enough to capture the intertemporal impact over several decades. The intertemporal optimization involves equating the marginal utility of consumption of every period. In the context of regulation, investment in compliance activity today translates to foregone consumption and foregone investment in the future, leading to a slower economic growth rate. This will in turn reduce labor income in the future.

C. Labor Market

CGE modeling assumes full employment and labor market equilibrium, and thus does not typically estimate transitional unemployment impacts. However, there are ways to incorporate frictions in the labor market. Cost of labor movement can be introduced to account for the costs incurred during the transfer from one location to another. It would also make sense for the case of structural changes where laborers equipped with sector-specific skills incur cost on training to fit for another type of work. Choice between labor and leisure is often added to represent a friction on the supply side. When regulation results in a lower real wage income, people have greater incentive to swap out of labor hours for leisure. CGE estimates are calculated against a counterfactual economic outcome that can never be observed. Such impacts may most appropriately reflect the long-term relationship between employment impacts and a regulation's effect on the overall economic performance of the economy. It is the only way to address the long-term impact on growth of diversion of capital investments from financially-productive investments to investments that generate non-financial benefits such as a cleaner environment.

APPENDIX B – ADDITIONAL DETAILS ON THE N$_{EW}$ERA MODEL

NERA developed the NewERA model to forecast the impact of policy, regulatory, and economic factors on the energy sectors and the economy. When evaluating policies that have significant impacts on the entire economy, one needs to use a model that captures the effects as they ripple through all sectors of the economy and the associated feedback effects. The NewERA model combines a macroeconomic model with all sectors of the economy (except for the electric sector) with a detailed electric sector model. This combination allows for a complete understanding of the economic impacts of different policies on all sectors of the economy.

The macroeconomic model incorporates all production sectors and final demand of the economy. Policy consequences are transmitted throughout the economy as sectors respond until the economy reaches equilibrium. The production and consumption functions employed in the model enable gradual substitution of inputs in response to relative price changes, thus avoiding all-or-nothing solutions.

The main benefit of the integrated framework is that the electric sector can be modeled in great detail yet through integration the model captures the interactions and feedbacks between all sectors of the economy. Electric technologies can be well represented according to engineering specifications. The integrated modeling approach also provides consistent price responses since all sectors of the economy are modeled. In addition, under this framework we are able to model electricity demand response.

There are great uncertainties about how the U.S. natural gas market will evolve, and the NewERA model is designed explicitly to address the key factors affecting future natural gas supply and prices. One of the major uncertainties is the availability of shale gas in the United States. To account for this uncertainty and the subsequent effect it could have on the domestic and international markets, the NewERA model includes resource supply curves for U.S. natural gas that can be altered for sensitivity analysis. The model also accounts for foreign imports and U.S. exports of natural gas, by using a supply (demand) curve for U.S. imports (exports) that represents how the global LNG market price would react to changes in U.S. imports or exports.

The electric sector model is a detailed model of the electric and coal sectors. Each of the more than 17,000 electric generating units in the United States is represented in the model. The model minimizes costs while meeting all specified constraints, such as demand, peak demand, emissions limits and transmission limits. The model determines investments to undertake and unit dispatch. Because the NewERA model is an integrated model of the entire U.S. economy, electricity demand can respond to changes in prices and supplies. The steam coal sector is represented within the NewERA model by a series of coal supply curves and a coal transportation matrix. The NewERA model represents the domestic and international crude oil and refined petroleum markets.

NewERA model outputs include demand and supply of all goods and services, prices of all commodities, and terms of trade effects (including changes in imports and exports). The model outputs also include gross regional product, consumption, investment, disposable income, and changes in "job equivalents" based on labor wage income.

Impacts on workers are often considered an important output of policy evaluations. Impacts on workers are complicated to estimate and to explain because they can include several different impacts, including involuntary unemployment, reductions in wage rates for those who continue to work, and voluntary reductions in hours worked due to lower wage rates. No model addresses all of these potential impacts. The N_{ew}ERA model is a long-run equilibrium model based upon full employment, and thus its results relate to the longer-term effects on labor income and voluntary reductions in hours worked rather than involuntary unemployment impacts. It addresses long-run employment impacts, all of which are based on estimates of changes in labor income, also called the "wage bill" or "payments to labor." Labor income impacts consist of two effects: (1) changes in real wage per hour worked; and (2) changes in labor market participation (hours worked) in response to changed real wage rates. The labor income change can also be expressed on a per-household basis, which represents one of the key components of disposal income per household. (The other key components of disposable income are returns on investments or "payments to capital," and income from ownership of natural resources). The labor income change can also be stated in terms of job-equivalents, by dividing the labor income change by the annual income from the average job. A loss of one job-equivalent does not necessarily mean one less employed person—it may be manifested as a combination of fewer people working and less income per person who is working. However, this measure allows us to express employment-related impacts in terms of an equivalent number of employees earning the average prevailing wage.

A. Overview

NERA's N_{ew}ERA modeling system is an integrated energy and economic model that includes a bottom-up representation of the electricity sector, including all of the unit-level details that are required to accurately evaluate changes in the electric sector. N_{ew}ERA integrates the electricity sector model with a macroeconomic model that includes all other sectors of the economy (except for the electricity sector) using a top-down representation. The model produces integrated forecasts for future years; the modeling for this study was for the period from 2013 to 2034 with modeling inputs and results for every third year in that period. The model produces a standard set of reports that includes the following information.

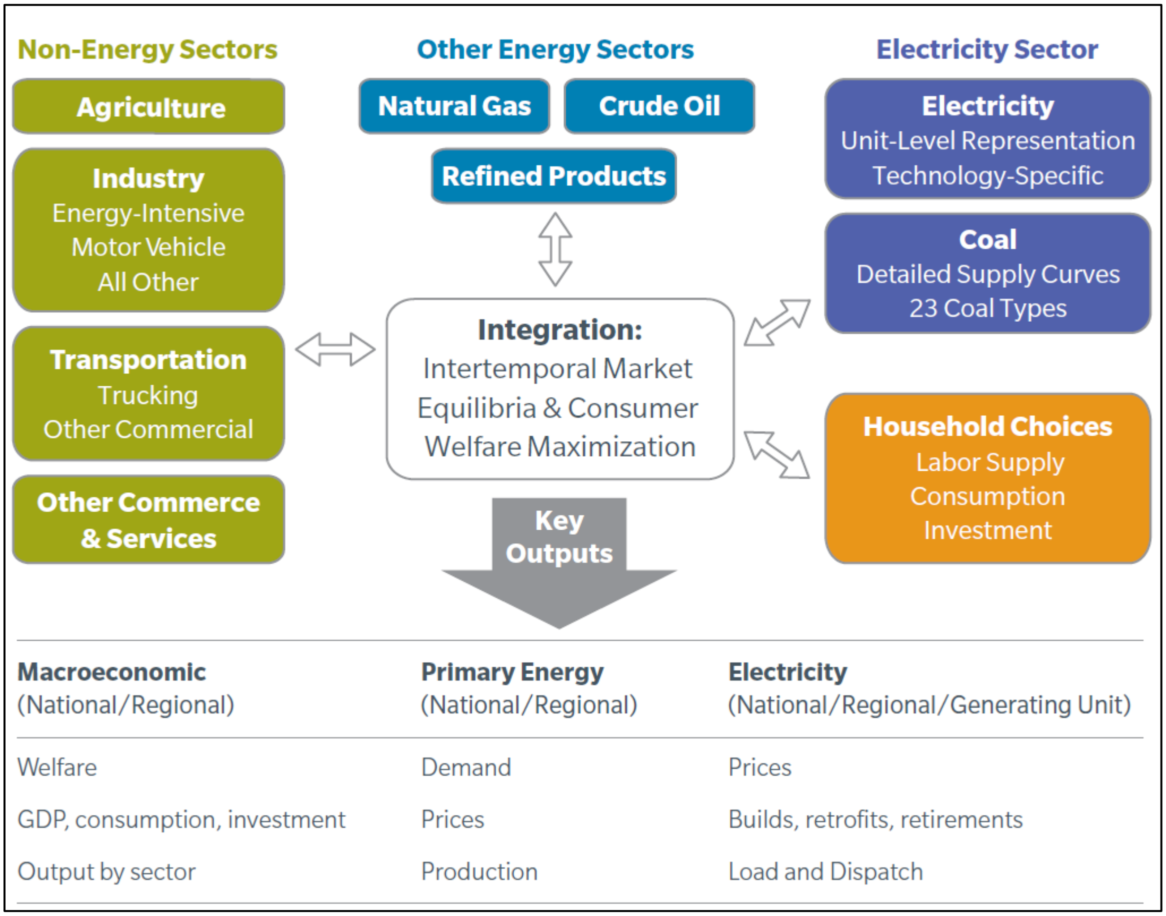
- *Unit-level investments in the electric sector* – retrofits in response to environmental policies, new builds (full range of new generation technologies represented), retirements based on economics.

- *Prices* – wholesale electricity prices for each of 32 U.S. regions, capacity prices for each U.S. region, delivered electricity prices by sector for each of 11 macroeconomic regions in N_{ew}ERA, Henry Hub natural gas prices and delivered natural gas prices to the electric sector for each U.S. region, minemouth coal prices for 24 different types of coal, delivered coal prices by coal unit, refined oil product prices (gasoline and diesel fuel), renewable energy credit (REC) prices for each state/regional renewable portfolio standard (RPS), and emissions prices for all regional and national programs with tradable credits.

- *Macroeconomic results* – gross domestic product (and gross regional product for each macroeconomic region), welfare, changes in disposable income, and changes in labor income and real wage rates (used to estimate labor market changes in terms of an equivalent number of jobs).

Figure B - 1 provides a simplified representation of the key elements of the N_{ew}ERA modeling system.

Figure B - 1: N_{ew}ERA Modeling System Representation



B. Electric Sector Model

The electric sector model that is part of the N_{ew}ERA modeling system is a bottom-up model of the electric and coal sectors. The model is fully dynamic and includes perfect foresight (under the assumption that future conditions are known). Thus, all decisions within the model are based on minimizing the present value of costs over the entire time horizon of the model while meeting all specified constraints, including demand, peak demand, emissions limits, transmission limits, RPS regulations, fuel availability and costs, and new build limits. The model set-up is intended to mimic (as much as is possible within a model) the approach that electric sector investors use to make decisions. In determining the least-cost method of satisfying all these constraints, the model endogenously decides:

- What investments to undertake (*e.g.*, addition of retrofits, build new capacity, repower unit, add fuel switching capacity, or retire units);

- How to operate each modeled unit (*e.g.*, when and how much to operate units, which fuels to burn) and what is the optimal generation mix; and

- How demand will respond. The model thus assesses the trade-offs between the amount of demand-side management (DSM) to undertake and the level of electricity usage.

Each unit in the model has certain actions that it can undertake. For example, all units can retire, and many can undergo retrofits. Any publicly-announced actions, such as planned retirements, planned retrofits (for existing units), or new units under construction can be specified. Coal units have more potential actions than other types of units. These include retrofits to reduce emissions of SO_2, NO_X, mercury, and CO_2. The costs, timing, and necessity of retrofits may be specified as scenario inputs or left for the model to endogenously select. Coal units can also switch the type of coal that they burn (with practical unit-specific limitations). Finally, coal units may retire if none of the above actions will allow them to remain profitable, after accounting for their revenues from generation and capacity services.

