Lower Mekong Power Developments: Drought, Renewable Disruptions, and Electricity Trade

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Contents

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II. Disclaimer

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III. Executive Summary

Electricity demand in Southeast Asia is rising rapidly, and the five countries in the Mekong region are all challenged to not only meet rapidly rising electricity demand needs but also adapt to the clean energy transition, manage concerns over energy infrastructure's environmental impacts on the Mekong River system, and respond to short-term shocks from COVID-19 pandemic and drought. This report seeks to provide policymakers with situational awareness on technological advances and energy system shocks and provides recommendations on how to make long-term decisions on energy infrastructure and market opportunities following the COVID-19 pandemic.

The Mekong River plays a defining role for mainland Southeast Asia, providing the world's richest and most productive freshwater fishery; delivering and replenishing nutrients and sediment to agricultural land along the riverbanks and on floodplains; and providing a key source of electricity to nearly 70 million people living in the river basin and beyond. Large-scale hydroelectric dams currently provide the majority of power generation in Cambodia, Laos, and Myanmar, with Laos also exporting significant amounts of hydroelectricity to Thailand. Thailand and its neighbors plan to install more than 170,000 MW of new power generation through the mid-2030s. Much of this is from fossil fuel generation and the project portfolio also reflects growing diversification into alternative renewable solar and wind, but some portion will come from the 342 proposed dams in the Lower Mekong watershed. While many proposed projects will not ultimately move ahead, decisions about which projects to invest in will have broad implications for the Mekong's ecosystem and the people who depend on it.

While each country in the region decides which projects move ahead inside its sovereign borders, Thailand imports electricity from Laos and plays an influential role over which type of projects move ahead by providing revenue guarantees in the form of power purchase agreements (PPAs). This electricity trade and rising regional grid integration provides an opportunity to improve sustainable development by allowing for higher levels of renewable energy penetration throughout the Mekong countries and substitution of renewable solar and wind for impactful hydropower projects.

Recent disruptions may provide an opportunity to rethink the future energy buildout. In 2019 and 2020, the combined impacts from severe drought and alterations to the natural flow of the Mekong River from upstream hydropower have undermined the flood pulse that fuels fisheries productivity in the Tonle Sap and reduced hydropower generation. The COVID-19 pandemic has caused widespread devastation to the global economy in 2020, and this temporarily but significantly reduced electricity demand in countries across the Mekong region as manufacturing dropped and lockdowns impacted power usage. The impacts of these events are immediate, but provide opportunities for Thailand and its neighbors to accelerate the transition towards a clean energy sector and adapt to the increasing threats of climate change. Looking to the post-COVID era, policymakers have an opportunity to rethink policies and design stimulus packages to build out a future that is more diverse, resilient, and economically and environmentally sustainable.

Key Takeaways and Recommendations:

- **Policymakers should reaffirm ambitions to accelerate the energy transition as an integral part of COVID-19 recovery plans**. Renewable energy investments will not only bring clear environmental benefits locally and globally, but also have knock-on effects that could support sustainable economic recovery from the COVID-19 economic impacts.

- **As Thailand moves towards carbon neutrality, it would be beneficial to strategically plan Thailand's role as an electricity trading hub for ASEAN to support the region's overall renewable energy and climate goals.** One of the greatest benefits of a regional electricity grid is that it supports higher levels of variable renewable energy electricity projects. As Thailand pursues a long-term goal of becoming an electricity hub, policymakers should plan not only for finding markets for excess power but also lay the foundation for Thailand and its neighbors to take advantage of higher amounts of regional variable renewable energy assets like solar and wind. Updating Thailand's next Power Development Plan to explicitly include non-hydropower projects in future imports from Laos would lay a forward-looking foundation for Thailand to be a sustainable and flexible electricity trading hub.
- **Refusing to sign new power purchase agreements for mainstream hydropower dams in Laos would have financial benefits for EGAT and manage risk for the eight Thai provinces which rely on the Mekong River's natural resources.** The four Mekong mainstream dam projects currently under consideration in Lao PDR (Luang Prabang, Pak Lay, Pak Beng, Sanakham) all intend to export electricity to Thailand, but there is rising concern inside Thailand about the economic, social, and environmental costs of these projects. Starting in late 2020, Thailand's top water official indicated that the Thai government might reconsider buying electricity from the Sanakham Dam and that Thailand could exercise its right under the 1995 Mekong Agreement to halt the project if the government determined that construction would negatively impact Thailand.[1] Refusing to sign agreements for mainstream dam projects would allow Thai policymakers to better consider costs and benefits of alternative projects, including floating solar proposed on the Nam Ngum 1 and Nam Theun 2 dams.
- **Policymakers around the region should prioritize investment towards modernization of the national and regional electricity grid to ensure successful integration of renewable energy technologies and electric vehicles.** Investment in new power generation has continuously attracted support from the private sector, but transmission infrastructure needs to be modernized and upgraded in order to support both the new power generation capacity broadly and in particular to incorporate higher levels of renewable energy and potential demand shifts due to electric vehicles.
- **The US and Japan should prioritize infrastructure funding from the U.S. Development Finance Corporation and Japan Bank for International Cooperation towards power generation and transmission projects in cross-border clean energy zones**. The Japan-U.S. Mekong Power Partnership (JUMPP) has already supported a series of technical assistance projects which support regional energy integration, cross-border power trade, higher deployment of advanced energy technologies, and a multi-sector nexus approach to planning which can help avoid or mitigate impacts of energy projects. The opportunities identified through these technical assistance projects supporting these efforts could be used to help inform investments from Japan and the United States, as well as ACMECS and like-minded development partners. Such projects could also take advantage of COVID-19 recovery funds aimed at green infrastructure.

[1] Apinya Wipatayotin, "Govt warns over Lao dam plan," *The Bangkok Post*, November 25, 2020, at https://www.bangkokpost.com/thailand/general/2025023/govt-warns-over-lao-dam-plan; Apinya Wipatayotin, "Thai govt threatens to veto new Lao dam," *The Bangkok Post*, December 12, 2020, at https://www.bangkokpost.com/thailand/general/2034151/thai-govt-threatens-to-veto-new-lao-dam.

1. Introduction

Demand for electricity is growing rapidly in Southeast Asia. Average annual electricity demand growth in Cambodia, Laos, Myanmar, and Vietnam over the last decade has often surpassed 10%. Thailand's electricity demand growth of 3.7% has been notably lower,[2] and the Power Development Plan 2018 projects a continued average growth rate of 3.8% in coming decades in line with economic projections.[3] This lower rate is in part because Thailand is a more developed economy and has already reached 100% electrification. However, projected installation of new power generation capacity is significant as the government aims to replace aging power plants, electrify the transportation sector, and capitalize on its geographic location to serve as an electricity trading hub. While each country in the region makes national determinations about its own energy mix, Thailand imports electricity from neighbors and plays an influential role over which type of projects move ahead in Laos by providing revenue guarantees in the form of power purchase agreements (PPAs).

Regional grid integration provides an opportunity to improve sustainable development by allowing for higher levels of renewable energy penetration throughout the Mekong countries. However, regional coordination in terms of power development and electricity trade is necessary to prevent ecological damage. The construction of dams on the mainstream of the Mekong and on its tributaries in Laos is intended to support regional electricity trade and provides a renewable alternative to fossil fuels—but while renewable, these dams reduce sediment delivery to the agricultural rice-baskets of Cambodia's floodplains and the Mekong Delta in Vietnam, block fish migration pathways, and alter the natural dry and wet seasonal variance in water levels. Without coordination, the Mekong River's natural and agricultural productivity could be further damaged even as the region's overall energy mix becomes less carbon intensive.

Recent disruptions may provide an opportunity to rethink the future energy buildout. In 2019 and 2020, the combined impacts from severe drought and alterations to the natural flow of the Mekong River from upstream hydropower have undermined the flood pulse, which underpins the river's rich fisheries and provides sediment to farms along the floodplains and in the Mekong Delta. The drought has also negatively impacted hydroelectric power generation, reducing power output and causing blackouts in Cambodia. For instance, Cambodia's hydroelectricity production dropped by 30% (400 MW out of an installed capacity of 1,341 MW) in 2019. The 2019-2020 drought is the second major drought in the last five years. Most climate projections for mainland Southeast Asia anticipate shifts to location, intensity, and amount of rainfall in ways that would impact future hydropower production, and El Niño events which usually cause low rainfall in

[2] Asian Development Bank, "Sector Overview," *Grid-Parity Rooftop Solar Project: Report and Recommendation of the President,* November 2016, accessed at https://www.adb.org/sites/default/files/linked-documents/49087-001-so.pdf.

[3] Thailand Ministry of Energy, "Thailand Power Development Plan 2018 (PDP 2018)" [original article in Thai: แผนพัฒนากำลังผลิตไฟฟ้าของประเทศไทย พ.ศ. 2561 – 2580], April 30, 2019, page 3.

Southeast Asia are becoming more intense.[4] The resulting risks to the power sector should be seriously considered, particularly in countries like Cambodia, Laos, and Myanmar which have high dependency on hydropower.

Other macroeconomic trends have also impacted the regional power sector. The COVID-19 pandemic has caused widespread devastation to the global economy in 2020, and Southeast Asia's economy contracted 4% in 2020.[5] Quarantine and lockdown practices have driven down demand for electricity in many countries, and for export-focused countries the global economic slowdown has impacted commercial and industrial electricity demand. Thailand's electricity demand shrinking 3% in 2020.[6] While disruptions to electricity consumption patterns resulting from the pandemic will not impact long-term electricity needs, the crisis has affected supply chains, workforce movement, and in some cases project pipelines. The drop in demand has also presented short-term financial difficulties to utility companies and may speed along policy changes. For instance, the Electricity Generating Authority of Thailand (EGAT) has announced changes to the reserve margin and is publicly rethinking some PPAs with Laos.

The impacts of the recent drought and COVID-19 are immediate, but they create opportunities for Thailand and its neighbors to accelerate the transition towards a sustainable energy future, adapt to the increasing threat of climate change, and lay out a stronger economic recovery in the post-pandemic environment. Southeast Asia has historically lagged other parts of the world in the adoption of renewable energy technology, but the short-term disruptions to the energy sector make cost competitiveness and resilience in the face of shocks even more important. Renewable energy has proven resilient throughout the pandemic. As decision-makers revisit national targets and plans post-COVID there is a real opportunity to rethink the role of renewable energy and use the momentum of economic recovery to push for reforms and policy changes which support higher integration of renewable energy.

This paper will build on the analysis from the 2019 *Thailand Energy Scenarios Study* to explore how technological innovations, drought, and the coronavirus are impacting the Mekong region's energy sector and what this means for Thailand and its neighbors. Thailand has historically been a regional leader and early adopter of renewable energy technologies, including solar panels, wind turbines, and now electric vehicles and battery storage. Despite the devastation caused in the short-term, the drought and pandemic provide an opportunity and motivation for

[4] Please check out the following references on climate change in Southeast Asia: Bin Wang, Xiao Luo, Young-Min Yang, Weiyi Sun, Mark A. Cane, Wenju Cai, Sang-Wook Yeh, and Jian Liu, "Historical change of El Nino properties sheds light on future changes of extreme El Nino," *Proceedings of the National Academy of Sciences of the United States of America,* November 5, 2019, at https://www.pnas.org/content/116/45/22512; Asian Development Bank (ADB), *The Economics of Climate Change in Southeast Asia: A Regional Review,* 2009, page 255; Jasparro, C. and J. Taylor, *Climate change and regional vulnerability to transnational security threats in Southeast Asia*, Geopolitics, 13(2), 2008, pages 232-256;

[5] Asian Development Bank (ADB), *Asian Development Outlook 2021: Financing a Green and Inclusive Recovery,* April 2021, page xxii.

[6] Energy Policy and Planning Office, "Electricity Consumption for the Whole Country (Classified By Sector)", Ministry of Energy, accessible from http://www.eppo.go.th/index.php/en/en-energystatistics/electricity-statistic.

policymakers in the region to rethink their future energy plans and transition to a more resilient future by strategically shifting towards renewables in national recovery and stimulus packages.

2. Current Power Situation in the Mekong Region

The International Energy Agency (IEA) estimates that Southeast Asia will see energy demand growth of 60% from 2019 through 2040. This is among the fastest rates in the world and makes the region a major contributor to future global energy demand.[7] According to government demand projections and power development plans, the five Mekong countries of Cambodia, Laos, Myanmar, Thailand, and Vietnam will require over 170,000 MW of new power generation in the coming two decades.