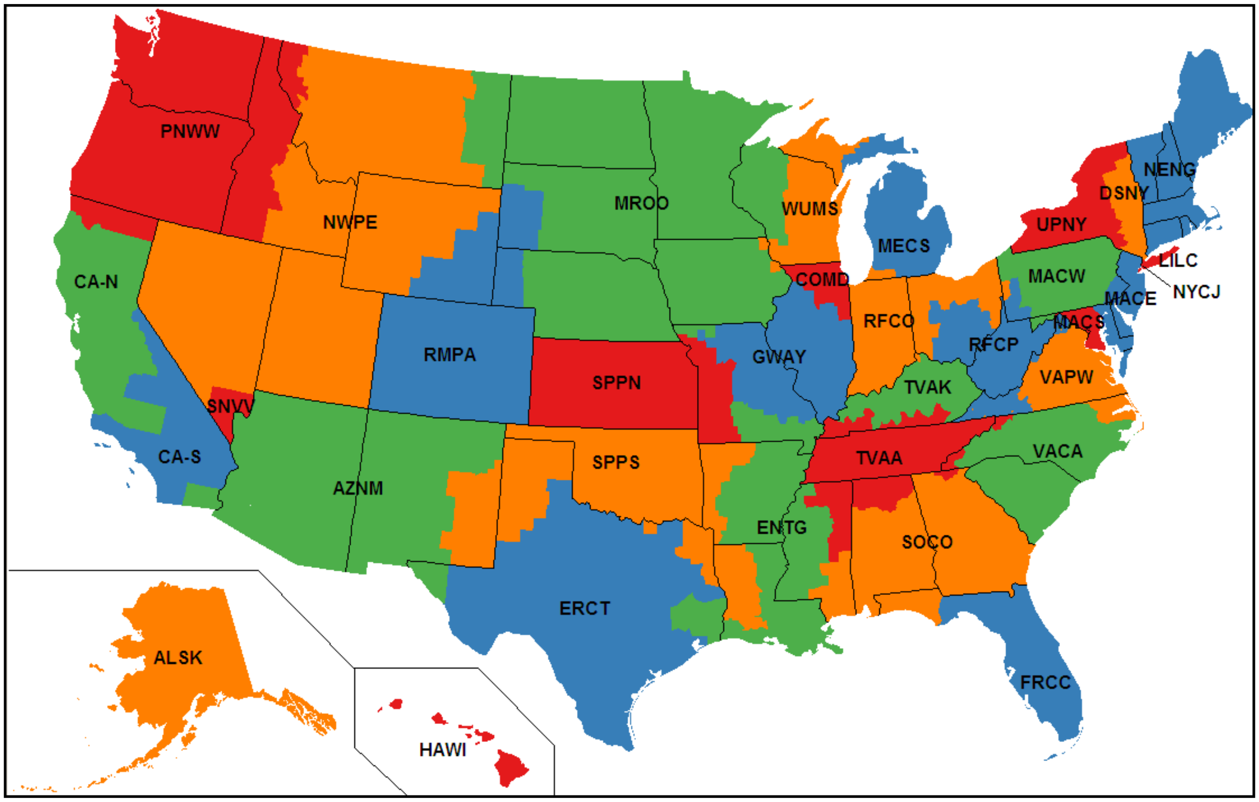
Most of the coal units' actions would be in response to environmental limits that can be added to the model. These include emission caps (for SO_2, NO_X, Hg, and CO_2) that can be applied at the national, regional, state or unit level. We can also specify allowance prices for emissions, emission rates (especially for toxics such as Hg) or heat rate levels that must be met.

Just as with investment decisions, the operation of each unit in a given year depends on the policies in place (*e.g.*, unit-level standards), electricity demand, and operating costs, especially energy prices. The model accounts for all these conditions in deciding when and how much to operate each unit. The model also considers system-wide operational issues such as environmental regulations, limits on the share of generation from intermittent resources, transmission limits, and operational reserve margin requirements in addition to annual reserve margin constraints.

To meet increasing electricity demand and reserve margin requirements over time, the electric sector must build new generating capacity. Future environmental regulations and forecasted energy prices influence which technologies to build and where. For example, if a national RPS policy is to take effect, some share of new generating capacity will need to come from renewable power. On the other hand, if there is a policy to address emissions, it might elicit a response to retrofit existing fossil-fired units with pollution control technology or enhance existing coal-fired units to burn different types of coals, biomass, or natural gas. Policies calling for improved heat rates may lead to capital expenditure spent on repowering existing units. All of these policies will also likely affect retirement decisions. The N_{ew}ERA electric sector model endogenously captures all of these different types of decisions.

The model contains 32 U.S. electricity regions (and six Canadian electricity regions). Figure B - 2 shows the U.S. electricity regions.

Figure B - 2: N_{ew}ERA Electric Sector Model – U.S. Regions



The electric sector model is fully flexible in the model horizon and the years for which it solves. When used in an integrated manner with the macroeconomic model, and to analyze long-term effects, the model is usually set up to solve out to twenty to thirty years in three-year time steps.

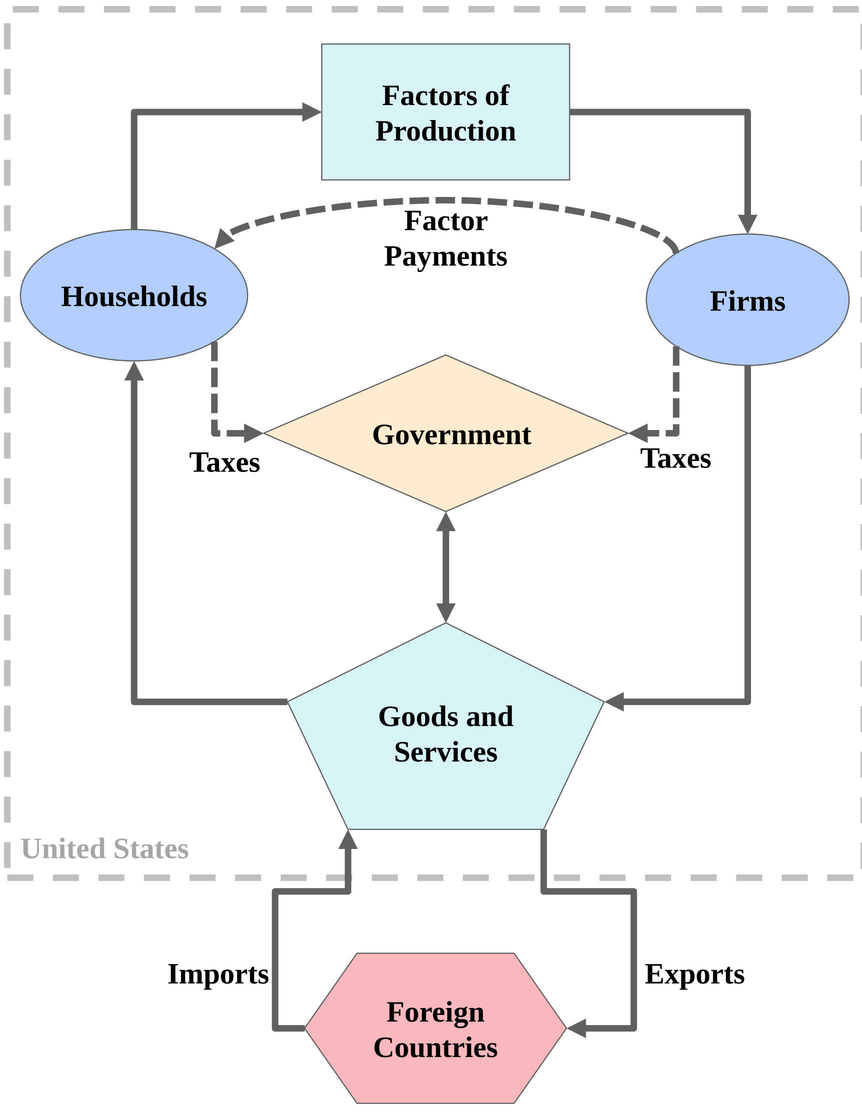
C. Macroeconomic Model

1. Overview

The N_{ew}ERA macroeconomic model is a forward-looking dynamic computable general equilibrium (CGE) model of the United States. The model simulates all economic interactions in the U.S. economy, including those among industry, households, and the government. Additional background information on CGE models can be found in Burfisher (2011).

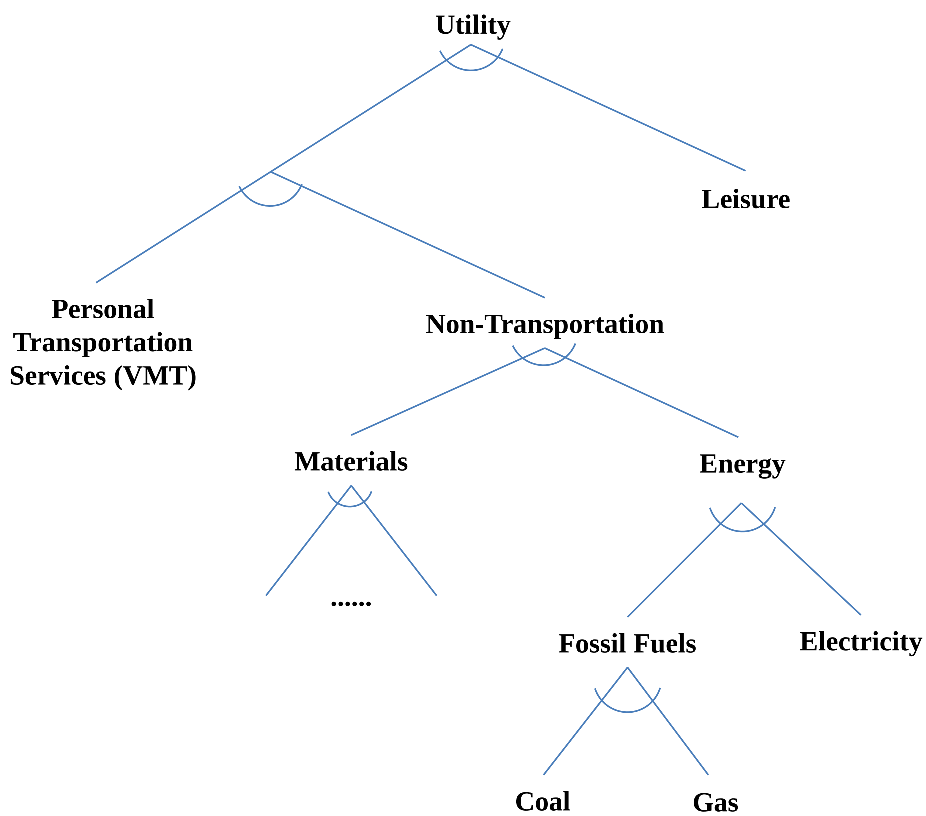
The N_{ew}ERA CGE framework uses the standard theoretical macroeconomic structure to capture the flow of goods and factors of production within the economy. A simplified version of these interdependent macroeconomic flows is shown in Figure B - 3. The model implicitly assumes "general equilibrium," which implies that all sectors in the economy are in balance and all economic flows are endogenously accounted for within the model. In this model, households supply factors of production, including labor and capital, to firms. Firms provide households with payments for the factors of production in return. Firm output is produced from a combination of productive factors and intermediate inputs of goods and services supplied by other firms. Individual firm final output can be consumed within the United States or exported. The model also accounts for imports into the United States. In addition to consuming goods and services, households can accumulate savings, which they provide to firms for investments in new capital. Government receives taxes from both households and firms, contributes to the production of goods and services, and also purchases goods and services. Although the model assumes equilibrium, a region in the model can run deficits or surpluses in current accounts and capital accounts. In aggregate, all markets clear, meaning that the sum of regional commodities and factors of production must equal their demands, and the income of each household must equal its factor endowments plus any net transfers received.

Figure B - 3: Interdependent Economic Flows in N_{ew}ERA's Macroeconomic Model



The model uses the standard CGE framework developed by Arrow and Debreu (1954). Behavior of households is represented by a nested Constant Elasticity of Substitution (CES) utility function. The model assumes that households seek to maximize their overall welfare, or utility, across time periods. Households have utility functions that reflect trade-offs between leisure (which reduces the amount of time available for earning income) and an aggregate consumption of goods and services. Households maximize their utility over all time periods subject to an intertemporal budget constraint based on their income from supplying labor, capital, and natural resource to firms. In each time period, household income is used to consume goods and services or to fund investment. Within consumption, households substitute between energy (including electricity, coal, natural gas, and petroleum), personal transportation, and goods and services based on the relative price of these inputs. Figure B - 4 illustrates the utility function of the households.

Figure B - 4: Household Consumption Structure in N_{ew}ERA's Macroeconomic Model



On the production side, Figure B - 5 shows the production structure of the commercial transportation and the trucking sector. Production structure for the rest of the industries is shown in Figure B - 6. The model assumes all industries maximize profits subject to technological constraints. The inputs to production are energy (including the same four types noted above for household consumption), capital, and labor. Production also uses inputs from intermediate products provided by other firms. The N_{ew}ERA model allows producers to change the technology and the energy source they use to manufacture goods. If, for example, petroleum prices rise, an industry can shift to a cheaper energy source. It can also choose to use more capital or labor in place of petroleum, increasing energy efficiency and maximizing profits with respect to industry constraints.

Figure B - 5: Commercial Transportation and Trucking Sector Production Structure in N_{ew}ERA's Macroeconomic Model

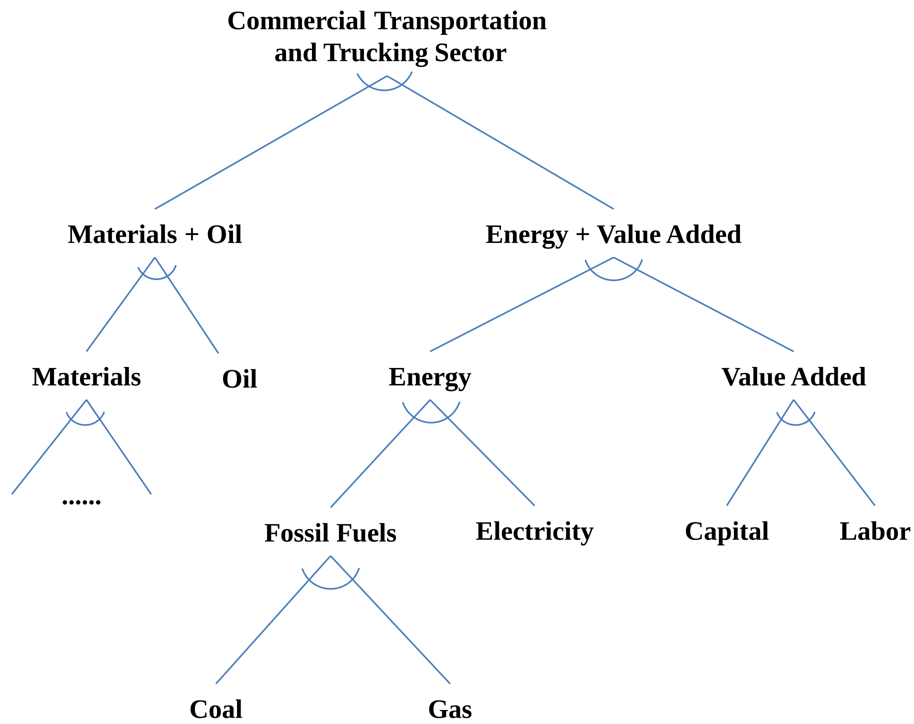
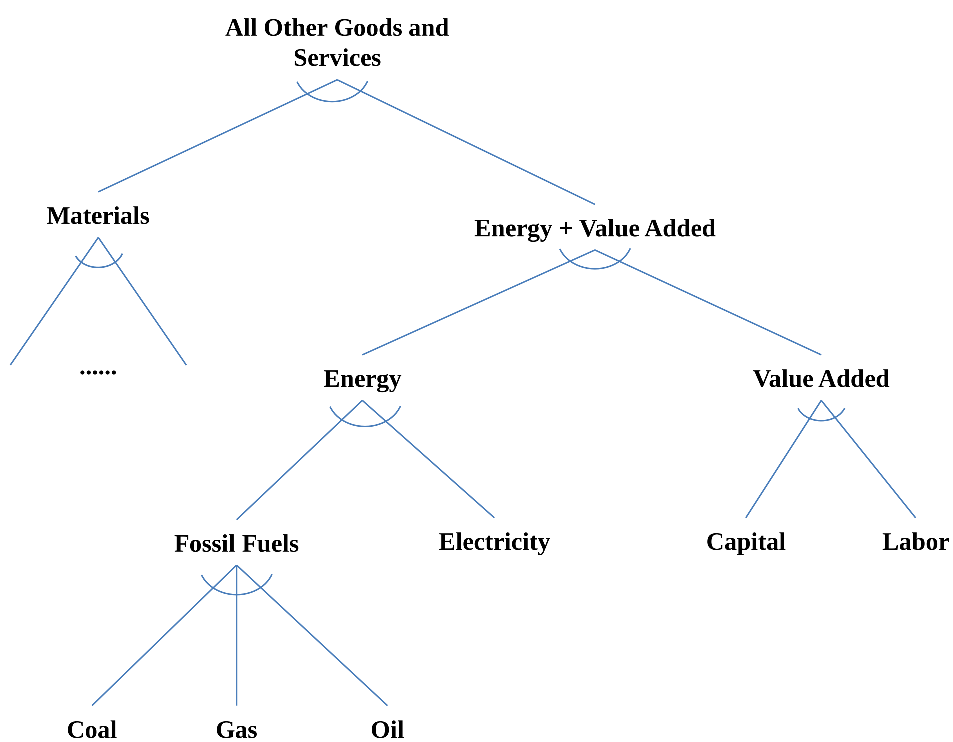


Figure B - 6: Production Structure for Other Sectors in N_{ew}ERA's Macroeconomic Model



All goods and services, except crude oil, are treated as Armington goods, which assume the domestic and foreign goods are differentiated and thus are imperfect substitutes (Armington 1969). The level of imports depends upon the elasticity of substitution between the imported and domestic goods. The Armington elasticity among imported goods is assumed to be twice as large as the elasticity between the domestic and imported goods, characterizing the greater substitutability among imported goods.

Business investment decisions are informed by future policies and outlook. The forward-looking characteristic of the model enables businesses and consumers to determine the optimal savings and investment levels while anticipating future policies with perfect foresight.

The benchmark year economic interactions are based on the IMPLAN 2008 database, which includes regional detail on economic interactions among 440 different economic sectors. The macroeconomic and energy forecasts that are used to project the benchmark year going forward are calibrated to EIA's Annual Energy Outlook (AEO) 2012.

2. Regional Aggregation

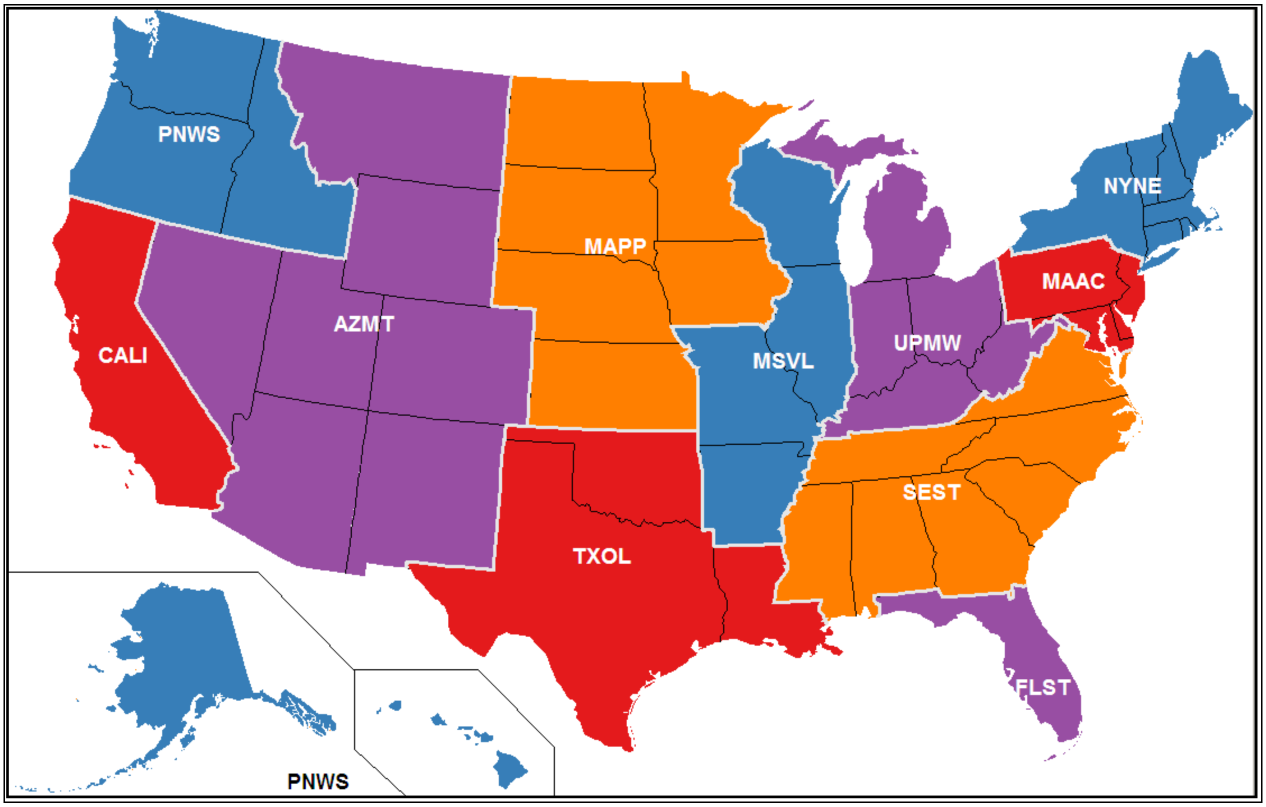
The N_{ew}ERA macroeconomic model includes 11 regions: NYNE (New York and New England), MAAC (Mid-Atlantic Coast), UPMW (Upper Midwest), SEST (Southeast), FLST (Florida), MSVL (Mississippi Valley), MAPP (Mid-America), TXOL (Texas, Oklahoma and Louisiana), AZMT (Arizona and Mountain states), CALI (California) and (PNWS) Pacific Northwest. The aggregate model regions are built up from economic data for the 50 U.S. states and the District of Columbia. The 11 standard N_{ew}ERA macroeconomic model regions and the states within each N_{ew}ERA region are shown in Figure B - 7.

3. Sectoral Aggregation

The N_{ew}ERA model includes a standard set of 12 economic sectors: five energy (coal, natural gas, crude oil, electricity, and refined petroleum products) and seven non-energy sectors (services, manufacturing, energy-intensive[27], agriculture, commercial transportation excluding trucking, trucking, and motor vehicles). These sectors are aggregated up from the 440 IMPLAN sectors. The model has the flexibility to represent sectors at different levels of aggregation, when warranted, to better meet the needs of specific analyses.

[27] The energy-intensive sector in the N_{ew}ERA modeling system includes pulp and paper, chemicals, glass, cement, primary metals, and aluminum.

Figure B - 7: N_{ew}ERA Macroeconomic Model Regions



4. Natural Gas and Oil Markets

There are great uncertainties about how the U.S. natural gas market will evolve, and the N_{ew}ERA modeling system is designed explicitly to address the key factors affecting future natural gas supply and prices. One of the major uncertainties is the availability of shale gas in the United States. To account for this uncertainty and the subsequent effect it could have on international markets, the N_{ew}ERA modeling system has the ability to represent supply curves for conventional natural gas and shale gas for each region of the model. By including each type of natural gas, it is possible to incorporate expert judgments and sensitivity analyses on a variety of uncertainties, such as the extent of shale gas reserves, the cost of shale gas production, and the impacts of environmental regulations.

The N_{ew}ERA model represents the domestic and international crude oil and refined petroleum markets. The international markets are represented by flat supply curves with exogenously specified prices. Because crude oil is treated as a homogeneous good, the international price for crude oil sets the U.S. price for crude oil.

Consumption of electricity as a transportation fuel could also affect the natural gas market. Along with alternative transportation fuels (including biofuels), the model also includes different vehicle choices that consumers can employ in response to changes in the fuel prices. The model includes different types of Electrified Vehicles (xEVs): Plug-in-Hybrid Electric Vehicles

(PHEVs) and Battery Electric Vehicles (BEVs). In addition, the model accounts for both passenger vehicles and trucks powered by CNG.

5. Macroeconomic Outputs

As with other CGE models, the N_{ew}ERA macroeconomic model outputs include demand and supply of all goods and services, prices of all commodities, and terms of trade effects (including changes in imports and exports). The model outputs also include gross regional product, consumption, investment, cost of living or burden on consumers, and changes in "job equivalents" based on changes in labor wage income. All model outputs are calculated by time, sector, and region.