All five lower Mekong countries face similar tensions between the need to meet rising energy demand, ensure energy security, and expand reliable electricity access alongside the need to conserve key natural resources, including those which depend on the Mekong River system's natural flow and underpin regional food security. Each country is unique as a result of differences in economic development levels, urbanization and population growth rates, electricity grid access, and geographic factors, all of which impact the baseline electricity market size and rates of national electricity demand growth.

2.1 Country Snapshots:

Vietnam has a connected national power grid and rapidly expanded electricity access from only 14% in 1993 to near universal electrification by 2014.[8] While per capita electricity use remains relatively low, demand has risen steadily and is largely driven by industrialization and urbanization. Much of this is to support expansion of energy intensive manufacturing but is also tied to rapidly rising household electricity consumption.

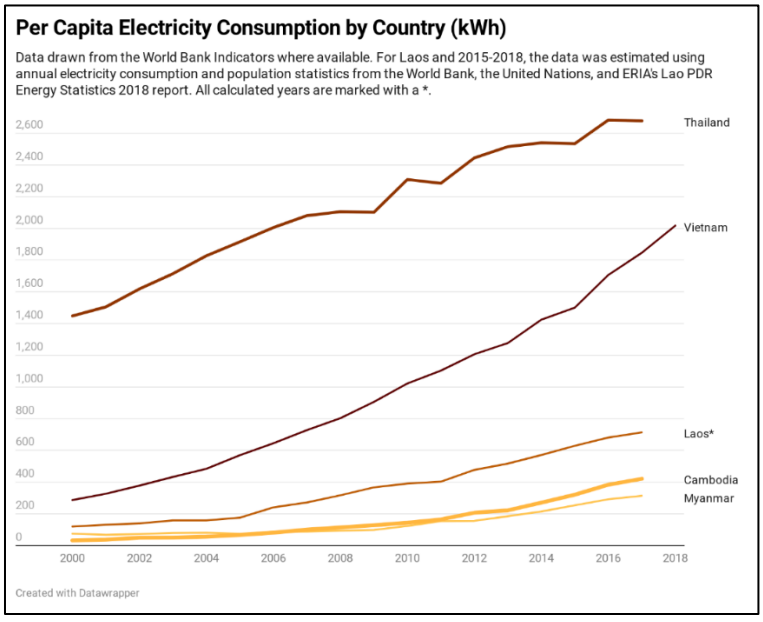
Although **Laos** is still building out a national electricity grid and improving reliability of access, it has made remarkable progress in expanding electricity access. In 2000 only 43% of the population had access to electricity; as of 2018, the electrification rate surpassed 97%.[9] Laos has among the lowest rates of electricity usage in ASEAN and much of the rapid electricity demand growth derives from the household level. Laos is unique in that much of the planned power generation capacity expansion is for export to neighboring markets and many projects bypass the national grid and connect directly across the border to the grid in Thailand.

[7] International Energy Agency, *Southeast Asia Energy Outlook 2019*, International Energy Agency, 7.
[8] Mr. Ousmane Dione, "Sustainable Energy Future in Vietnam," Prepared Remarks for the 2nd High Level Meeting of the Vietnam Energy Partnership Group, November 27, 2018, accessed at https://www.worldbank.org/en/news/speech/2018/11/27/sustainable-energy-future-in-vietnam.
[9] World Bank, "Access to electricity (% of population) – Lao PDR," *The World Bank – Data,* accessed 9/18/2020, https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?locations=LA.

Table 1 Electrification rates are drawn from World Bank statistics. Recent Annual Electricity Demand Growth rates are drawn from ERIA national energy outlooks and national power development plans. Projected Annual Electricity Demand Growth are drawn from the ADB's Cambodia Energy Sector Assessment, ERIA Myanmar Energy Outlook, Thailand PDP2018, and Vietnam's draft PDP8. Per capita electricity consumption is calculated using EIA figures (2018) and ADB reports (2017). Current Installed Power Capacity (MW) is taken from the Mekong Infrastructure Tracker. Projected Capacity is taken from the national energy plan for each country.

Country	Cambodia	Lao PDR	Myanmar	Thailand	Vietnam
Electrification Rate (%)	70%	97%	50%	100%	100%
Recent Annual Electricity Demand Growth (%) (2010 – 2018)	18.3%	10.50%	13.9%[1]	3.80%	10.5%[2]
Projected Annual Electricity Demand Growth (%)	8.80% to 2030	N/A	7% to 2040	3.8%	9.1% to 2025, 7.9% to 2030
Per Capita Electricity Use (kWh/capita)	517 kWh per capita (2018)	725kWh per capita (2017)	335 kWh per capita (2018)	2,676 kWh per capita (2018)	2,271 kWh per capita (2018)
Installed Power Capacity (MW) in 2021	2,382 MW	10,516 MW	6,012 MW	54,971 MW	65,509 MW
Projected Capacity (MW)	16,000 MW by 2030	26,000 MW	13,410 MW in 2030[3]	77,211 MW in 2037	137,200 MW in 2030

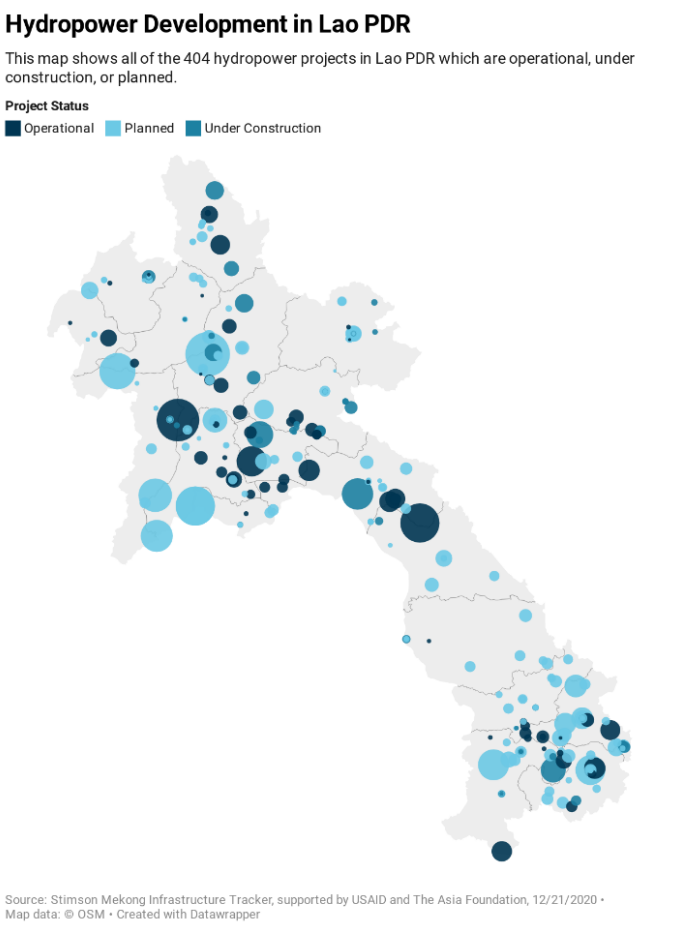
[1] *Myanmar statistics for energy demand run through 2017.*
[2] *Vietnam statistics run 2011 – 2019.*
[3] *Drawn from high demand scenario in Master Energy Plan 2015, as that is most in line with recent electricity demand growth rates.*



The Battery of Southeast Asia

Laos has for decades pursued income generation through becoming the "Battery of Southeast Asia" and selling electricity to neighboring countries. Hydroelectricity—alongside natural resources like timber and minerals—is viewed as a key export to bring income into the country. Most of Laos's current electricity production is from hydropower dams, although 20% is produced by coal and Laos has biomass and solar pilot projects. To date, the majority of Laos's power generation has been developed for export to Thailand, which began purchasing power from Laos's first hydropower project in 1971 and has increased its power imports significantly over the years. However, Laos has sought to diversify through sales to other neighbors. In addition to a 2016 MOU to sell 9,000 MW Thailand, Laos has signed an agreement to export up to 5,000 MW to Vietnam by 2030, 6,000 MW to Cambodia by 2030, and 300 MW to Myanmar by 2025.[10]

To produce all this electricity for export, Laos plans to build hundreds of hydroelectric dams. Lao policymakers point to a technical hydropower potential of more than 26,000 MW as the rationale for a focus on hydropower, and there are more than 335 dams in some phase of development in Laos. Sixty-one of them are already operational, 40 are currently under construction, and 234 more projects have been proposed and are undergoing some level of study or review.[11] Two hundred and sixty-three (or 79%) of these are smaller than 15 MW and are considered small-scale hydropower, but the remaining projects range in size significantly and include projects like the Xayaburi Dam which are more than 1,000 MW.



[10] "Lao electricity exports increase 145 percent in 2016 – 2020 period," *Xinhua*, February 5, 2020, at http://www.xinhuanet.com/english/2020-02/05/c_138757433.htm.

[11] Mekong Infrastructure Tracker, which is curated by the Stimson Center and supported by USAID and The Asia Foundation, August 21, 2020.

Cambodia and Myanmar's electricity demand growth is due to a combination of industrialization, urbanization, and expansion into new markets as the national grids reach rural communities. In Cambodia, a boom in urban real estate construction has driven a supply and demand mismatch with a reported 700% increase in demand reported from 2018 to early 2019.[12] Due to limited domestic power generation capacity, approximately one-fifth of Cambodia's electricity needs are met through imports and this will continue to be the case into the near future. There are efforts to diversify and expand domestic power generation: the Mekong Infrastructure Tracker shows that Cambodia currently has 1480 MW of new power plants under construction, mostly coal and solar. The Power Development Plan 2020 – 20230 anticipates building up to 3,600 MW of natural gas power plants by 2030.[13]

Myanmar's electricity demand growth is among the highest in ASEAN and has consistently outpaced supply, resulting in frequent brownouts and blackouts. New grid-scale power generation development has been relatively slow to materialize, although 15 projects with 985 MW of installed capacity came online between 2016 and 2020.[14] Tenders for new projects in 2019 and 2020 were criticized due to short turnaround times and unattractive terms for investors, and policymakers are exploring options to import electricity from neighboring China and Laos to help make up short-to-medium term gaps in the next few years. Despite low current levels of electrification, Myanmar plans to reach full electrification in part through grid expansion and in part through installing distributed and off-grid renewable energy installations in remote rural areas with no grid access.[15]

Thailand has the second-highest electricity demand in Southeast Asia, but its annual electricity demand growth is rising at a slower pace than its neighbors. Much of Thailand's existing power infrastructure is aging, and the Power Development Plan 2018 (PDP2018) estimated that 25,310 MW of the 56,431 MW installed between 2018 and 2037 would replace older plants planned for retirement. Most new power generation would be renewable energy or modern natural gas power plants. Thailand has existing excess capacity that has at various points surpassed 40% of the peak demand, much higher than the general global practices of maintaining a reserve of 15%. This history of setting excess capacity—and slowly rising costs for Thai consumers, as it cost money to maintain idle generation—has prompted questioning of the official demand projection curves. Recent statements indicate that Thailand's reserve margin is likely to drop in the near future, signaling a potential opportunity to reduce future reliance on imported hydropower.

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[12] Shaun Turton, "Chinese construction rush aggravates Cambodia's electricity shortage," *Nikkei Asian Review*, April 8, 2019, accessed September 28, 2020, at https://asia.nikkei.com/Economy/Chinese-construction-rush-aggravates-Cambodia-s-electricity-shortage.

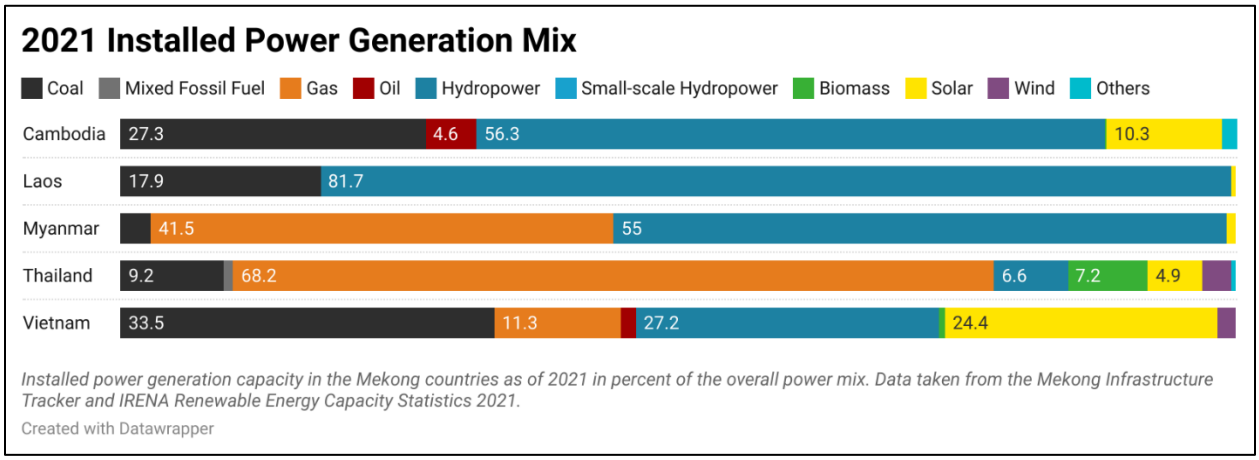
[13] Chea Vannak, "Cambodia to add power generation from natural gas," *Khmer Times*, November 24, 2020, accessed June 3, 2021 at https://www.khmertimeskh.com/50785544/cambodia-to-add-power-generation-from-natural-gas/.

[14] Data from the Stimson Mekong Infrastructure Tracker, supported by USAID and the Asia Foundation, June 3, 2021, at https://www.stimson.org/2020/mekong-infrastructure-tracker-tool/.

[15] The Government of the Republic of the Union of Myanmar, *Myanmar Energy Master Plan*, December 2015, page 33.

The Mekong countries collectively plan to build more than 170,000 MW of new power generation capacity through the mid-2030s. To put this into perspective, bringing 170,000 MW online would be comparable to adding more than three times the entire installed capacity of Thailand in 2020 to the regional electricity grid by the mid-2030s. This rapid buildout will result in a substantial change to the region's overall power mix.

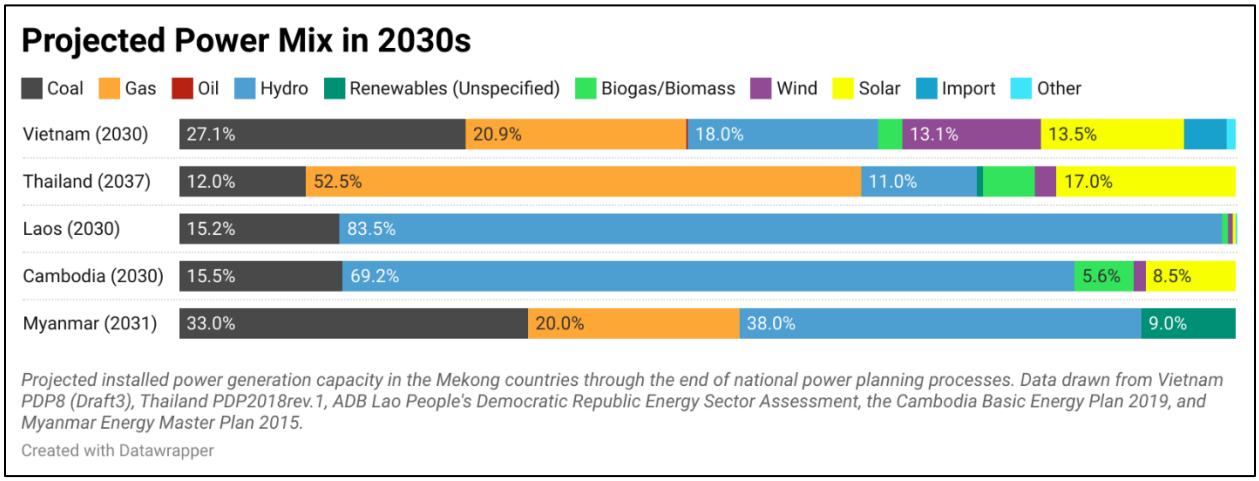
As of 2020, hydropower plays a major role in the region's energy supply and provides well over half the total installed power supply in Cambodia (60%), Laos (80%), and Myanmar (60%). Hydropower also contributes a significant but shrinking portion of Vietnam's power capacity (dropping from 45% in 2010 to 35% in 2020).[16] While domestic hydropower in Thailand is limited, combined with imported hydroelectricity from Laos it still made up approximately 12% of Thailand's total electricity supply in 2017. Fossil fuels still play a major role in the region's electricity supply. Natural gas has dominated Thailand's power system for decades, and although policymakers have sought to diversify gas still provides more than half of Thailand's electricity supply (57%). Coal has been a growing contributor to the regional power supply and currently provides around a third of Cambodia (30%) and Vietnam's (38%) electricity mix. Approximately 10,000 MW of new coal projects are currently under construction in Laos, Cambodia, and Vietnam.[17] This fossil fuel expansion is taking place with concurrent expansion of advanced renewable energy—defined here as solar, wind, and biomass—which has expanded rapidly in recent years and as of 2020 made up approximately 19% of Thailand's and 9% of Vietnam's installed capacity.



The Mekong region's future power mix will look quite different. Stated power development plans suggest that most new demand will be met by fossil fuels. Myanmar and Vietnam's most recent

[16] Installed capacity figures taken from the Mekong Infrastructure Tracker, which is curated by the Stimson Center and supported by USAID and The Asia Foundation, December 23, 2020, at https://www.stimson.org/2020/mekong-infrastructure-tracker-tool/.
[17] Data from the Stimson Mekong Infrastructure Tracker, supported by USAID and the Asia Foundation, June 3, 2021, at https://www.stimson.org/2020/mekong-infrastructure-tracker-tool/.

official development plans incorporate large amounts of new coal projects. Combined with high levels of natural gas, both countries anticipate more than half of the total power supply in 2020 to come from fossil fuels. Thailand's government anticipates a limited downsizing of the role of natural gas from about 57% to 53%, while the roles of hydropower through electricity imports from Laos and domestically produced renewable power will rise. And Laos's most recent national plan anticipates diversification away from hydropower through expanding production of coal and non-hydropower renewables.



These national plans are however in flux and liable to alteration due to changes in the global power market—particularly the gas market—and political, social, and economic pressures to incorporate higher levels of renewable energy. Economics are the key determining factor for investments, with additional considerations of ease of integration and management, familiarity with technology, and then a broad range of additional factors which relate to national interests. Southeast Asia is highly vulnerable to climate change—Thailand and Myanmar are among the top ten most climate-vulnerable countries in the Global Climate Risk Index 2021, and Cambodia and Vietnam are among the top twenty.[18] Climate change and environmental degradation are increasingly framed as issues of national interest in Southeast Asia. For instance, Vietnam's National Assembly created a legal framework in November 2020 for enforcing carbon reduction plans.[19] This will have an impact on national and regional energy planning.

ASEAN countries share a target of supplying 35% of the region's installed power capacity from renewable energy by 2025.[20] While this target is not enforceable and not all countries are on

[18] David Eckstein, Vera Kunzel, and Laura Schafer, *Global Climate Risk Index 2021: Who suffers most from extreme weather events? Weather-related loss events in 2019 and 2000 – 2019*, Germanwatch, January 2021, pages 42-47, at https://germanwatch.org/en/19777.
[19] Viet Anh, "Five years after Paris accord, extreme weather the new normal," *VN Express,* December 12, 2020, at https://e.vnexpress.net/news/news/five-years-after-paris-accord-extreme-weather-the-new-normal-4204062.html.
[20] ASEAN Centre for Energy, *ASEAN Plan of Action for Energy Cooperation (APAEC) 2016 – 2025: Phase II: 2021-2025*, November 23, 2020, page 2, accessible at https://aseanenergy.org/asean-plan-of-action-and-energy-cooperation-apaec-phase-ii-2021-2025/.

track to meet it, some have drastically altered national plans in response to global trends and market stressors. In 2017, neither Cambodia nor Vietnam had significant deployments of large-scale solar power. As of June 2021, Cambodia has 245 MW of installed solar capacity and Vietnam has at least 14,417 MW of solar.[21] Due to rapid price drops and concerns of overreliance on hydropower, Cambodian policymakers anticipate rapidly scaling up solar power to meet approximately 20% of the national power supply by the mid-2020s.[22] Policymakers in Vietnam have not yet finalized the next Power Development Plan 8 (PDP8), but early indications are that solar, wind, and gas may make up significantly larger portions and displace up to 17 GW of coal-fired power plants that had been planned previously.[23] In February 2020 the National Assembly passed Resolution 55 to this effect.[24]

2.2 What is Thailand's Role in the Broader Mekong Region?

Although Laos, Cambodia and Myanmar utilities and regulators will ultimately make the decision to move forward with individual power projects, Thailand still has significant influence over energy project outcomes as a foreign investor in and power purchaser from neighboring countries. Approximately one third of the 170,000 MW of planned new capacity over the coming fifteen years will be built to meet Thailand's projected energy needs. As of 2020, Thailand has been involved in developing, financing, and/or constructing 65% of Laos's current generation capacity. Thailand is similarly involved in 40% of the projects currently under construction and approximately 27% of the proposed projects in Laos.[25] While Thailand is not nearly so heavily involved in Cambodia, Myanmar, or Vietnam's electricity market, Thai companies are involved in some existing and planned projects. China is also heavily influential in the power sector as a regional project developer, investor, and construction contractor. In some cases, overwhelmingly so: Chinese companies were involved in 28 out of 29 winning bids under a 2020 solar tender in Myanmar.[26] But Thai companies are involved in both more projects and a higher amount of installed power generation than China.[27]

[21] Data from the Stimson Mekong Infrastructure Tracker, supported by USAID and the Asia Foundation, June 3, 2021, at https://www.stimson.org/2020/mekong-infrastructure-tracker-tool/.
[22] Chhut Bunthoeun, "Four solar projects approved," *Khmer Times*, July 15, 2019, at https://www.khmertimeskh.com/623720/four-solar-projects-approved/.
[23] Tim Ha, "Vietnam considers scrapping half of coal power plant pipeline in favor of gas and renewables."
[24] Frederick Burke, Dang Chi Lieu, and Nguyen Thanh Hai, "Vietnam's Politburo issues Resolution on the orientation of the National Energy Development Strategy to 2030 with a vision to 2045," Baker McKenzie, February 2020, accessible at https://www.bakermckenzie.com/en/insight/publications/2020/02/vietnam-national-energy-development-strategy.
[25] Calculations drawing on data from the Mekong Infrastructure Tracker, which is curated by the Stimson Center and supported by USAID and The Asia Foundation, September 21, 2020, https://www.stimson.org/2020/mekong-infrastructure-tracker-tool/.
[26] Kyaw Ye Lynn and Thomas Kean, "Chinese companies dominate Myanmar solar tender," *China Dialogue*, September 22, 2020, accessed June 3, 2021, at https://chinadialogue.net/en/energy/chinese-companies-dominate-myanmar-solar-tender/.
[27] Data from the Stimson Mekong Infrastructure Tracker, supported by USAID and the Asia Foundation, accessed December 7, 2020, at https://www.stimson.org/2020/mekong-infrastructure-tracker-tool/.

Many of the Thai companies involved abroad are private businesses choosing to invest for commercial gain, and these investments are not under the direct purview of the Thai government. However, the Thai government is involved in providing key guarantees that provide economic rationale for many projects in Laos because the state-owned utility the Electricity Generating Authority of Thailand (EGAT) agrees to purchase the electricity that these projects produce. Power purchase agreements (PPAs) are important factors in ensuring project viability because they ensure that an individual project has a market for its power after construction and can be used to estimate income. Having a guaranteed PPA helps manage risk and PPAs with reliable and creditworthy off takers are often required to secure good financing terms for project developers.

The Electricity Generating Authority of Thailand (EGAT) has signed PPAs for several key projects in Laos including the Nam Theun 2 Dam, Theun-Hinboun Hydropower Plant, Hongsa Coal Power Plant, and Xayaburi Dam. The Lao utility Electricite du Laos (EDL) has not historically had the financial capital to invest in large power projects or a large enough domestic market to absorb the electricity from these projects as they came online. Within this context, a revenue guarantee in the form of a PPA from Thailand has been essential in securing investment for many projects and EGAT's willingness to sign PPAs plays an outsized role in determining which projects move ahead in Laos and which projects remain in a future pipeline.