Impacts on workers are often considered an important output of policy evaluations. Impacts on workers are complicated to estimate and to explain because they can include several different impacts, including involuntary unemployment, reductions in wage rates for those who continue to work, and voluntary reductions in hours worked due to lower wage rates. No model addresses all of these potential impacts. The N_{ew}ERA model is a long-run equilibrium model based upon full employment, and thus its results relate to the longer-term effects on labor income and voluntary reductions in hours worked rather than involuntary unemployment impacts. It addresses long-run employment impacts, all of which are based on estimates of changes in labor income, also called the "wage bill" or "payments to labor." Labor income impacts consist of two effects: (1) changes in real wage per hour worked; and (2) changes in labor market participation (hours worked) in response to changed real wage rates. The labor income change can also be expressed on a per-household basis, which represents one of the key components of disposal income per household. (The other key components of disposable income are returns on investments or "payments to capital," and income from ownership of natural resources). The labor income change can also be stated in terms of job-equivalents, by dividing the labor income change by the annual income from the average job. A loss of one job-equivalent does not necessarily mean one less employed person—it may be manifested as a combination of fewer people working and less income per person who is working. However, this measure allows us to express employment-related impacts in terms of an equivalent number of employees earning the average prevailing wage.

D. Integrated N_{ew}ERA Model

The N_{ew}ERA modeling framework fully integrates the macroeconomic model and the electric sector model so that the final solution is a consistent equilibrium for both models and thus for the entire U.S. economy.

To analyze any policy scenario, the system first solves for a consistent baseline solution; it then iterates between the two models to find the equilibrium solution for the scenario of interest. For the baseline, the electric sector model is solved first under initial economic assumptions and forecasts for electricity demand and energy prices. The equilibrium solution provides the baseline electricity prices, demand, and supply by region as well as the consumption of inputs—capital, labor, energy, and materials—by the electric sector. These solution values are passed to the macroeconomic model.

Using these outputs from the electric sector model, the macroeconomic model solves the baseline while constraining the electric sector to replicate the solution from the electric sector model and imposing the same energy price forecasts as those used to solve the electric sector baseline. In addition to the energy price forecasts, the macroeconomic model's non-electric energy sectors are calibrated to the desired exogenous forecast (*e.g.*, EIA's latest AEO forecast) for energy consumption, energy production, and macroeconomic growth. The macroeconomic model solves for equilibrium prices and quantities in all markets subject to meeting these exogenous forecasts.

After solving the baseline, the integrated N_{ew}ERA modeling system solves for the scenario. First the electric sector model reads in the scenario definition. The electric sector model then solves for the equilibrium level of electricity demand, electricity supply, and inputs used by the electric sector (*i.e.*, capital, labor, energy, emission permits). The electric sector model passes these equilibrium solution quantities to the macroeconomic model, which solves for the equilibrium prices and quantities in all markets. The macroeconomic model then passes to the electric sector model the following (solved for equilibrium prices):

- Electricity prices by region;
- Prices of non-coal fuels used by the electric sector (*e.g.*, natural gas, oil, and biofuels); and
- Prices of any permits that are tradable between the non-electric and electric sectors (*e.g.*, carbon permits under a nationwide greenhouse gas cap-and-trade program).

The electric sector model then solves for the new electric sector equilibrium, taking the prices from the macroeconomic model as exogenous inputs. The models iterate—prices being sent from the macroeconomic model to the electric sector model and quantities being sent from the electric sector model to the macroeconomic model—until the prices and quantities in the two models differ by less than a fraction of a percent.

This decomposition algorithm allows the N_{ew}ERA model to retain the information in the detailed electricity model, while at the same time accounting for interactions with the rest of the economy. The detailed information on the electricity sector enables the model to represent regulatory policies that are imposed on the electricity sector in terms of their impacts at a unit level.

E. References to the Appendix

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Arrow, K.J., and G. Debreu. 1954. "Existence of an Equilibrium for a Competitive Economy." *Econometrica* 22:265-290.

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Employment Impacts of Three Air Rules Estimated Using a CGE Model

Addendum to *Estimating Employment Impacts of Regulations: A Review of EPA's Methods for Its Air Rules*

Prepared for U.S. Chamber of Commerce

Anne E. Smith, Ph.D., Senior Vice President
Will Gans, Ph.D., Consultant

February 2013

Purpose of this Addendum

- This report evaluating EPA's employment impact estimation practices found that EPA's current use of a cost-to-jobs multiplier based on a paper by Morgenstern, Pizer, Shih (MPS) has these flaws:
  - Is a partial analysis that fails to consider employment impacts to the full economy.
  - Always projects positive job impacts, no matter how costly the regulation.
- The report included a case study showing that a full-economy, CGE-based analysis of the Utility Mercury and Air Toxics Standard (MATS) finds negative impacts to worker income across the full economy, in contrast to EPA's MPS-based estimate of small positive worker income impacts.
  - The CGE analysis used engineering costs for MATS comparable to EPA's.
- Subsequently, the U.S. Chamber asked NERA to develop full-economy, CGE-based worker income estimates for several other recent air rules.
  - Again, use engineering cost estimates comparable to those in EPA's RIAs.
  - Determine whether the case study finding that MPS-based estimates are inconsistent with a full-economy view can be viewed as a general finding.

Rules Analyzed in This Addendum

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- Cross-State Air Pollution Rule ("CSAPR") of 2011
  - Although CSAPR has been vacated, the RIA's MPS-based employment impact estimates can still be compared to those from a full-economy CGE analysis.
  - EPA used MPS multiplier to assess rule's employment impacts.
- Industrial Boiler MACT for Major and Area Sources ("Boiler Rule")
  - EPA used MPS multiplier to assess rule's employment impacts.
- A potential 65 ppb NAAQS for ozone
  - Use the EPA cost estimates for this potential NAAQS level from 2008 & 2010 RIAs, but assess those costs relative to the current 75 ppb NAAQS.
  - Prior RIAs did not include any employment impact estimates.
- All 3 combined -- to explore the cumulative nature of impact estimates

All of these analyses were conducted with CAIR (not CSAPR) in the baseline: is consistent with the RIAs from which the cost estimates are obtained, and enables the 3 set of results to be compared to each other.

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The CGE Model Used: $N_{ew}ERA$

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- Same model as used in the MATS case study in the report.
  - Detailed description of model is in Appendix B of the report.
- For the electric sector rules (e.g., MATS, CSAPR), we do not directly "input" the RIA's engineering costs to the CGE model.
  - Need to let $N_{ew}ERA$ estimate compliance costs by year given technology and fuel choices that can achieve compliance.
  - By using same technology and similar fuel cost assumptions as in EPA RIA, $N_{ew}ERA$ gets to a similar but not exact compliance cost in the electricity sector.
- Acronyms for $N_{ew}ERA$ sectors used in this addendum:

ELE – Electricity

GAS – Natural gas extraction & transport

COL – Coal mining and transport

EIS – Energy-intensive manufacturing

M_V – Motor vehicle manufacturing

MAN – All other manufacturing

CRU – Crude oil extraction

OIL – Oil refining

SRV – Commercial & service sectors

AGR – Agriculture

TRK – Commercial trucking

TRN – All other commercial transportation

Summary of These Additional Analyses: Full-Economy Impacts Are Consistently Negative, Contrary to MPS-Based Estimates

NERA Economic Consulting

Rule	Sectors Subject to Rule	Modeled Costs, Annualized (billions, 2010$)	Job-Eq. Impact Estimates	
			EPA (using MPS)	N_{ew}ERA (using CGE)
MATS (*)	Electricity	$10.4 (in 2012)	+8,000 (-15,000 to 30,000)	-71,000
CSAPR	Electricity	$0.5 (in 2013)	+700 (-1,000 to 3,000)	-34,000
Boiler MACT	Most industry other than ELE	$2.4	+2,200 (-4,100 to 8,500)	-28,000
65 ppb Ozone	All sectors + households	$26.5	Not estimated	-609,000
3 above combined	All sectors + households	3 above combined	Not estimated	-750,000

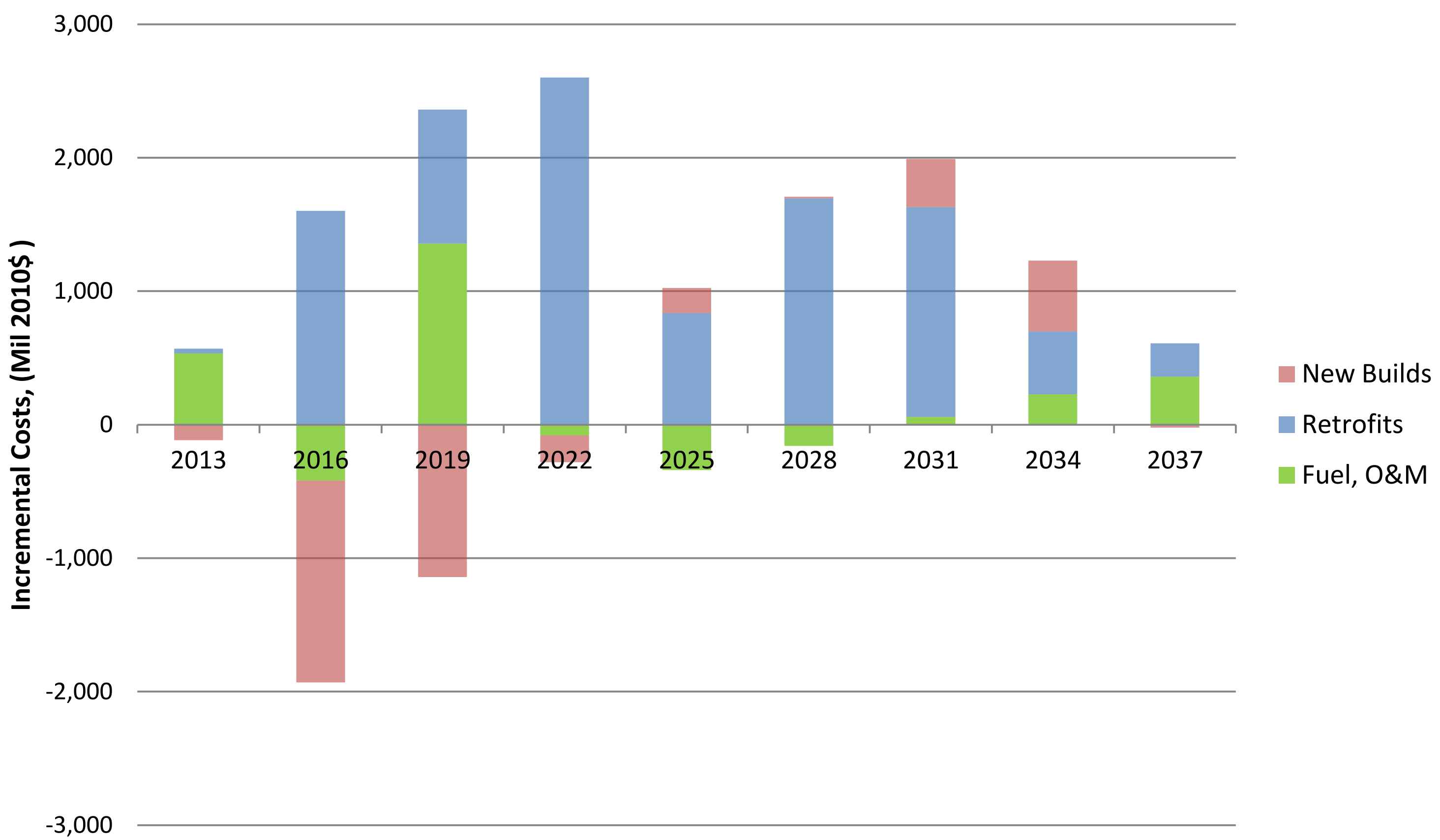
(*) Analysis reported in the report. (MATS impact analysis was performed relative to baseline with CSAPR. The 3 additional policies in this addendum were analyzed relative to a baseline with CAIR for comparability to EPA's RIAs for those 3 rules.)

CSAPR – Overview

- CSAPR requires 28 Eastern states to reduce SO_2 & NO_X emissions to help states achieve the NAAQS.
- Emission caps, starting in 2012; Phase 2 in 2014
  - We implemented the specific emissions caps, including limits on inter-state allowance trading as constraints in N_{ew}ERA's electric sector.
  - N_{ew}ERA optimizes the generators' choices to retrofit, retire, fuel-switch, buy allowances, &/or reduce generation in order to comply with the emissions caps.
    - Resulting electricity price changes are passed to other sectors and households.
    - Resulting up-front compliance investments increase labor and capital demand from the rest of the economy.