Thai Civil Society Backlash against Mainstream Mekong Dams

Thailand began importing hydroelectricity as early as 1971 when the first hydroelectric dam was built in Laos, and it has slowly but steadily expanded the amount of power purchases over time. Thailand has long-term memorandums of understanding with the Government of Laos committing to power imports, the most recent of which was signed in 2016 and expanded the purchase amount from 7,000 MW to 9,000 MW of electricity from Laos by 2030.[28] That's nearly a third of the total technical hydropower potential and Laos. The MoU does not specify which projects the power will come from but sets a target that is filled by PPAs with individual projects. Power purchased to date includes electricity from the first mainstream Mekong dam, the Xayaburi Dam. Although no other mainstream Mekong dam PPAs have been signed Thailand has come up as a potential power purchaser for the Pak Beng, Pak Lay, Luang Prabang, and Sanakham dams.

Thai stakeholders have been some of the most outspoken and active in raising public attention to environmental and social impacts of hydropower projects. Thai activists have had a significant role in stalling further large-scale hydropower development policies inside Thailand after major protests and pushback against the Pak Mun Dam in the early 1990s turned hydropower into a

[28] "Thailand signs up for more Lao power," *The Nation Thailand,* September 8, 2016, accessed September 21, 2020, at https://www.nationthailand.com/Economy/30294834.

political issue and raised public attention to the serious environmental and social impacts of hydropower. Only two large-scale dams have come online since 1993, and both were renovations of existing projects.

Thai activists have also utilized their experiences protesting against domestic projects to push back against dams on the mainstream of the Mekong. A local advocacy group, the Thai Mekong People's Network from Eight Provinces, has been extremely active in supporting public protests, engaging with the companies and government agencies involved, and even pursuing lawsuits to stop construction of dams on the Mekong mainstream. In 2012, villagers in the network sued the EGAT for signing a PPA with developers of the Xayaburi Dam without assessing the project's environmental impacts.[29] In 2017 another organization, the Chiang Khong Conservation Group, joined with local communities filed a lawsuit challenging the consultation process for the Pak Beng Dam and requiring the government to do more about the potential negative impacts of the project.[30]

While the first lawsuit is still ongoing, it's clear that the network has changed the conversation about the Mekong River's importance. In February 2020, the communities and activists involved in campaigns won a major victory when a rapids-blasting project on the Mekong River was officially cancelled by the Thai Cabinet after decades of consideration.[31] In April 2020, the Thai Mekong People's Network issued a statement flagging the serious local impacts for the first completed dam on the river and encouraging the government not to buy power from Luang Prabang or other mainstream Mekong dams due to the severe costs and rising excess electricity.[32] After years of engagement and dialogue, in November and December 2020 the top water official in Thailand has begun to echo the concerns raised by these communities in public statements. While nothing is certain, the Thai government is currently considering not signing a PPA or even taking action to block the Sanakham Dam from being built.[33] This would likely result in the project becoming unbankable, as Thailand is the only potential purchaser of this electricity.

[29] Radio Free Asia, "Thai villagers sue over dam," *Radio Free Asia,* August 7, 2012, at https://www.rfa.org/english/news/laos/xayaburi-08072012171723.html.

[30] Niwat Roykaew, "Why Thai communities are defending their rights to the Mekong River in court," *The Nation*, June 8, 2017, at https://www.nationthailand.com/opinion/30317588; Pratch Rujivanarom, "State agencies face legal dispute over Pak Beng dam," June 8, 2017, at https://www.nationthailand.com/national/30317575.

[31] Pai Deetes, "Victory on the Upper Mekong: Thai abinet Terminates Rapids Blasting Project," *International Rivers,* February 6, 2020, at https://www.internationalrivers.org/news/blog-victory-on-the-upper-mekong-thai-cabinet-terminates-rapids-blasting-project/.

[32] Thai Mekong People's Network from Eight Provinces, "Public statement – Don't buy power from Luang Prabang Dam: Mekong Dams are Unnecessary for Thailand's Power Sector (English translation)," April 7, 2020, at https://www.mymekong.org/document/public-statement-dont-buy-power-from-luang-prabang-dam-mekong-dams-are-unnecessary-for-thailands-power-sector/.

[33] Apinya Wipatayotin, "Govt warns over Lao dam plan," *The Bangkok Post*, November 25, 2020, at https://www.bangkokpost.com/thailand/general/2025023/govt-warns-over-lao-dam-plan.; Apinya Wipatayotin, "Thai govt threatens to veto new Lao dam," *Bangkok Post*, December 12, 2020, at https://www.bangkokpost.com/thailand/general/2034151/thai-govt-threatens-to-veto-new-lao-dam.

2.3 Current Plans for Electricity Trade

The concept of regional electricity trade is not new. Members of the Association of Southeast Asian Nations (ASEAN) have for more than thirty years discussed the benefits and taken slow but progressive steps towards a more connected power system. The Asian Development Bank (ADB) has been supporting efforts towards power trade and interconnection in the Greater Mekong Subregion (GMS) for nearly three decades. A 2012 study by the ADB indicated that integration in the GMS could save up to 19% or $200 billion of total energy costs for the region.[34]

The benefits of an interconnected grid would be numerous: integrated power trade would allow for greater flexibility and resilience in response to short-term and localized disruptions and would broadly support the deployment of higher levels of renewable energy integration. Renewable energy technologies like solar and wind can be variable at a local scale, but as part of a broader grid the variability and uncertainty smooth out. The International Energy Agency indicates that higher levels of regional integration would allow for better planning and responsiveness to weather-dependent resources in ASEAN as has been seen in other interconnected regions globally.[35] Recognizing these potential benefits, all ten Southeast Asian countries signed an MOU in 2007 to work towards realizing an ASEAN Power Grid. This included a series of political and technical commitments to review national legal frameworks and plans to support power trade with neighbors, harmonize technical specifications and regulations, and coordinate in identifying public and private resources to support key infrastructure projects like interconnections and transmission lines.[36]

Although ASEAN members recognize the benefits of integration, progress towards implementing the plans has been slow. There are significant hurdles to integration, the most obvious being the lack of sufficient physical connectivity between national grids to support large-scale electricity trade. However, there are also significant operational and policy challenges including significant electricity price differentials, domestic concerns over how integration would affect national control over the electricity grid, and harmonization of grid codes and management processes. Progress has been slow in the face of these difficulties—but there has been progress, and the Greater Mekong Subregion is the first mover within ASEAN given the existence of many limited capacity interconnections for bilateral electricity trade. The first operational example of a multilateral agreement is electricity trade between Laos, Thailand, Malaysia, and Singapore.

[34] Asian Development Bank, "Greater Mekong Subregion Power Trade and Interconnection: 2 Decades of Cooperation, September 2012, Page 26.

[35] IEA, *Establishing Multilateral Power Trade in ASEAN,* 2019, page 66, accessible at https://www.iea.org/reports/establishing-multilateral-power-trade-in-asean,

[36] ASEAN, "Memorandum of Understanding on the ASEAN Power Grid," August 23, 2007.

Thailand's Energy Development Pathways: Previous Scenarios Explored

In 2019, Pact supported a study examining the socio-political, economic, and environmental risks and impacts of three different potential scenarios for Thailand's future power purchases from neighboring countries. Keeping in mind the development trajectory outlined in the Power Development Plan 2018, this draft report identified specific projects likely to make up the power imports under three technically and economically feasible scenarios and quantitatively modeled the impacts across scenarios. The three scenarios explored were:

- A High Power Import Scenario, which considered the likelihood that Thailand would continue to invest in and import high amounts of electricity from Lao PDR and Myanmar given the constraints with developing domestic coal and nuclear projects. This scenario included 18,000 MW of coal and hydropower projects in neighboring countries.

- The PDP 2018 Scenario assumed that the most recent power projections were accurate in planning for imports of just under 10,000 MW by 2037, including those specifically listed in the Power Development Plan and 3,500 MW of unspecified hydropower in Laos.

- The Advanced Domestic Renewable Energy Scenario considered the potential for Thailand to substitute domestically available renewable energy for imports from Laos, dropping imports to only 6,000 MW to include only those projects which were already under construction and had signed PPAs with Thailand in mid-2019.

Considerations for comparison across the scenarios included key elements of energy security (availability, affordability, and price risk), as well as socio-economic and environmental indicators such as sediment trapping and flow, river connectivity, biodiversity hotspots and conservation zones affected, and floodplain connectivity. Initial impact analysis identified that the Advanced Domestic Renewable Energy Scenario would have both the fewest overall impacts and the best outcomes in terms of energy security indicators. Consultation on the working report also identified opportunity to develop more specific and directly comparable scenarios which would meet the import levels required under Thailand's MOU with Laos through different combinations of projects and power sources.

Table 2 Comparisons of the impacts of each of the three scenarios on sediment flow, overall river connectivity (a measurement the percent of the river which remained undammed and therefore free-flowing and connected for purposes of fish migration and other ecological flows), and remaining connectivity to the ocean for the Mekong and Salween rivers. For more information, see the full report: https://mekongsip.org/download/thailands-energy-development-pathways-risks-costs-and-benefits-for-different-import-scenarios/.

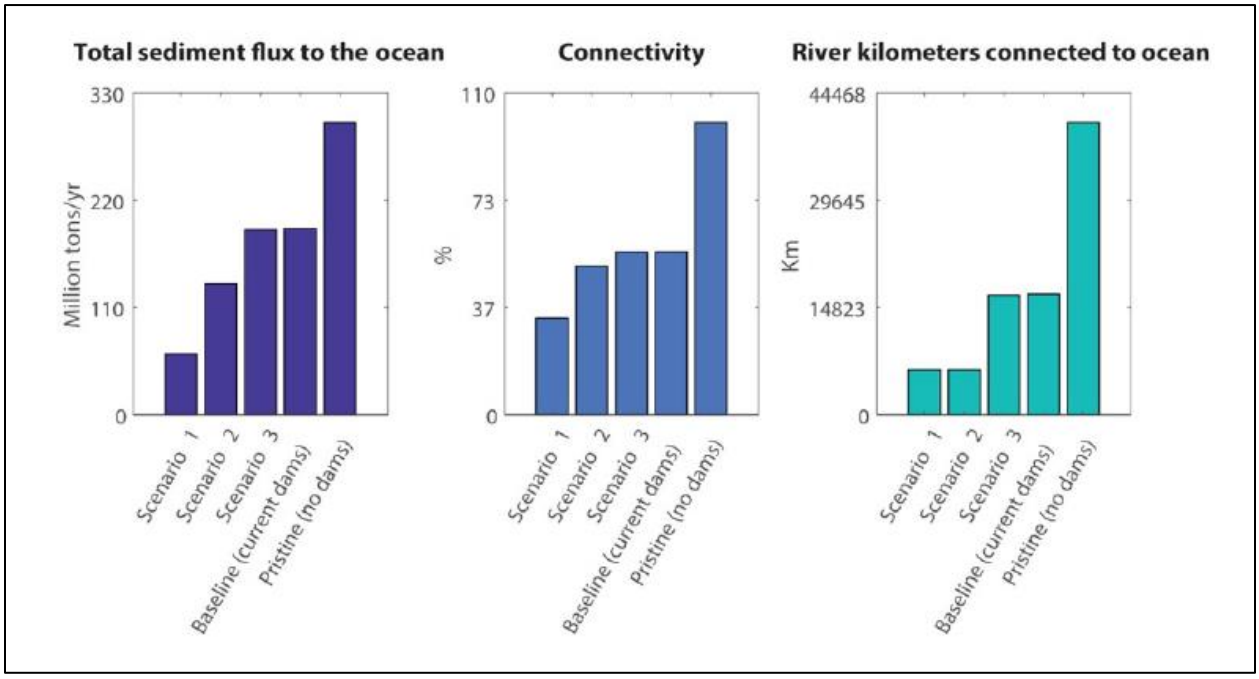


Table 3 Energy security indicators from the Thailand Energy Development Pathways report.

Energy Security Indicators	Assessment/Metric	Scenario 1 – High Imports	Scenario 2 – PDP 2018	Scenario 3 – High Renewable Energy
Availability	Generation Capacity to Demand Ratio	1.40	1.42	1.39
Least Cost Supply	Cost of Generation per MWh using 2037 LCOE in 2018 USD	$77.22	$79.26	$74.51
Price Risk Exposure	Qualitative	Climate Change Risks: About 55% of the portfolio (coal and natural gas) is exposed to carbon pricing risk. Renewables account for only 20% of the generation portfolio	Climate Change Risks: About 68% of the portfolio is exposed to carbon pricing risk (coal and natural gas). Renewables account for only 20% of the generation portfolio.	Climate Change Risks: About 53% of the portfolio is exposed to carbon pricing risk (coal and natural gas). Renewables account for almost 40% of the generation portfolio.