CSAPR – Annualized Electric Sector Costs Projected by N_{ew}ERA

NERA Economic Consulting



Annualized Compliance Costs (billions of 2010$)		
EPA	1.5 (2012)	0.8 (2014)
N_{ew}ERA	0.5 (2013)	0.1 (2016)

CSAPR – Comparison of Labor Impacts

NERA Economic Consulting

- EPA employment impact: jobs created by retrofits and ongoing compliance.
- NewERA: employment down because of additional electric sector costs passed to rest of economy.

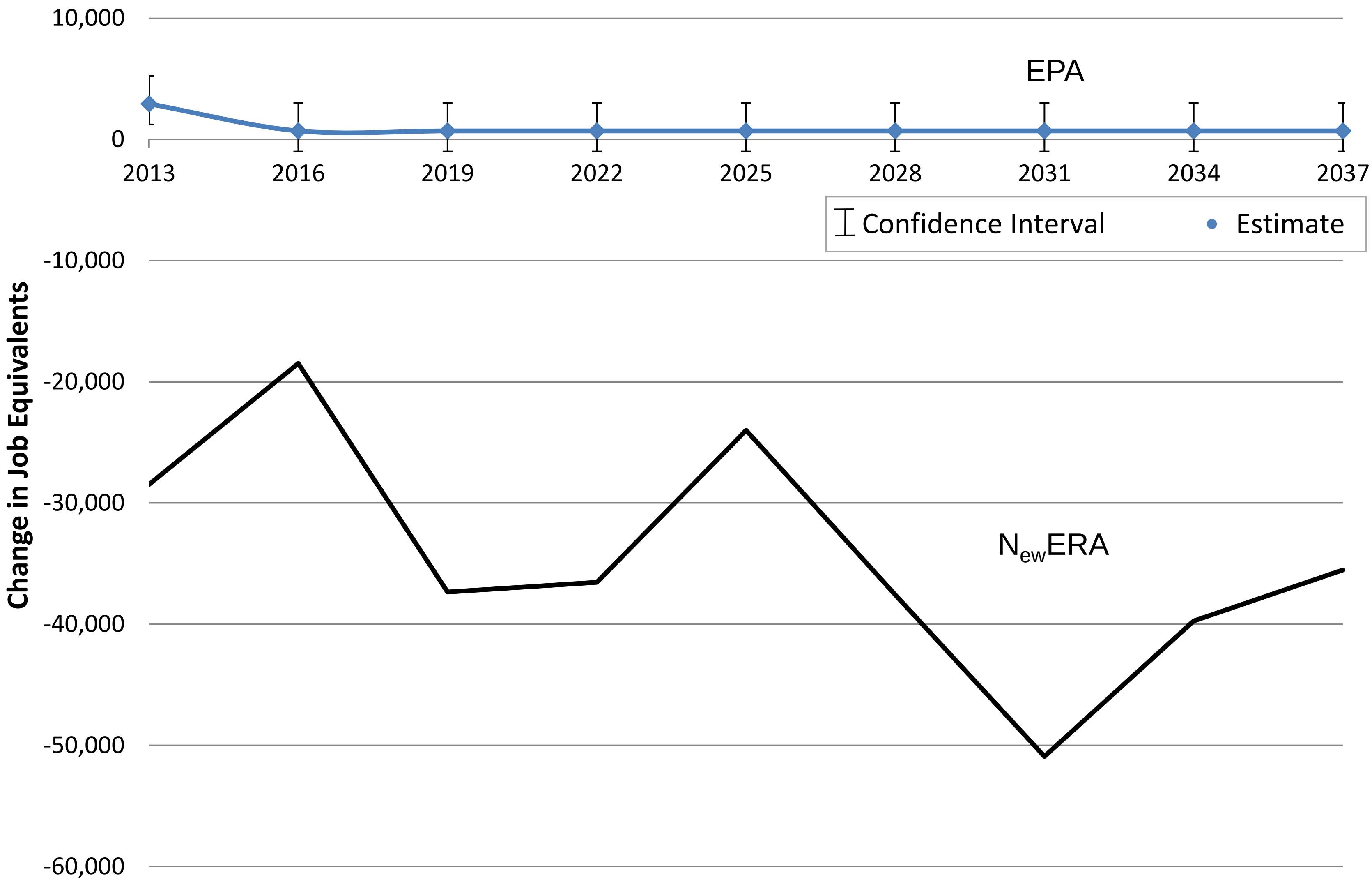
(Job Equivalents)	**EPA** based on Morgenstern et al. (2002)	**NewERA**
Employment Estimate	**+700** (per year)*	**-34,300** (avg, 2013-2037)**

* Statistical estimate, C.I. of -1,000 to +3,000

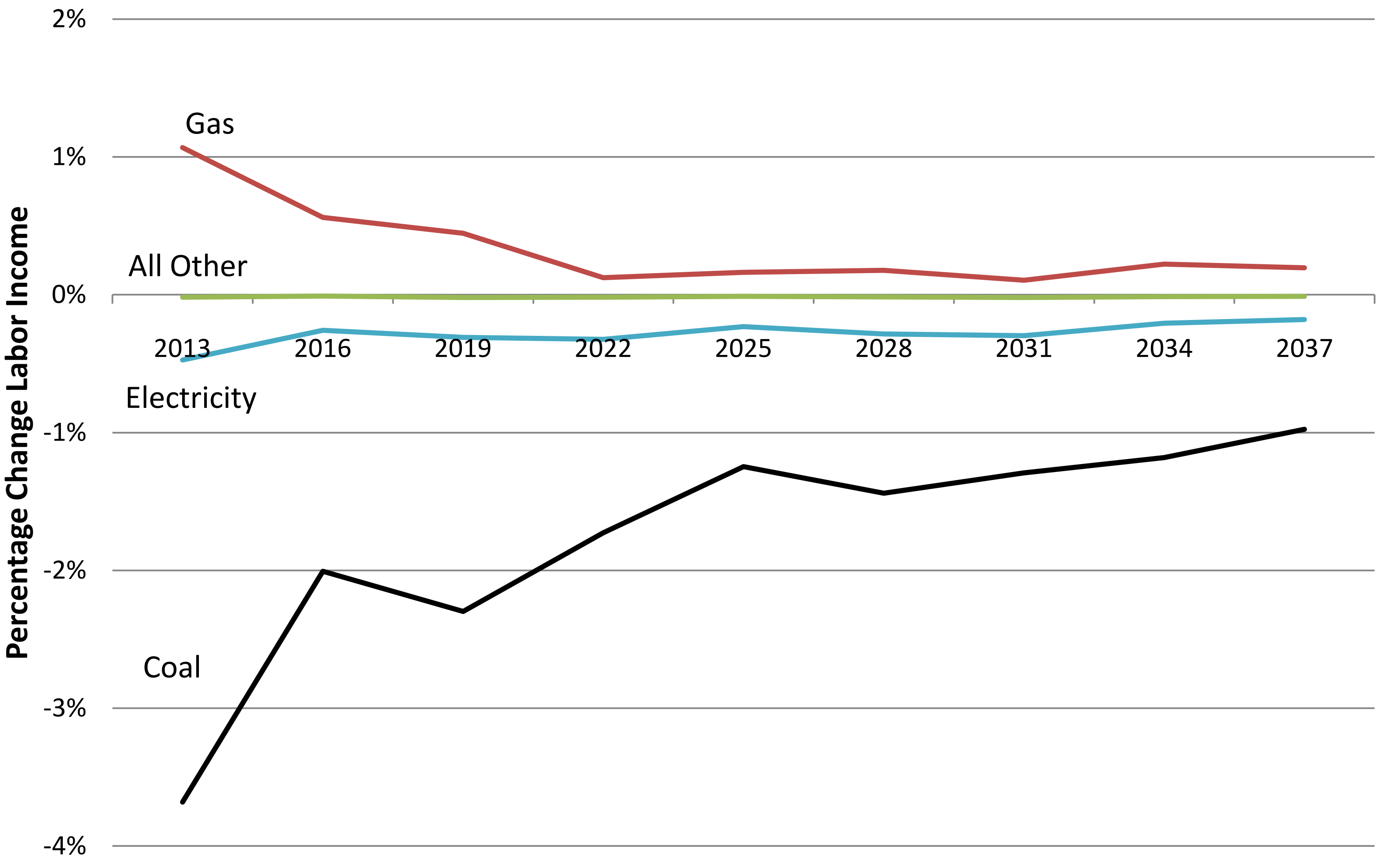
** Estimate varies by year

CSAPR – Labor Impacts by Year (as Change in Job-Equivalents of Total U.S. Labor Income)

NERA Economic Consulting

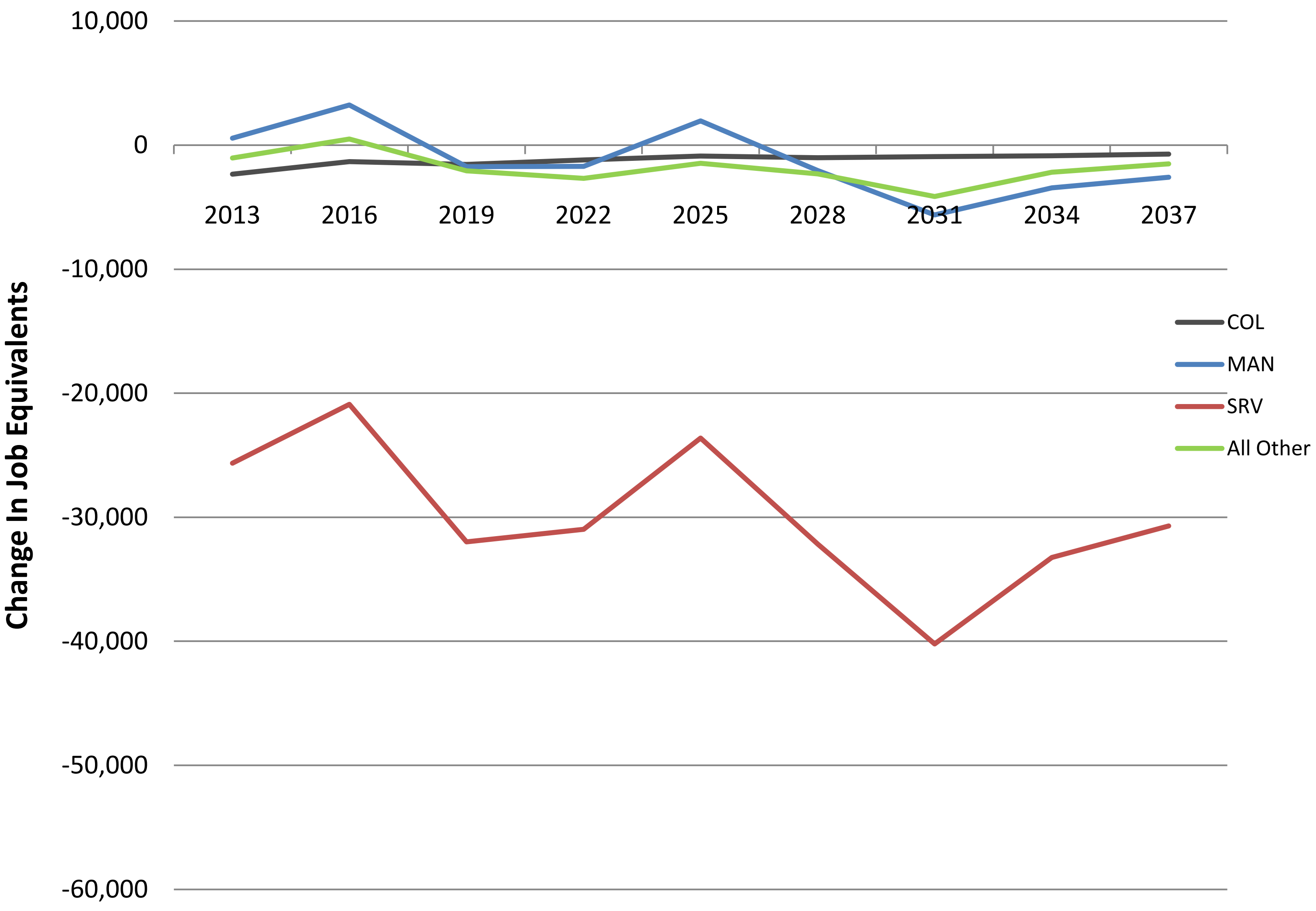


CSAPR – Labor Impacts by Sector (as Percentage Change Relative to Baseline)



CSAPR – Labor Impacts by Sector (as Change in Job-Equivalents of Total Sectoral Labor Payments)

NERA Economic Consulting



Boiler Rule – Overview

- Rule affects 14,000 “major” & 183,000 “area” boilers.
  - Major: (> 10 tpy emissions): Emissions Limits (PM, CO, HAP metals, SO_2, Hg) and annual maintenance checkups mandated.
  - Area: (< 10 tpy): energy assessment for area boilers (emissions limits only for coal units).
- Applies to most sectors other than electricity sector.
- EPA based its cost estimates on presumed control technologies by type of boiler.
- EPA’s cost estimates are used as direct cost increases to N_{ew}ERA’s non-electric sectors.
  - We estimated portion of EPA’s total cost that is one-time capital expenditure and portion that is recurring and input each with different timing.
  - Allocated to each N_{ew}ERA sector based on mapping from EPA’s costs by SIC codes.
  - New boiler costs allocated by same shares as or existing source costs.

Boiler Rule – Cost Inputs Derived from Data in RIA

NERA Economic Consulting

Total Annualized Boiler Rule costs reported in RIA of $2.4 billion (2008$).

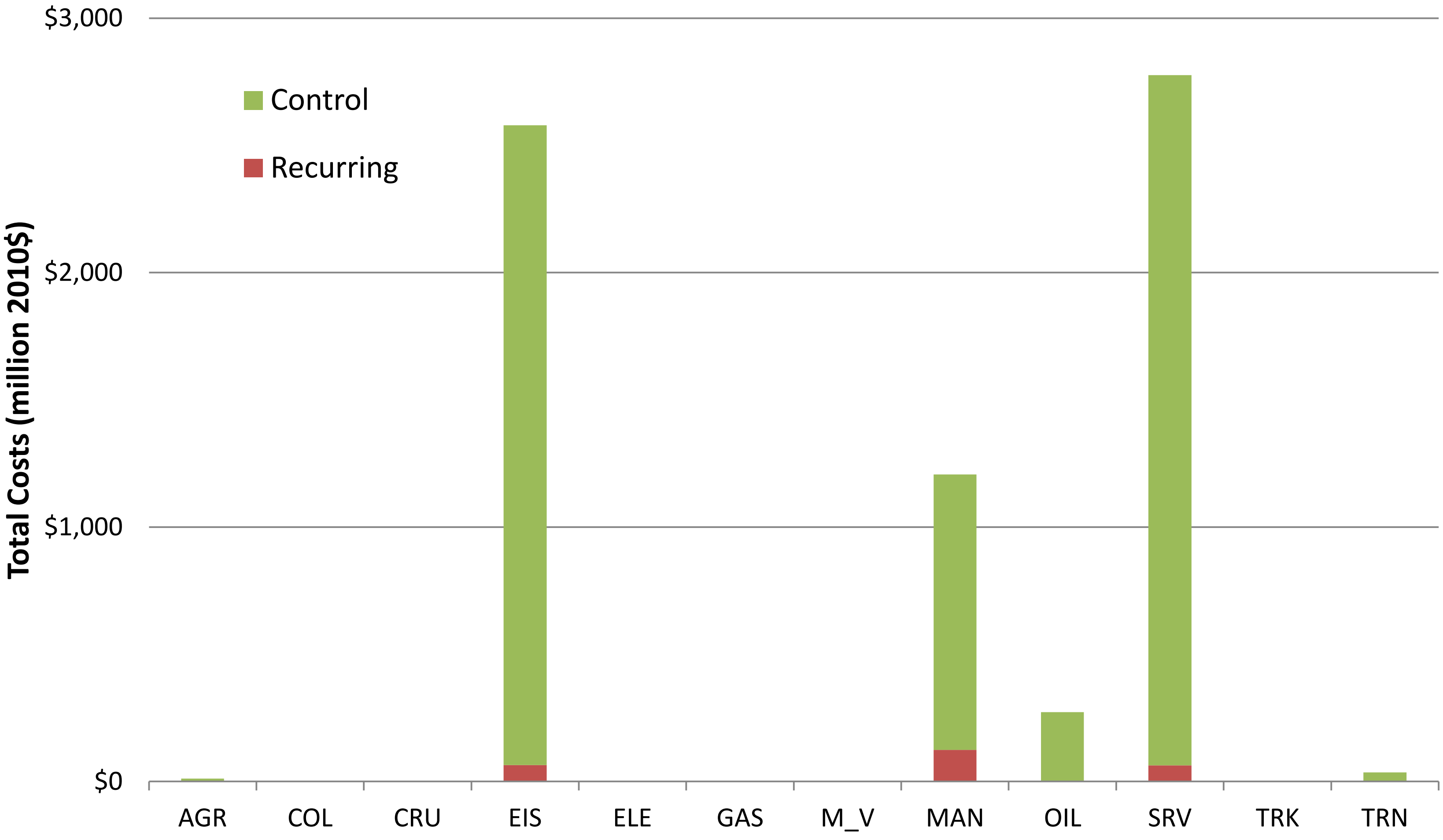
We need separate recurring and capital costs for the N_{ew}ERA model.

The disaggregation of the $2.4 billion costs was obtained from technical appendices supporting the RIA.

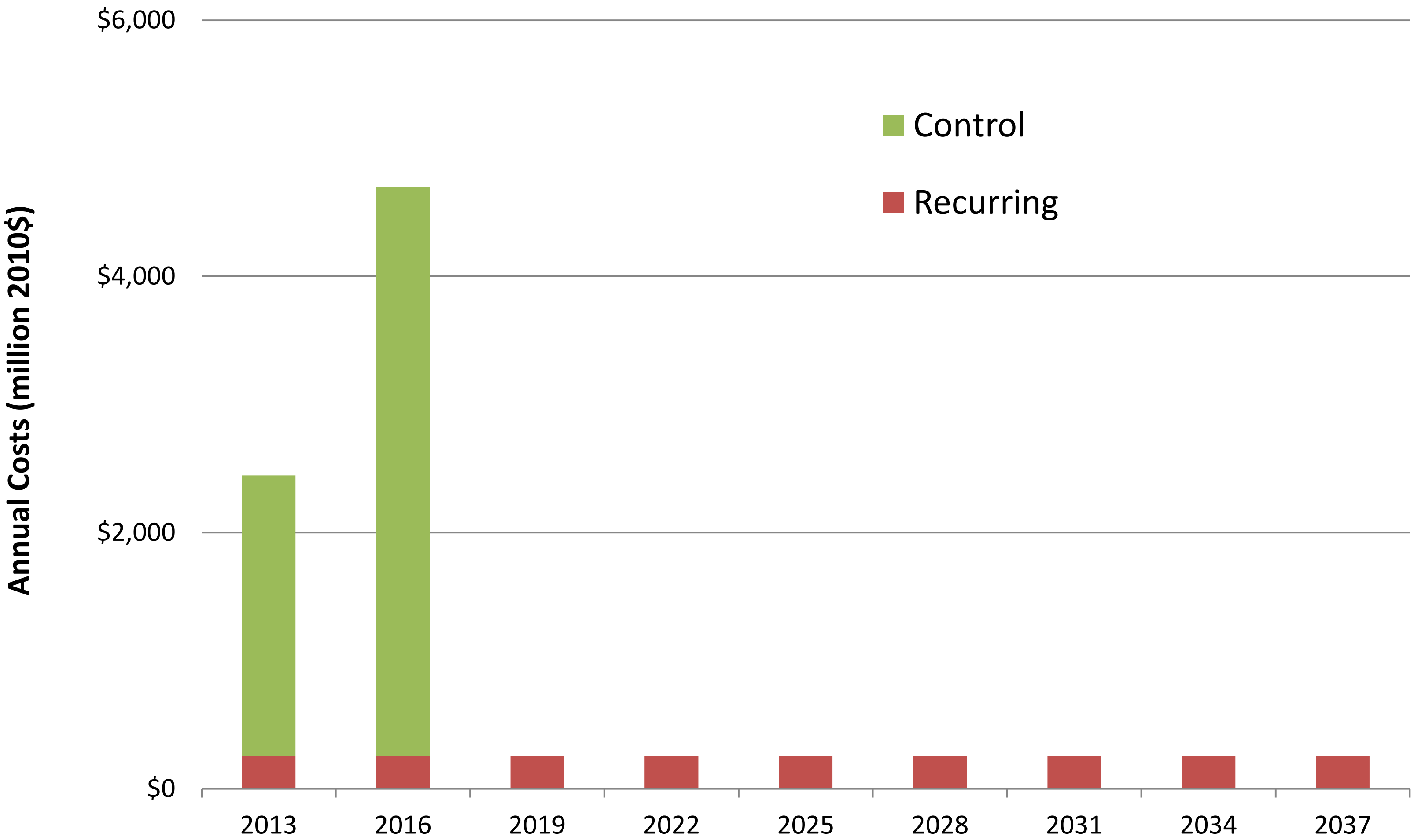
(million 2010$)	Recurring Costs	Capital Control Costs
Area Rule	$ 94	$ 1,411
Major Rule	$ 165	$5,216
Total Indust. Boiler	$ 259	$6,627

Boiler Rule – Cost Inputs by Sector in N_{ew}ERA

NERA Economic Consulting



Boiler Rule – Cost Inputs by Year



Boiler Rule – Comparison of Labor Impact Estimates

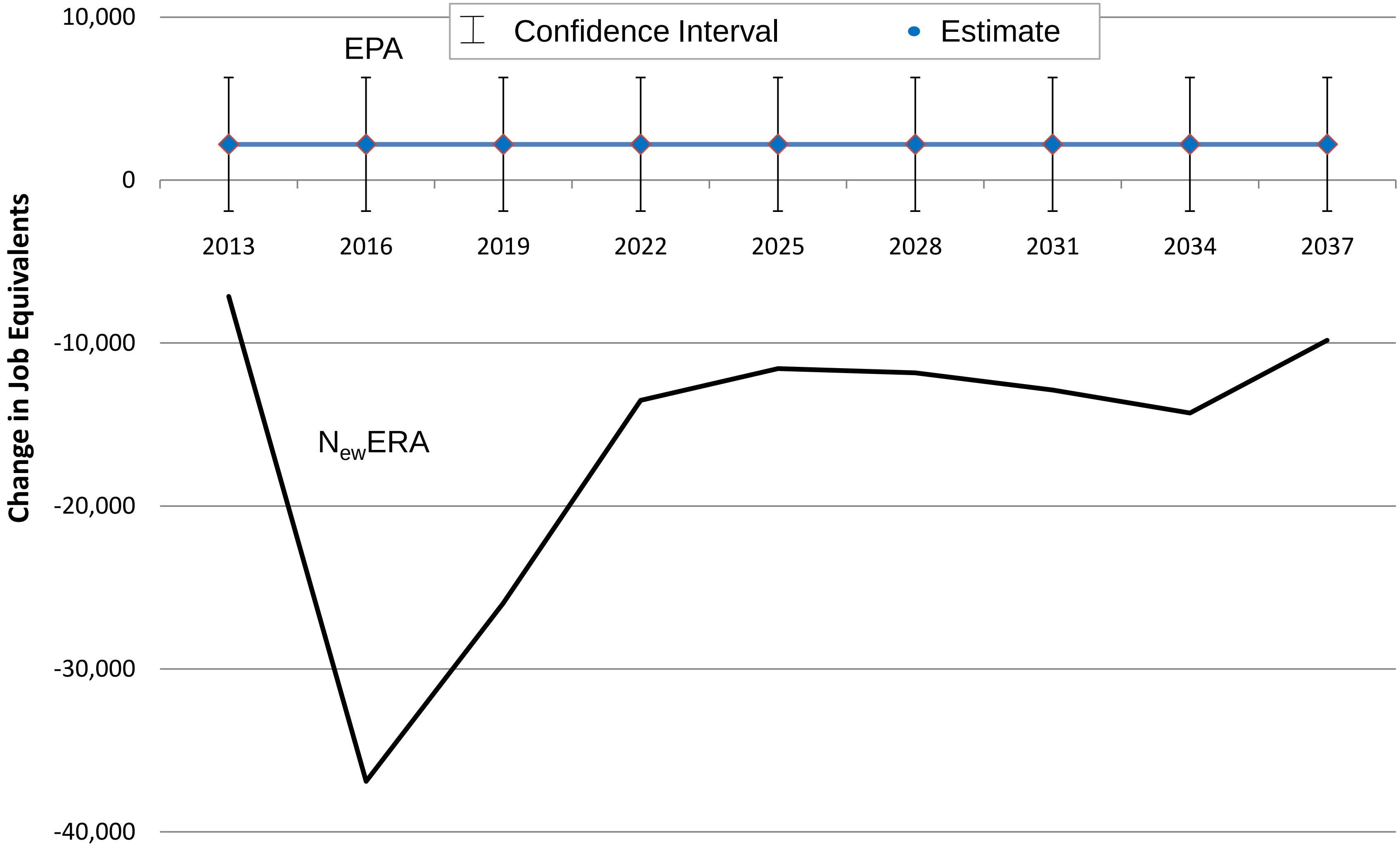
NERA Economic Consulting

(Job Equivalents)	**EPA** from RIA, based on Morgenstern et al. (2002)	**N_{ew}ERA**
Employment Estimate	**+2,200** (per year)*	**-27,585** (avg, 2013-2037)**