In 2017, the ASEAN Power Grid Consultative Committee agreed to key principles of power trade. Shortly thereafter, Laos, Thailand, and Malaysia agreed to sell 100 MW of Laos-produced hydropower through Thailand's grid to Malaysia. This agreement took many years of negotiation to bring to fruition and was a significant step forward on regional power trade as outlined under the ASEAN Master Grid. The three countries had to overcome pricing differences, agree on a wheeling process to pass electricity through the Thai grid, and manage regulatory harmonization. The flow of this trade is directionally limited, but this agreement is the first multinational power trade agreement in the region and has provided valuable experience to Thailand in terms of regulatory arrangements to wheel power. In September 2019, Laos, Thailand, and Malaysia agreed to increase the amount of electricity traded to 300 MW in 2021. And in 2020, Singapore officials signed on to import 100 MW of electricity from Malaysia as part of this power integration after years of consideration.[37]

Thailand's experience managing this small-scale multilateral power trade—along with the excess domestic power capacity discussed previously—has likely motivated their push to become a regional power hub. Thailand has considered and planned for electricity imports from Myanmar and Cambodia under previous power development plans, but more recently the Thai government has expressed interest in instead selling electricity to its neighbors. In June 2019 the Thai Ministry of Energy's Permanent Secretary indicated that the country planned to further develop transmission and become an electricity trading hub for the region through sourcing hydropower from Laos and reselling it to Malaysia, Cambodia, and Myanmar.[38] EGAT began conversations with Myanmar and Cambodia about exporting up to 500 MW of electricity to them starting in 2023.[39]

Thailand's ambitions to become a regional power trading hub make sense geographically—Thailand shares land borders with four other ASEAN countries and is linked through its neighbors to China, Vietnam, and Singapore. If the obstacles to closer regional grid integration can be overcome, Thailand's positioning could allow it to act as a key transmission hub to meet electricity needs in other countries. Thailand's direct neighbors Cambodia and Myanmar both face short-term electricity shortages, and Thailand currently has significant and costly excess capacity available for sale, making a shift towards exports timely.

However, questions must be addressed about the scale of electricity trade envisioned, the timeline for anticipated energy trade, and the plan's long-term economic and environmental sustainability. Thailand's stated short-term power trade targets add up to a modest 800 MW,

[37] Audrey Tan, "Singapore may tap region's low-carbon energy sources in future," *The Straits Times*, November 26, 2020, at https://www.straitstimes.com/singapore/environment/singapore-may-tap-regions-low-carbon-energy-sources-in-future.
[38] Chiang Rai Times News, "Thailand to develop power transmission lines to become electricity hub of ASEAN," *Chiang Rai Times,* June 25, 2019, accessed September 22, 2020, at https://www.chiangraitimes.com/asean/thailand-to-develop-power-transmission-lines-to-become-electricity-hub-of-asean/.
[39] Yuthana Praiwan, "Egat talks power trade with Cambodia, Myanmar," *Bangkok Post,* November 5, 2019, accessed September 22, 2020, https://www.bangkokpost.com/business/1787454/egat-talks-power-trade-with-cambodia-myanmar.

assuming that all agreements currently under discussion with Myanmar and Cambodia are signed. This amount of power can clearly be absorbed by short-term demand in neighboring countries. However, Thailand's excess electricity capacity has historically been in the range of 40%.[40] Outside analysis indicates that the excess reached over 16,000 MW or nearly 60% of Thailand's installed capacity in 2020. Even assuming that around 15% of Thailand's 2020 peak demand would need to be maintained as spinning reserve, that leaves over 10,000 MW of excess electricity. Such a high amount will be far less easily absorbed regionally because of physical grid limitations and domestic political considerations in Thailand's neighboring countries.

Thailand's national grid is much larger than that of its immediate neighbors. For perspective, that 4,600 MW of Thailand's excess power is higher than the total installed capacity of Cambodia and just above that of Myanmar. While buying excess capacity from Thailand may make sense in terms of regional efficiency, most countries in the region are still aiming to build up domestically available power sources. Within this context, the assumptions that underpin projections of longer-term appetite for imported electricity from Thailand should be examined. This section provides brief explorations of the energy situation in Thailand's neighbors and how this might impact their interest in purchasing electricity from Thailand:

- **Cambodia**, which has existing but limited grid-connections to Thailand, Laos, and Vietnam, has for years been dependent on imported electricity and has sought to expand domestic power generation. However, massive blackouts in 2019 inspired policymakers to quickly sign a memorandum of agreement to directly purchase 2,900 MW of electricity from coal power plants in southern Laos by 2027.[41] That is approximately 24% of Cambodia's total projected electricity needs by 2030. The blackouts also prompted movement on a series of new domestic power plants including solar, coal, natural gas, and wind. These and other projects are still in the pipeline: 1,181 MW of new generation capacity are currently under construction in 2020, and there are specific proposals for projects with capacity of up to 10,146 MW.[42] Assuming that Cambodia's MOU with Laos moves forward as planned, Cambodia's electricity needs in the early 2030s would likely already be met. While there might be interest in small-scale purchases from Thailand along the lines of what's currently under discussion, it is unlikely that Cambodia has the demand or political appetite to import significantly more power from Thailand. This is particularly true given that Cambodia has significantly underdeveloped solar and wind resources which are available domestically.

[40] The 40% statistic is taken from: International Energy Agency, "Report Extract: 2020 Regional focus: Southeast Asia," December 2020, at https://www.iea.org/reports/electricity-market-report-december-2020/2020-regional-focus-southeast-asia;
[41] Asia News Network, "Laos electricity export up 125 per cent in five years," *Phnom Penh Post,* February 5, 2020, accessed September 21, 2020, at https://www.phnompenhpost.com/business/lao-electricity-export-125-cent-five-years.
[42] Data from Stimson Mekong Infrastructure Tracker, supported by USAID and The Asia Foundation, accessed December 21, 2020, at https://www.stimson.org/2020/mekong-infrastructure-tracker-tool/.

- **Myanmar**'s electricity demand is rising rapidly, but progress on domestic power supply buildout has been slow and politically fraught. Myanmar has significant hydropower resources, but progress on large-scale projects has stalled in the face of environmental concerns and disputes with affected communities. Myanmar is a likely candidate for importing electricity given these constraints. However, Myanmar has a plethora of choices: the government is currently exploring power trading agreements with Laos and China as well as Thailand. Areas bordering Laos already purchase small amounts of electricity (10 MW) from Laos currently, and Myanmar is on track to slowly increase this to 300 MW in 2025. There has also been initial agreement to purchase 1,000 MW of electricity from China's Yunnan province, although the grids are not yet connected.[43] It's reasonable to anticipate that Myanmar might purchase some electricity from Thailand, but it's difficult to accurately estimate the amount with so many agreements in play. Even if there is political will, the current lack of an existing national grid and slow movement on building interconnections to neighboring countries will likely remain a constraint for the near-term.
- **Malaysia** is a more feasible long-term purchaser of large amounts of electricity simply because it is a much larger electricity market and has grid connections to the market in Singapore. Peninsular Malaysia's installed capacity stood at 24,139 MW in 2018.[44] Projected annual electricity demand growth averages 3.1% through 2050,[45] and electricity trade is anticipated to help to meet some of this future demand. The size of Malaysia's grid and national demand mean that it could more easily absorb excess capacity—however, there are challenges in terms of grid congestion. Thailand's existing domestic transmission lines between the southern region of Thailand near Malaysia and other parts of Thailand are already near capacity. This constrains further electricity trade until the transmission lines on the Thai side can be upgraded. The existing interconnection has maximum transmission capacity of 300 MW,[46] which acts as a constraint under the ongoing discussions about electricity trade between Laos-Thailand-Malaysia-Singapore. There would need to be further investment in interconnections to support higher levels of electricity trade. This is possible and even likely to occur, but the timeline is not yet clear and would require significant additional investment.

[43] Nan Lwin, "Chinese electricity: Blessing or curse for Myanmar?" *The Irrawaddy*, March 13, 2020, accessed June 3, 2021, at https://www.irrawaddy.com/opinion/analysis/chinese-electricity-blessing-curse-myanmar.html.

[44] Suruhanjaya Tenaga (Energy Commission), *Peninsular Malaysia Electricity Supply Industry Outlook 2019,* 2019, page 14.

[45] Zaharin Zulkifi, "Chapter 11: Malaysia Country Report," *Energy Outlook and Saving Potential East Asia 2020*, Han, P. and S. Kimura (eds), ERIA: Jakarta, page 178. Accessible at https://www.eria.org/uploads/media/Books/2021-Energy-Outlook-and-Saving-Potential-East-Asia-2020/18_Ch.11-Malaysia.pdf.

[46] Sabar Md Hashim, "Malaysia's recent development in RE & ASEAN Power Connectivity," UNESCAP, slide 15, at https://www.unescap.org/sites/default/files/Mr.%20Sabar%20Md%20%20Hashim%20-%20Malaysia%20Presentation.pdf; Energy Policy and Planning Office, "Electricity Trade between Thailand and Malaysia," Ministry of Energy, March 29, 2016, accessed June 3, 2021, at http://www.eppo.go.th/index.php/en/energy-information-services/electricity-trade-between-thailand-and-malaysia.

- **Singapore** is also a potential long-term purchaser of electricity from mainland Southeast Asia, although the grid congestion challenges discussed above for Malaysia also act as constraints for Singapore. Singapore has ample domestic generation capacity, but it is almost entirely from fossil fuels: approximately 95% of Singapore's electricity in 2020 came from natural gas.[47] Singapore has significant motivation to expand electricity trade to meet climate commitments as it has limited domestic land to build out renewable energy resources.[48] However, this requires both overcoming the physical constraints as well as economic considerations given the ample domestically available electricity supply. There are opportunities to import electricity from more locally available renewable energy resources in Malaysia or Sumatra in Indonesia. Discussions are also underway to develop the Australia – ASEAN Power Link to connect vast and cheap solar power in Australia to the Singaporean market.[49] Electricity trade with Thailand should be considered within these broader connectivity plans and options but will need to be economically competitive to grow beyond the ongoing trial trade discussed above.

Looking beyond these most likely countries, Laos, Vietnam, and China are all engaged in electricity trade. However, Laos's geographic position and role as a direct exporter of electricity to both Vietnam and China makes it unclear how Thailand could effectively contribute.

- **Laos** is well known for its "Battery of Southeast Asia" strategy and currently exports significant amounts of electricity to Thailand. Laos currently imports electricity on a seasonal basis in areas of southern Laos which remain under-integrated with the national grid and when dry-season water levels reduce hydropower productivity.[50] Laos pays nearly twice as much per kilowatt-hour to import electricity from Thailand as Thailand pays to purchase electricity from Laos, and this significant loss is pushing Lao utilities to explore diversification of the electricity supply to reduce costly dependence on Thailand.[51] As Laos build out and diversifies its domestic power production, it's likely that the need to import electricity will drop.
- **Vietnam** faces projected electricity shortages, but electricity imports have long been politically challenging and controversial. Vietnam's most recent power development plan (PDP) only allowed for a total of 1.2% of electricity—or approximately 1,554 MW—of

[47] Singapore Energy Market Authority, "Chapter 02: Energy Transformation," *Singapore Energy Statistics* Microsite, accessible at https://www.ema.gov.sg/singapore-energy-statistics/Ch02/index2.
[48] Matthew Mohan, "Trial to import electricity from Malaysia a 'useful first step' as Singapore prepares to connect with regional grid: Experts," *Channel News Asia*, January 1, 2021, accessed June 3, 2021, at https://www.channelnewsasia.com/news/singapore/singapore-importing-eletricity-malaysia-power-energy-13775308.
[49] A. Odysseus Patrick, "The $16 billion plan to beam Australia's Outbakc sun onto Asia's power grids," *The Washington Post*, August 10, 2020, at https://www.washingtonpost.com/climate-solutions/2020/08/10/australia-solar-energy-asia/.
[50] Department of Energy Policy and Planning, Lao PDR Ministry of Energy and Mines, *Lao PDR Energy Outlook 2020*, February 2020, page 65, at https://www.eria.org/uploads/media/Research-Project-Report/Lao-Energy-Outlook-2020/Lao-PDR-Energy-Outlook-2020.pdf.
[51] Asia News Network, "Laos' excess power sparks export drive," *The Phnom Penh Post*, September 23, 2020, at https://www.phnompenhpost.com/business/laos-excess-power-sparks-export-drive.

power imports from China and Laos by 2030.[52] Vietnam has negotiated with Laos to import up to 5,000 MW of electricity by 2030. These deals are moving forward: in 2020, Vietnam signed MOUs to purchase power from eight new projects in Laos through the mid-2020s.[53] While PDP8 may revise import projections upwards, it's unlikely that Thailand would play a direct role due to geography and Vietnam's ability to buy directly from Laos.