* Statistical estimate, C.I. of -1,000 to +3,000

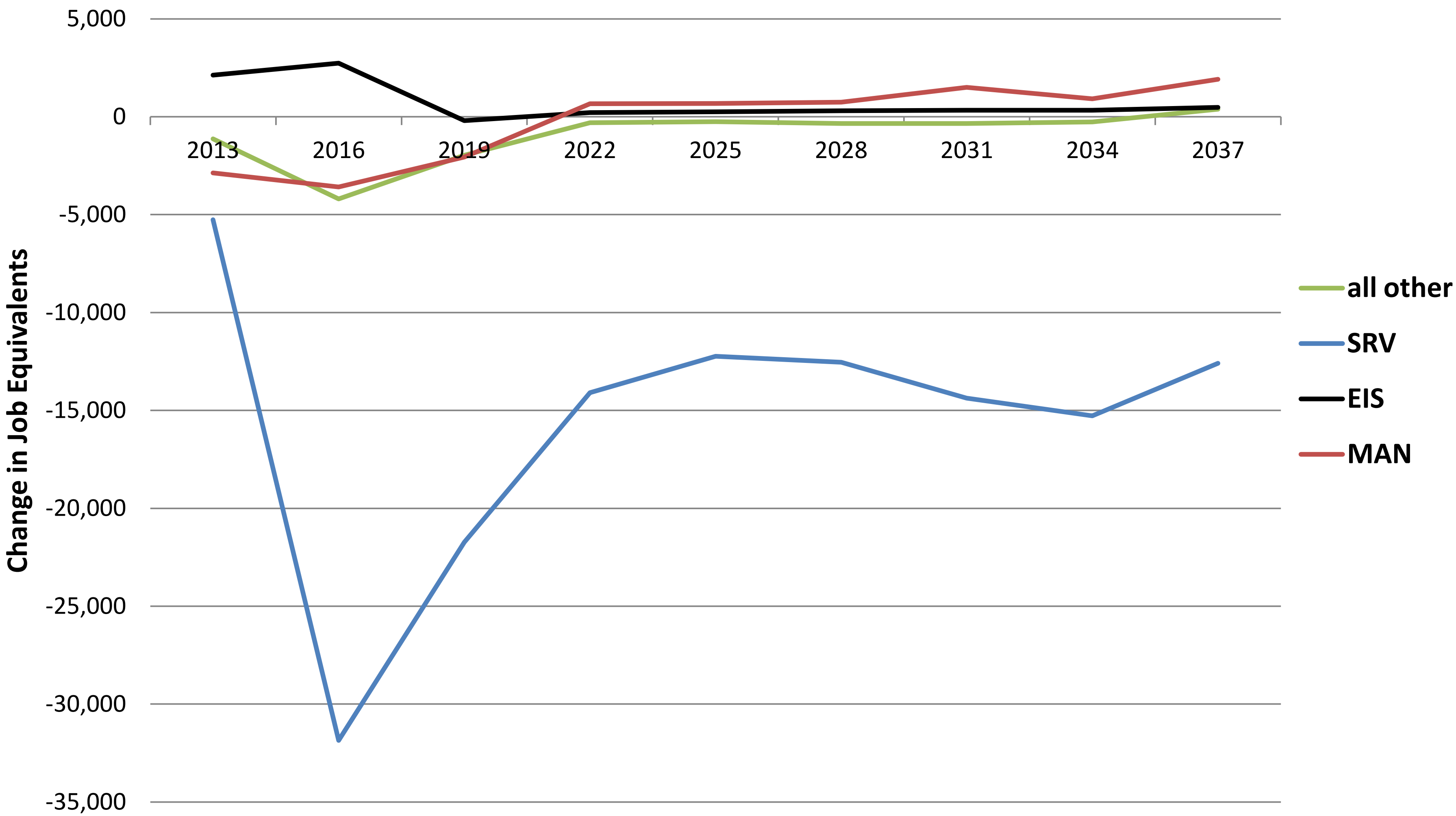
** Estimate varies by year

Boiler Rule – Labor Impacts by Year (as Change in Job-Equivalents of Total U.S. Labor Income)



Boiler Rule – Labor Impacts by Sector (as Change in Job-Equivalents of Total Sectoral Labor Payments)

NERA Economic Consulting



Ozone Rule – Overview

NERA Economic Consulting

- Current NAAQS of 75 ppb is under review by EPA and likely to be revised to a level between 50 ppb and 70 ppb.
- We analyzed one possible new NAAQS level: 65 ppb
  - Used cost estimates for 65 ppb from the 2008 ozone NAAQS RIA (and in the 2010 ozone reconsideration RIA).
  - Adjusted those cost estimates to assume starting from full attainment of the current 75 ppb standard.
- No employment impact estimates exist in the RIAs to compare our estimates to.
  - Next ozone NAAQS RIA is likely to contain employment impact estimates.

Ozone Rule – Cost Assumptions

NERA Economic Consulting

- RIA cost estimates for 65 ppb are mostly for unknown types of actions/investments:
  - "Known" controls: $4.5 billion/year, versus "unknown" controls: $39 billion/year (2006$).
  - We subtract RIA's cost of getting to 75 ppb from the above.
  - We allocate remainder of RIA's costs (converted to 2010$).
    - to N_{ew}ERA sectors (and households)
    - over time and to regions
- Sectoral allocation methods used:
  - For electric sector: Force in SCRs to all coal-fired units in 36 projected non-attainment states, if not already projected to have SCR by compliance date.
  - For rest of sectors and households:
    - "Known" control costs for non-EGU point sources allocated to N_{ew}ERA sectors based on their NAICS codes.
    - "Unknown" costs apportioned to sectors/households and to regions according to their projected NO_x emissions.

Ozone Rule – Location of Projected Nonattainment Areas

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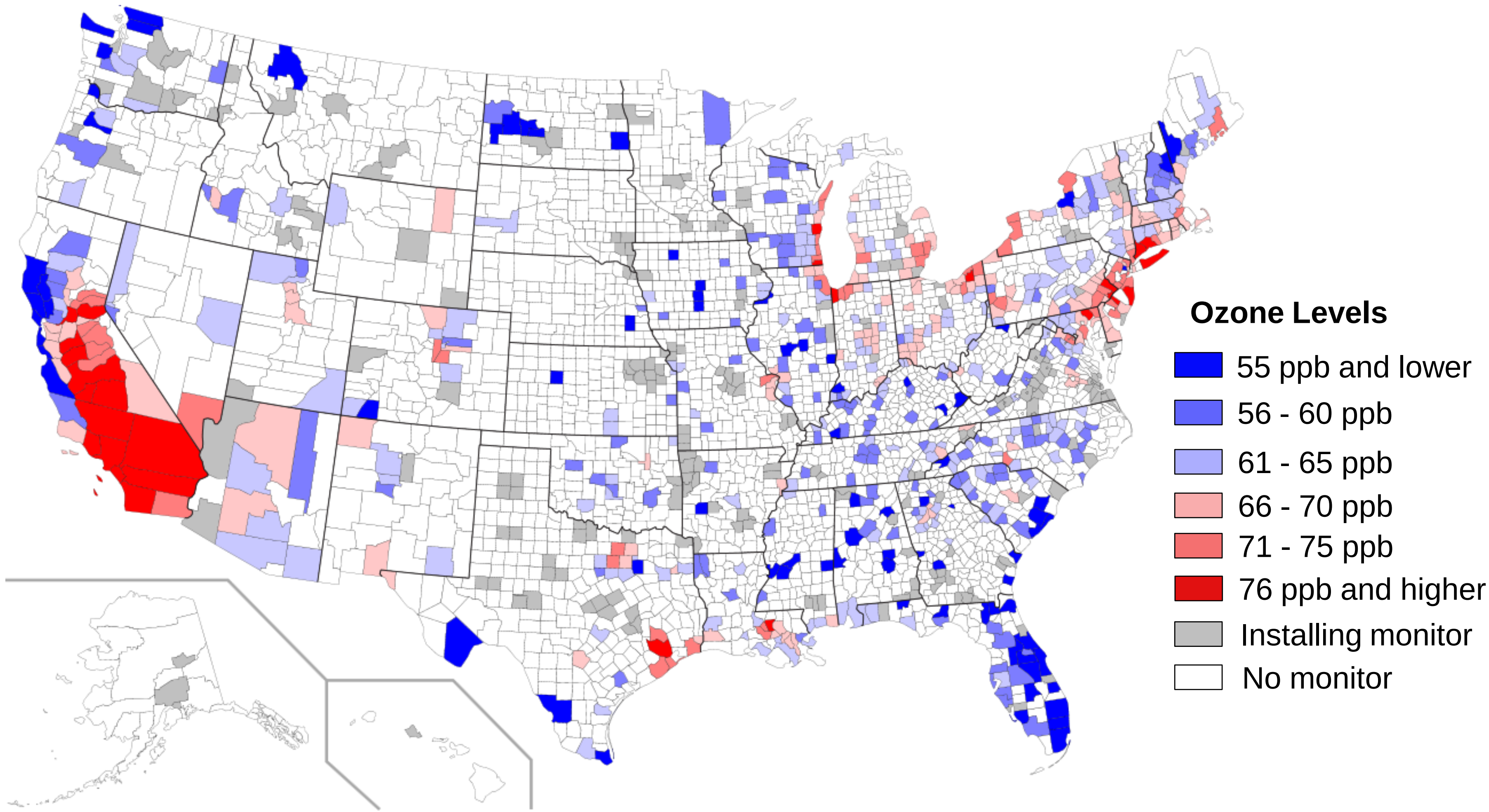

Based on EPA (2008)

Ozone Rule – Allocation of Costs over Time

NERA Economic Consulting

- In April 2012, EPA announced that areas would have between 3 and 20 years to come into attainment with the 2008 standards based on their current ozone levels. We assume same number of years until attainment time, clock starting in 2017 (consistent with a rulemaking in 2014).

Area Classification	Current Ozone Level	Attainment Time
Marginal	76-85 ppb	3 years
Moderate	86-99 ppb	6 years
Serious	100-112 ppb	9 years
Serious-15	113-118 ppb	15 years
Serious-17	119-174 ppb	17 years
Extreme	175 ppb and higher	20 years

- Each sector/region cost category is converted to a total present value, then 50% is assumed to be capital expenditure made in years from 2017 until region's compliance date. Other 50% is assumed to be recurring cost, which is applied on annual basis to all years from compliance year forward.

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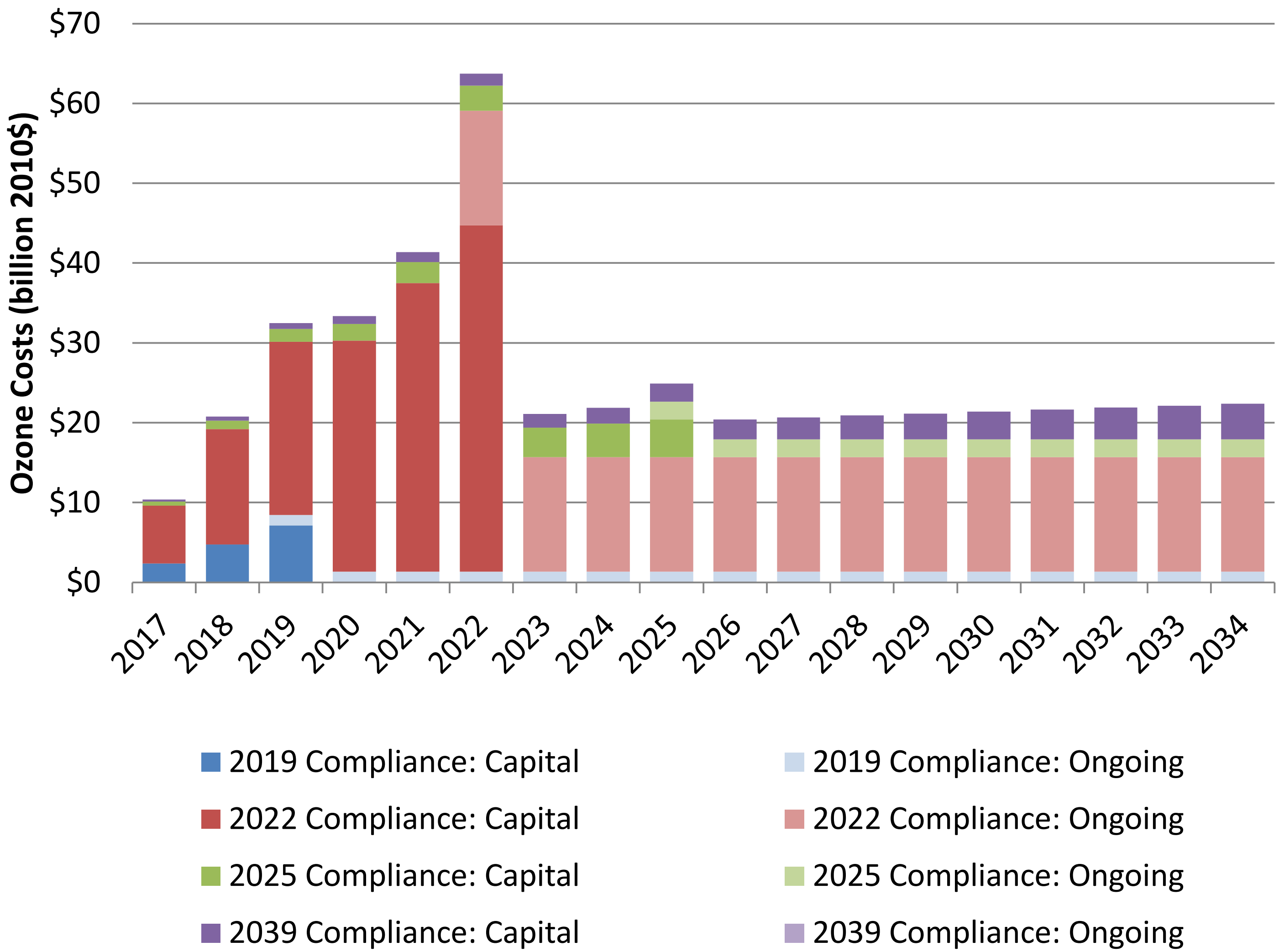
Ozone Rule – Compliance Cost Inputs by Year



Ozone Rule – Labor Impact Estimates

	EPA	NewERA
(Job Equivalents)	from RIA	Annual Average, 2013-2037
Employment Estimate	(no estimate)	**- 609,364**

Ozone Rule – Labor Impacts by Sector (as Change in Job-Equivalents of Total Sectoral Labor Payments)

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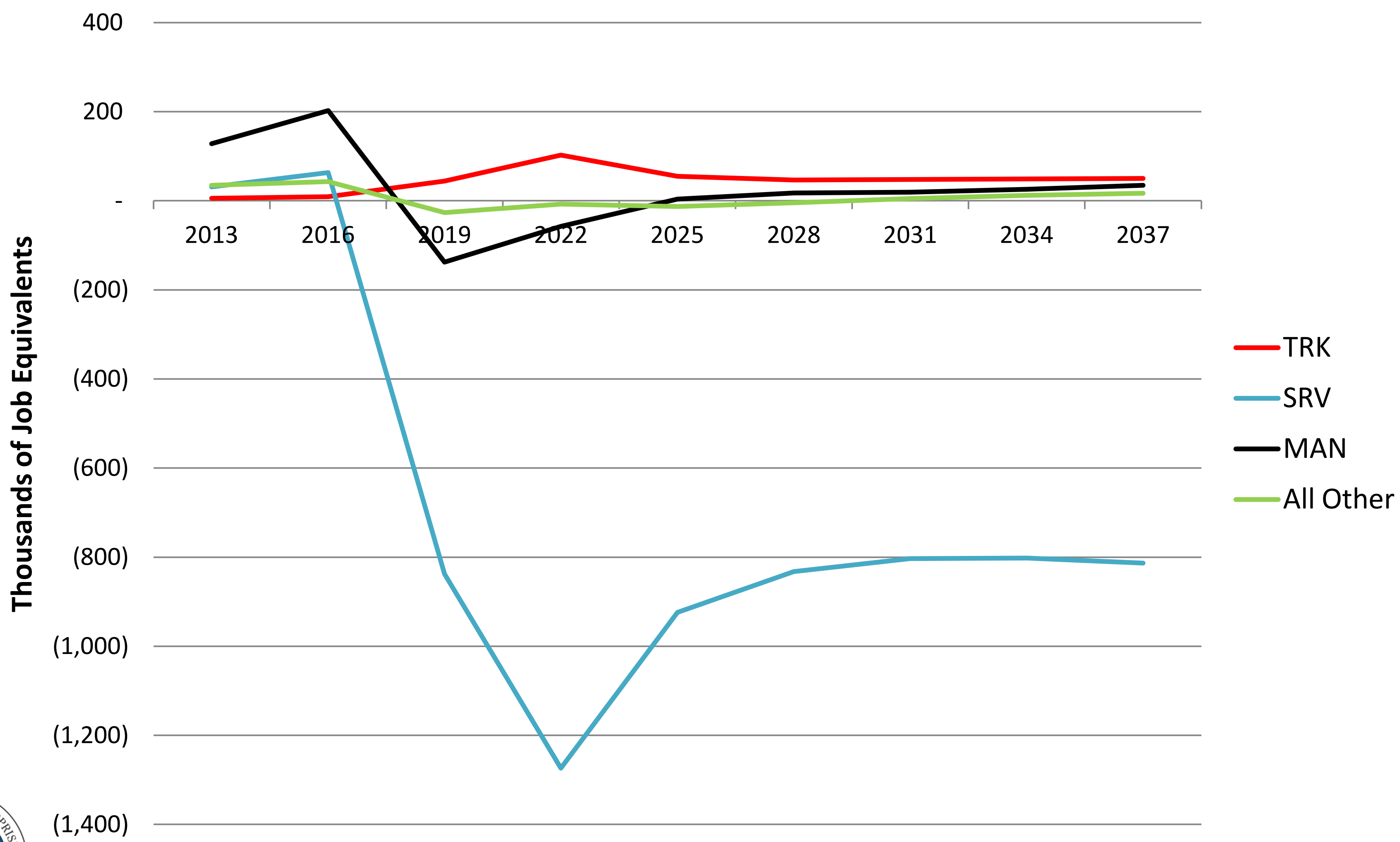

Combination of Rules – Overview

- Combined CSAPR, Boiler, Ozone rules by inputting their individual costs in same manner, but all simultaneously.
- No significant overlap in rules was identified requiring adjustments to avoid double-counting.
  - CSAPR requires NO_x and SO_2 controls in ELE only, and our Ozone Rule's requirements for SCRs are automatically accounted for in the CSAPR compliance strategy that N_{ew}ERA estimates endogenously.
  - Ozone Rule requirements for non-electric sectors would affect only NO_x and VOC emissions, while Boiler Rule requirements affect only PM. These require different types of technologies, and so are additive not duplicative.
- Ozone is dominant impact, but all rules contribute to employment and other economic impacts.

Combined Rule – Comparison to Labor Impacts of Individual Rules

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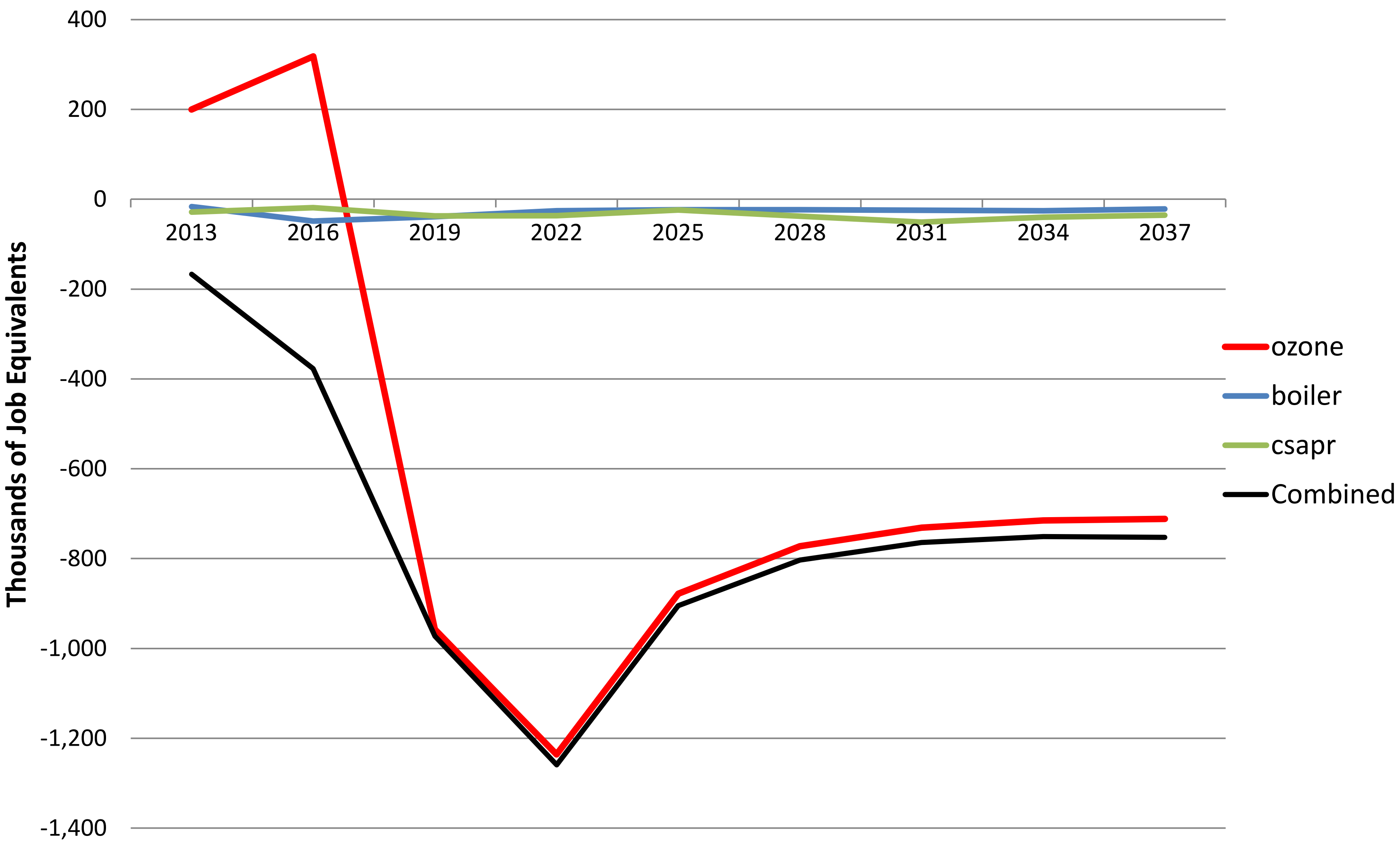

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