- **China** has long been involved as an investor in projects around Southeast Asia with the intent to purchase electricity—however, since the mid-2000s as hydropower in Yunnan came online, China's southwestern provinces have actually faced excess capacity challenges due to grid congestion and domestic competition. As recently as 2019, Chinese companies have expressed interest in exporting hydropower from southwestern China to Southeast Asia. If this situation changes again, China is most likely to purchase electricity directly from the Lao utilities rather than Thailand due to grid connections and logistics. There are also geopolitical considerations—China Southern Grid is the majority owner of EDL- Transmission as well as many existing hydropower projects in northern Laos. If China seeks to import electricity from Southeast Asia, there are political reasons to prioritize purchases directly from these projects in Laos rather than via Thailand.

Thai policymakers and their counterparts in neighboring countries will need to assess whether hydroelectricity produced in Laos and wheeled through Thailand's grid would be competitive in future power markets, and particularly against locally produced renewable energy. While Thailand has been ahead of the curve in early deployment of renewable technologies, other countries in ASEAN are increasingly looking at renewables as an affordable and locally produced solar power and adjusting national power plans to take advantage of low prices. New solar projects in Cambodia and Malaysia have been signed for $0.035/kWh and $0.042/kWh respectively.[54] Laos sells electricity to Thailand starting at four cents per kilowatt-hour for older projects, but rising to approximately $0.069/kWh for newer projects like the Xayaburi Dam, which came online in 2019.[55] When the cost of transmission is taken into account, it's unclear

[52] Vietnam, *Decision N. 428 on the Approval of the Revised National Power Development Master Plan for the 2011-2020 Periods with the Vision to 2030,* March 18, 2016, page 5 (English) or page 6 (Vietnamese), at https://policy.asiapacificenergy.org/node/2760.
[53] Anh Minh, "Vietnam to buy 1.5 billion kWh of power annually from Laos," *VN Express,* January 5, 2020, accessed at https://e.vnexpress.net/news/business/industries/vietnam-to-buy-1-5-billion-kwh-of-power-annually-from-laos-4037485.html; and Dat Nguyen, "Vietnam to purchase more power from Laos," *VN Express*, December 7, 2020, at https://e.vnexpress.net/news/business/economy/vietnam-to-purchase-more-power-from-laos-4202781.html.
[54] Cecilia Keating, "Cambodia's 60 MW solar auction draws record-low bid," *PV Tech*, September 6, 2019, accessed September 21, 2020 at https://www.pv-magazine.com/2020/01/09/five-bidders-set-to-secure-490-mw-in-malaysias-third-solar-auction/; Emiliano Bellini, "Five bidders set to secure 490 MW in Malaysia's third solar auction," *PV Magazine,* January 9, 2020, accessed September 21, 2020 at https://www.pv-magazine.com/2020/01/09/five-bidders-set-to-secure-490-mw-in-malaysias-third-solar-auction/.
[55] Thailand Ministry of Energy, Energy Policy and Planning Office, "Xayaburi Hydroelectric Power Project," March 29; 2016, accessed September 21, 2020 at http://www.eppo.go.th/index.php/en/energy-information-services/xayaburi-hydroelectric-power-project. Note: the US cent figure will depend on the exchange rate, but is approximately 0.069 as of June 2021.

how competitive Thailand's excess imported hydroelectricity would be against locally produced electricity in these countries, particularly from renewables.

As Thailand moves ahead with regional electricity trade, policymakers must consider how the long-term integration of variable renewable energy technologies to ensure longer-term sustainability of acting as an electricity trading hub. The current discussion around excess power imported from Laos appears to refer to excess capacity from large-scale hydropower projects, some of which have not yet been constructed and which are likely to have serious environmental, economic, and food security impacts for communities in Thailand, Laos, Cambodia, and Vietnam. This has increasingly become a regional political issue as local communities and environmental organizations raise concerns over these impacts, including many of the provinces in northeastern Thailand within the Mekong basin.

If policymakers in Thailand seek to build a more flexible future as a power trading hub while continuing to purchase power from Laos, they should explore whether the future imports from Laos could include a more diverse power mix. This would have political benefits domestically, by showing the government is responsive to local concerns in north and northeast Thailand but could also improve reliability of imported electricity. If Laos continues to develop primarily hydropower, it will continue to face seasonal constraints in its ability to effectively supply power during the dry months. A more diverse power mix could help firm power that Laos sells to Thailand and ultimately help ensure that the regional grid of the future is able to effectively balance fluctuations in the grid from the continued growth of renewables inside Thailand and elsewhere.

3. The Growth of Renewables in Southeast Asia

As recently as 2017, Thailand was the only mainland Southeast Asian country which had deployed significant solar, wind, and biomass power generation capacity. The situation has changed drastically: by the end of 2019 Vietnam's installed solar capacity had surpassed that of Thailand. As of 2021 Electricity Vietnam reported that Vietnam had connected 9.5 GW of rooftop solar to the grid, which is in addition to approximately 10,000 MW of megawatts of utility-scale solar.[56] Cambodia's current installed solar PV capacity stands at 150 MW and Cambodian policymakers are now pushing for solar to make up 20% of the country's total installed capacity by 2023. Myanmar's first solar plant came online in 2018, with more than 1 GW of additional solar under development.

Renewable Energy Potential in Mekong Countries

Energy Type	Cambodia	Laos	Myanmar	Thailand	Vietnam
Solar Potential (MW)	8100 MW	8812 MW	26962 MWp	22801 MWp	13326 MWp
Wind Potential (MW)	65000 MW	455630 MW	33829 MW	380980 MW	26763 MW
Biomass Potential (GWh)	15025 GWh	6408 GWh	58312 GWH	200,000+ GWh	84875 GWh

Compiled by Aaditee Kudrimoti and Courtney Weatherby referencing data from the Asian Development Bank and national power development plans.

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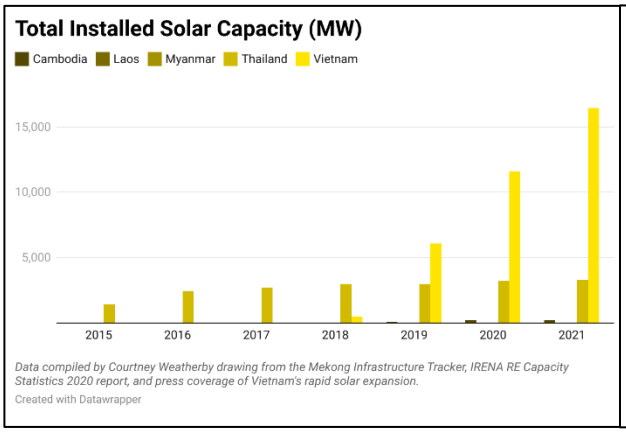
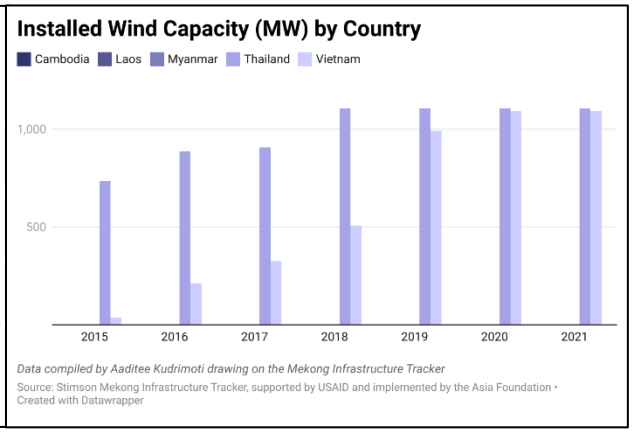




[56] EVNSolar, "Do You Know?", data updated May 31, 2021, accessed May 31, 2021 at https://solar.evn.com.vn/#/; Nhan Dan, "Rooftop solar power has exploded, with a total capacity of nearly 9,300 MWp," *Nhan Dan*, January 1, 2021, accessed June 3, 2021, at https://nhandan.vn/tin-tuc-kinh-te/dien-mat-troi-mai-nha-phat-trien-bung-no-tong-cong-suat-len-toi-gan-9-300mwp-630350.

Distributed Generation & Rooftop Solar

Power planners tend to focus on utility-scale or commercial power plant pipelines—but unlike conventional power generation, renewable energy potential is broadly distributed and can be affordably accessed at a small-scale. Thailand's planners have long recognized the distributed nature of renewable energy: as early as 2006, EGAT provided a feeder tariff to purchase electricity from projects less than 1 MW through the Very Small Power Producer program (VSPP). Most of this was targeted towards renewable energy projects including not only solar but micro-hydropower, biomass, biogas, and waste-to-energy projects.[57] Starting in 2013 the Thai government introduced a new Feed-in-Tariff policy that allowed a combination of household and commercial rooftop solar to contribute 100 MW each towards the national solar capacity target of 1000 MW.[58] There was limited uptake among residential households due to unattractive pricing schemes, a lack of supportive financing schemes, and other tax and regulatory issues. The Power Development Plan 2018 expanded plans for renewable energy and originally included 10,000 MW of rooftop solar power to be developed in tranches of 100 MW annually through 2027 and then 1000 MW annually over the following decade. However, a continued lack of uptake prompted Thailand's Minister of Energy to push for revisions to rooftop solar policies in 2020 to attract further investment.[59]

While residential rooftop solar growth has been slow, industrial rooftop solar has been rapidly expanding and Vietnam stands out as a late but rapid adopter. Vietnam's first national push for rooftop solar began in 2019. Some companies quoted savings of approximately 30-40% of their monthly electricity bills through deployment of rooftop solar.[60] Rooftop solar investment took off after April 2020, when Vietnam instituted a generous feed-in-tariff for rooftop solar in order to support further power development without exacerbating land pressures and help reduce pull on the transmission grid that was available to projects which came online before December 31, 2020.[61] The generous terms and timeline pushed frenzied investment that significantly surpassed expectations and Vietnam added 9.3 GW of mostly industrial and commercial rooftop solar into the grid in 2020, across 102,000 rooftop solar systems.[62] Such rapid deployment has brought

[57] ERIA, "Status on Renewable Energy SPP and VSPP," in Han, P., S. Kimura, W. Wongsapai and Y. Achawangku (eds.), *Study on Biomass Supply Chain for Power Generation in Southern Part of Thailand*, ERIA Research Project Report, 2019, page 2, accessible at https://www.eria.org/uploads/media/8_RPR_FY2018_09_Chapter_1.pdf.

[58] S. Tongsopit, S. Chaitusaney, A. Limmanee, N. Kittner, and P. Hoontrakul, "Scaling Up Solar PV: A Roadmap for Thailand," Energy Research Institute, Chulalongkorn University, July 2015, page 9, accessible at https://www.dede.go.th/download/files/1_ScalingUpSolarPV.pdf.

[59] Yuthana Praiwan, "Minister seeks solar rooftop revisions," *The Bangkok Post,* June 30, 2020, accessed June 3, 2021, at https://www.bangkokpost.com/business/1942988/minister-seeks-solar-rooftop-revisions.

[60] Vien Thong, "Rooftop solar power, an idea whose time has comein Vietnam," *VN Express*, July 18, 2020, accessed June 3, 2021, at https://e.vnexpress.net/news/business/data-speaks/rooftop-solar-power-an-idea-whose-time-has-come-in-vietnam-4132356.html.

[61] Thu Vu, "Vietnam's extraordinary rooftop solar success deals another blow to the remaining coal pipeline," Institute for Energy Economics and Financial Analysis (IEEFA), January 12, 2021, accessed June 4, 2021, at https://ieefa.org/ieefa-vietnams-extraordinary-rooftop-solar-success-deals-another-blow-to-the-remaining-coal-pipeline/.

[62] Edgar A. Gunther, "Vietnam rooftop solar records major boom as more than 9GW installed in 2020," *PV Tech,* January 6, 2021, accessed June 4, 2021, at https://www.pv-tech.org/vietnam-rooftop-solar-records-major-boom-as-more-than-9gw-installed-in-2020/.

challenges of overcapacity and grid management. In early 2021 the Ministry of Industry and Trade indicated that it would cut the rooftop solar tariff from $0.084/kWh to $0.052 – 0.058/kWh moving forward.[63] While this shows the challenges of rapidly scaling up, continued investment even after the favorable tariff terms expired indicate that rooftop solar is commercially attractive to companies. There are opportunities to learn lessons from Vietnam's and Thailand's experiences and challenges for other Mekong countries.

This rapid deployment is driven by increasing cost-competitiveness of renewable energy technologies. The average global cost of solar has dropped nearly 90% since the end of 2009, and the average cost of wind has dropped approximately 55-60% since 2010.[64] The result is that starting in the mid-2010s, the cost of variable renewable energy technologies began to be cost-competitive with traditional power generation. As of late 2019, the levelized cost of electricity from utility-scale solar projects ranges between $0.032 and $0.044 per kilowatt-hour.[65] There are many reasons for this—economy of scale in production (particularly mass solar panel production in China), regulatory reform, improved manufacturing efficiency, and increased familiarity among financiers have all played a role.

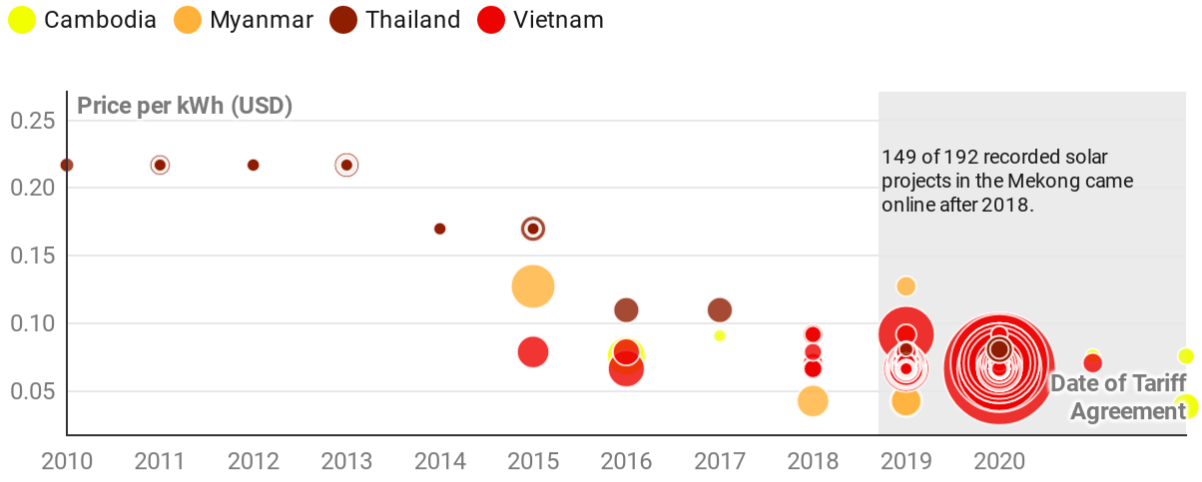
Feed-in-tariff prices began dropping as a result of these trends, but a noticeable and rapid driver of low prices globally has been the adoption of competitive procurement practices. This often takes the form of an auction, wherein governments post a tender for renewable energy and private companies bid on a project with the lowest price winning. The competition and transparency, combined with shifts in the supply chain and financing terms associated with auction systems, have substantially driven down PPA prices in just a few years and in many cases have supported low record prices for solar electricity. Cambodia's first solar project was completed in 2017 with a price of $0.091/kWh. Cambodian solar projects that came online from 2019 onwards were priced at approximately $0.070-$0.080/kWh.[66] In 2019, the ADB supported a solar auction that achieved the lowest power purchase tariff for a solar project recorded in Southeast Asia at $0.034/kWh.[67] Myanmar, has also seen drops: Myanmar's first solar project signed in 2015 sold power for $0.1275/kWh, but in mid-2020 Myanmar received bids of $0.035 /kWh at its first large solar auction.[68] In early 2020 Malaysia signed a solar

[63] Reuters, "Vietnam to cut rooftop solar feed-in tariff in bid to ease grid pressure," *Reuters*, March 17, 2021, accessed June 4, 2021, at https://www.reuters.com/article/vietnam-energy-solar-idAFL4N2LF1ZL.
[64] IRENA, *Electricity Storage and Renewables: Costs and Markets to 2030*, Oct. 2017, accessible at https://www.irena.org/publications/2017/Oct/Electricity-storage-and-renewables-costs-and-markets.
[65] Lazard, Lazard's Levelized cost of Energy Analysis – Version 13, November 2019, page 2.
[66] Price Trends for Solar Power in Mekong Region, datawrapper.dwcdn.net/yFJiM/2/.
[67] Asian Development Bank. "ADB-Supported Solar Project in Cambodia Achieves Lowest-Ever Tariff in ASEAN." *Asian Development Bank*, Asian Development Bank, 25 Nov. 2019, https://www.adb.org/news/adb-supported-solar-project-cambodia-achieves-lowest-ever-tariff-asean.
[68] Emiliano Bellini, "Myanmar's 1 GW solar tender concludes with lowest bid of $0.0348/kWh," *PV Magazine,* September 24, 2020, at https://www.pv-magazine.com/2020/09/24/myanmars-1-gw-solar-tender-concludes-with-lowest-bid-of-0-0348-kwh/.

project for $0.042/kWh.[69] These low prices indicate that the renewable energy transition is not slowing despite the global economic situation during the COVID pandemic.

Price Trends for Solar Power in Mekong Region

This chart shows electricity price tariffs for solar power plants in the Mekong region. Colors represent country and size of the dot represents the size of the power plant.



Thai and Vietnamese projects follow scheduled feed-in-tariffs as they were updated through the years. Other projects utilize publicly reported rates for projects and tenders.

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Thailand has long been a renewable energy leader in the ASEAN region: as early as 2007, the government established adder tariffs to incentivize small-scale renewable energy investments. In 2015 Thailand began setting official renewable energy targets in national development plans, and the most recent PDP 2018 set a target of 12,725 MW of solar capacity and 1,485 MW of wind capacity by 2037, or 18.4% of installed capacity.[70]

[69] Emiliano Bellini, "Five bidders set to secure 490 MW in Malaysia's third solar auction," *PV Magazine,* January 9, 2020, accessed September 21, 2020 at https://www.pv-magazine.com/2020/01/09/five-bidders-set-to-secure-490-mw-in-malaysias-third-solar-auction/.

[70] Ministry of Energy, *Thailand Power Development Plan 2018*, April 30, 2019, page 14.

Challenges of Variable Renewable Energy

Utilities have historically been hesitant to scale up renewable energy, largely due to concerns about variability of power production and concerns about cost. Energy planners' primary mandate is to ensure adequate electricity to avoid blackouts and buildout the energy system to meet future electricity needs. Avoiding brownouts and ensuring steady electricity supply requires rapid responses to fluctuations in electricity demand and supply, and traditional power systems are built around the need to ensure sufficient baseload power supply (usually from thermal power plants or hydroelectric dams) plus a range of more variable options which can kick in to respond to increases in demand (often natural gas).

Unlike traditional power plants, solar and wind are variable and produce electricity depending on when sunshine and wind are available. Both are predictable using weather forecasting, but output changes from moment to moment and day to day. Grid operators have pointed to this variability as an obstacle to high levels of renewable energy because of concerns that solar and

wind cannot serve as baseload energy supply without mechanisms such as storage. In the case of Vietnam, there have also been challenges of effectively integrating the amount of solar that can come online in a short time: after adding over 9GW to the grid in 2020, the National Power Dispatching Center indicated in early 2021 that it would likely need to curtail 1.3 billion kWh of solar power production due to local overcapacity.[71] In this case the challenge is the lack of parallel investment in transmission infrastructure.

The amount of variable renewable electricity that can be integrated into an existing grid without causing stability problems has historically been estimated by various studies at approximately 30%.[72] For the United States or Europe which have more advanced grid technology and management practices, higher penetration levels are manageable. Europe overall relied on renewables for 38% of the electricity produced in 2020, with individual locations achieving significantly higher levels of penetration when production was high.[73] California has at certain points relied on renewable energy for over 80% of the total electricity production and 41% of peak generation.[74]

[71] Viet Nam News, "Solar power capacity to be cut due to oversupply," January 19, 2021, accessed June 3, 2021, at https://vietnamnews.vn/economy/858458/solar-power-capacity-to-be-cut-due-to-oversupply.html.

[72] Milligan et al., "Review and Status of Wind Integration and Transmission in the United States: Key Issues and Lessons Learned," National Renewable Energy Laboratory, March 2015, p. 17, at http://www.nrel.gov/docs/fy15osti/61911.pdf.

[73] David Vetter, "It's Official: in 2020, Renewable Energy Beat Fossil Fuels Across Europe," *Forbes*, January 25, 2021, accessed June 3, 2021, at https://www.forbes.com/sites/davidrvetter/2021/01/25/its-official-in-2020-renewable-energy-beat-fossil-fuels-across-europe/?sh=148ef0de60e8.

[74] Rocco Canonica and Kassia Micek, "Rapid renewables growth brings challenges for US states: Part 1 – California," *S&P Global*, April 8, 2020, accessed June 3, 2021, at https://www.spglobal.com/en/research-insights/articles/rapid-renewables-growth-brings-challenges-for-us-states-part-i-california.

Ability to integrate variable renewable energy will vary depending on the status of the grid, but excepting Vietnam the Mekong countries are still in relatively early phases of renewable energy integration and can effectively manage lower levels of renewable energy through alternative methods of grid management. Doing so requires changes to grid operations and regulatory codes: for instance, building flexibility into the power purchase agreements with existing plants; updating national grid codes; and reconsidering prioritization of utility-owned power plants.[75] Integrating modern weather into daily and weekly planning of the energy supply is a key step to ensure efficient integration. Measurements on the consumer side such as peak shaving and demand-side management could also help manage the pull on the grid during times when renewable energy production is under capacity.

Over time, as countries in the region slowly build out grid capacity, integrating smart metering and other technologies can provide real-time electricity demand tracking and support an immediate supply response.[76] As Vietnam has proven, a lack of preparation in terms of physical infrastructure or operational changes to dispatching can lead to a waste of electricity production. As renewable energy penetration in other countries reaches similar levels of penetration, adoption of a holistic management approach, improvements to physical infrastructure, and battery storage will become more important.

In early stages of variable renewable energy penetration, the grid can avoid disruptions largely through operational changes, weather forecasting, demand side management, and improvements to system efficiency. However, as the role of renewable energy grows, the grid's reliability will benefit from inclusion of electricity storage. Pumped hydropower and battery technologies are the most widely commercially viable energy storage technologies and receive most of the policy-attention in the Mekong region.

Pumped hydropower storage is a quintessentially familiar technology because it operates much as traditional hydropower plants do: pumped storage plants use excess electricity during times of low demand to pump water from a lower reservoir into an upper reservoir, which can then be run through a turbine to produce power at a later time when electricity is needed. Pumped storage is cost-effective at large scales and can support the integration of variable renewables into a grid by acting as a sink for excess renewable electricity. Moreover, pumped hydropower can store power over longer periods of time than battery storage technologies. This technology faces similar limitations as a traditional hydropower project in terms of reliance on appropriate terrain. If built on an existing river system then pumped storage can have similar environmental impacts in terms of land use and environmental flows. However, there are many cases of pumped

[75] International Energy Agency, "Partner Country Series: Thailand Renewable Grid Integration Assessment," (International Energy Agency, October 12, 2018), page 13.
[76] Jurgen Weiss and Bruce Tsuchida, "Integrating Renewable Energy into the Electricity Grid," the Brattle Group, June 2015, p. 4-5.

storage projects are built as closed systems that use artificial ponds to avoid damming a river. While such projects still have land-use impacts, they avoid the negative social and ecological impacts on river systems.

Given pumped storage's relative cost-efficiency and technological familiarity, both Vietnam and Thailand are pursuing pumped hydropower storage developments to back up the increasing grid penetration of variable renewables. Vietnam's most recent power plan included planned pumped storage capacity of 2,400 MW by 2030.[77] A few different projects are under study, but the 1,200 MW Bac Ai project is already under construction and is likely to come online between 2025-2030.[78] Thailand completed its first pumped hydropower plant in 2004, and currently has three operational projects: the Srinagarind Dam, the Bhumibol Dam, and the Lamtakong Pumped Storage Hydropower Plant. The most recent Power Development Plan included an additional 500 MW to be added to the grid as an upgrade to the Lamtakong Dam, which was just completed in early 2020 and brings Thailand's total installed pumped storage capacity to 1,531 MW.[79] While Thailand likely has additional potential, the requirements in terms of land and environmental considerations are important limiting factors.

Battery storage has recently started to attract policy attention because of rapid price drops and its successful deployment in the US and Europe. Common battery types include lead-acid batteries, flow batteries, high-temperature sodium batteries, and lithium-ion batteries. There are differences in terms of how long each type of battery can efficiently store energy, life cycle, scalability, and other key considerations which make different battery types suitable for different uses. Lithium-ion batteries are most economically competitive for short-term storage over the course of a few hours and currently hold most of the stationary battery market, in part because they have also dominated the electric vehicle market and have reaped the greatest benefits in terms of price drops. Bloomberg New Energy Finance indicates that the cost of lithium-ion battery technologies fell by 87% between 2010 and 2019.[80] As with solar and wind technologies, the rate of battery price drops continues to significantly outpace predictions. In 2017 the International Renewable Energy Agency had estimated that lithium-ion battery prices might hit $145/kWh by 2030; as of late 2019, the price was $156/kWh and expected to drop well below

[77] Franz Gerner, Debabrata Chattophadhyay, Morgan Mazilian, and Ky Hong Tran, "Is Pumped Storage Hydroelectric Power Right for Vietnam?", Live Wire: 2017/75, World Bank Group, Washington DC, page 5, at https://openknowledge.worldbank.org/handle/10986/28619.
[78] Vietnam Electricity, "Ceremony of implementing construction and launching emulation for completing discharge gate work cluster of Bac Ai Pumped Storage Hydropower Project," *Vietnam Electricity*, January 6, 2020, accessed September 23, 2020, at https://en.evn.com.vn/d6/news/Ceremony-of-implementing-construction-and-launching-emulation-for-completing-discharge-gate-work-cluster-of-Bac-Ai-Pumped-Storage-Hydropower-Project-66-142-1744.aspx.
[79] Electricity Generating Authority of Thailand, "Battery of the Northeast," Lamtakong pumped-storage Hydropower Plant Units 3-4 start commercial operation," *EGAT*, January 6, 2020, accessed September 23, 2020, at https://www.egat.co.th/en/news-announcement/news-release/battery-of-the-northeast-lamtakong-pumped-storage-hydropower-plant-units-3-4-start-commercial-operation-for-power-security.
[80] Bloomberg New Energy Finance, "Battery Pack prices fall as Market Ramps Up with Market Average at $156/kWh in 2019," BNEF, December 3, 2019, accessed September 24, 2020, at https://about.bnef.com/blog/battery-pack-prices-fall-as-market-ramps-up-with-market-average-at-156-kwh-in-2019/?sf113554299=1.

$100/kWh by 2030.[81] Even conservative projections anticipate across-the-board price drops for almost all electrochemical battery types, meaning that the future will likely be cheaper and have a diversity of options.

The rapid drop in price for battery storage has led the United States, China, Japan, South Korea, and many countries in the European Union to support deployment of battery storage alongside new renewable energy power plants to firm up electricity production and increase grid reliability. While Southeast Asia is still in the early phase of battery deployment, Thailand and Vietnam have both scaled up solar and wind projects in recent years and are looking to 18% or higher RE penetration by the mid-2030s. Vietnam has begun to explore the potential to use battery storage to help manage variability from the thousands of megawatts of new solar projects that have come online in the last two years. With support from the U.S. Trade and Development Agency, Vietnam Electricity hired General Electric in April 2019 to perform a feasibility study on the economic and technical viability of deploying large-scale battery storage on the grid.[82]

Although Vietnam is now outpacing Thailand in terms of renewable power generation investment, Thailand is still ahead of the curve in storage. As of mid-2020, EGAT is already trialing battery energy storage systems. There are currently two utility-scale battery systems in Thailand which can purchase excess power from the grid and sell it back during peak hours: the Bamnejnarong Power Station (16 MW of generation capacity each hour) and the Chaibandal Power Station (21 MW capacity per hour).[83] In May 2020, the Asian Development Bank agreed to finance the first private-sector investment in a hybrid wind-battery system in Thailand, which will add an integrated 1.88 MWh battery system to an existing 10 MW wind farm to provide on-site battery storage to smooth out fluctuations.[84] The project will sell most electricity directly into the grid but will store excess capacity in the battery in order to reduce strain on the grid and store power for sale until times of higher demand. This project will act as a proof of concept for hybrid projects, supporting scale-up in the future.

Regardless of plans for local deployment of battery storage, Thailand will have a key future role in the lithium-ion battery supply chain. The Thai renewable energy company Energy Absolute (EA) put Thailand on the global map as a potential battery hub in 2017 with an announcement that it was investing in a lithium-ion battery production facility with one-gigawatt-hour

[81] Ibid.
[82] General Electric, "Vietnam Electricity awards GE battery energy storage feasibility study funded by U.S. Trade and Development Agency," April 12, 2019, accessed September 24, 2020 at https://www.ge.com/news/press-releases/vietnam-electricity-awards-ge-battery-energy-storage-feasibility-study-funded-us.
[83] EGAT, "Energy storage system" is the key to unlocking the security of future energy" [translated from Thai: "ระบบกักเก็บพลังงาน" กุญแจปลดล็อคสู่ความมั่นคงของพลังงานแห่งอนาคต], Electricity Generating Authority of Thailand, January 2, 2020, accessed September 21, 2020 at https://www.egat.co.th/index.php?option=com_content&view=article&id=3275:2020106-01&catid=49&Itemid=251.
[84] Asian Development Bank, "ADB finances first wind power and battery storage project in Thailand," May 18, 2020, accessed September 23, 2020, at https://www.adb.org/news/adb-finances-first-wind-power-and-battery-storage-project-thailand.

production capacity annually.[85] Though EA built its reputation on production of biofuels, the company shifted into renewable power generation, rapidly scaled up to become one of the largest private electricity generating companies in the country, and then diversified into battery storage and electric vehicles. Like Tesla, Energy Absolute has invested in various stages of the supply chain: it and its subsidiaries produce renewable energy, manufactures car and utility-scale batteries, manufactures electric vehicles and ferries, and has entered into agreements to provide public charging stations at convenience stores and gas stations in Thailand.[86]

When EA's lithium-ion battery factory comes online in late 2020, it will be the first lithium-ion battery plant in ASEAN. Given Thailand's role as a key investor in power plants around the Greater Mekong Subregion, Thai companies have an opportunity to support similar pilot battery storage deployment in neighboring countries in a way that would help reduce strains on the relatively underdeveloped national and regional grids as the region moves towards greater integration.

3.1 Electric Vehicle Deployment

Lithium-ion batteries are also used for electric vehicles. Electric vehicle (EV) penetration in Southeast Asia is still extremely low, but regional governments are pushing for broad deployment to reduce fossil fuel demand and carbon emissions from the transport sector as well as address concerns over local air pollution. Air pollution in Bangkok and many other large cities in Asia has reached hazard levels in recent years. While regional air pollution has many causes, in Bangkok the high levels of air pollution are partially attributable to emissions from diesel engines.[87] Widespread deployment of EVs could help reduce air pollution, and the Thai the government has set targets for slowly increasing local deployment. In March 2020, the government announced a strategy to make Thailand a hub for electric vehicles within ASEAN by 2025 through building out more charging stations, providing promotional incentives for vehicle and battery manufacturing and use, and setting targets for EV deployment domestically.[88]

While widespread adoption of EVs is years away, it may have increase total energy demand depending on whether EVs charge during peak hours or off hours. EVs can act as mobile battery energy storage, but the way in which they are operated and charged will determine whether EVs provide greater grid flexibility or strain the electricity system. If EVs are habitually charged during peak demand hours, then they will be placing additional pressure on the grid at a time which already requires utility operators to ramp up production. This would increase the overall daily

[85] Bloomberg New Energy Finance, "Energy Absolute plots Asian project rivaling Musk's Gigafactory," BNEF, May 24, 2017, accessed September 24, 2020, at https://about.bnef.com/blog/energy-absolute-plots-asian-project-rivaling-musks-gigafactory/.
[86] Srisamorn Phoosuphanusorn, "'Tesla of Thailand; power vision of electric paradise," *Bangkok Post,* July 8, 2019, accessed September 24, 2020, at https://www.bangkokpost.com/business/1708635/tesla-of-thailand-powers-vision-of-electric-paradiseTesla.
[87] Thailand Clean Air Network, *Clean Air White Paper, Thailand,* March 3, 2020, page 15.
[88] "Thailand 'to be regional EV hub' in five years," *The Bangkok Post,* March 11, 2020, accessed September 25, 2020, at https://www.bangkokpost.com/auto/news/1876469/thailand-to-be-regional-ev-hub-in-five-years.

peak load and require additional power capacity buildout. However, if electric vehicles are managed smartly in a way that manages demand based on pricing and grid strain, then they could instead help to smooth the daily electricity demand curve by recharging at off-peak hours and potentially contributing into the grid when not being used during times of peak demand.[89]

This flexible type of operational management would require some changes in behavior on the part of consumers. Changes to pricing mechanisms could push customers to reduce demand voluntarily during times of peak demand, and digitization of the network could balance charging times throughout the night instead of during peak evening hours. This is likely possible but would require modernization of the electricity system in terms of smart metering. It would also likely require socialization of pricing differentials between peak and off-peak hours and the use of economic incentives to convince customers to charge their vehicles in ways that smooth the demand curve but might be less immediately convenient for individual customers.

[89] International Energy Agency, *Energy Technology Perspectives 2020,* September 2020, page 95-96.

4. Recent Shocks to the Power Sector

The technologies that underpin the renewable energy transition may in some instances cause short-term disruptions to management of the power sector, but they are ultimately going to become a new normal and contribute to an energy system which is more flexible and resilient. Many international organizations—the International Energy Agency; the International Renewable Energy Agency; research institutes like the National Renewable Energy Laboratory in the United States; bilateral development partners such as USAID or JICA; and multinational financial institutions—are providing assistance to Southeast Asian countries to incorporate these new technologies into national energy plans. More immediately challenging and problematic are the unexpected disruptions that have been caused in 2019 and 2020 by the major drought affecting the Mekong and the impacts of the coronavirus pandemic.

4.1 Drought and Hydropower Reliability

Mainland Southeast Asia is intimately tied together by the Mekong River, which flows from its headwaters in the Tibetan Plateau in China and runs through Myanmar, Laos, Thailand, Cambodia, and Vietnam on its way to the ocean. Like most other rivers in the region, the Mekong is characterized by extreme seasonal variance, with relatively low water levels during the dry season (November – April) and a rapid rise in volume during the wet season (May to October). This seasonal variability has historically been highly predictable, and the wet season influx of rain into the Mekong River system drives a relatively unique hydrological phenomenon known as the Mekong flood pulse. As water levels in the mainstream of the Mekong rise, the water pressure reverses the directional flow of the Tonle Sap river, causing it to back up and expanding the Tonle Sap lake.

Starting in March 2019—mid-way through the 2018/2019 dry season—parts of the Mekong region began experiencing a drought. The rains began late, ended early, and led to 2019 rainfall totals well below the average. In July 2019 when the wet season is usually well underway, the Mekong River Commission declared record low water levels along large reaches of the lower Mekong. Despite rapid and intense rainfall from a few major instances of storms, the flood pulse in 2019 was weak. The annual Tonle Sap reversal which fuels the Mekong's world-renowned fisheries production was a month and a half late and ended well over a month earlier than usual. Starting in November, the Mekong River Commission began projecting severe drought in late 2019 to early 2020.[90]

[90] Mekong River Commission, "Drought continues to hit Mekong countries, risking stress on crop production, water shortages," November 19, 2019, accessed September 25, 2020, at http://www.mrcmekong.org/news-and-events/news/drought-continues-to-hit-mekong-countries-risking-stress-on-crop-production-water-shortage/.

2019 was among the driest years on record in the region, and unfortunately 2020 rainfall levels have been even lower. Rainfall in the Lower Mekong through July was 45% lower than the recent average and 37% lower than the same timeframe in the record low year of 2019.[91] Drought is a recurring and regular challenge for the Mekong region, but the severity and frequency of droughts in recent years have risen. Climate change predictions also indicate a likely shift in the timing and intensity of rainfall which will affect the flood pulse and Mekong River's hydrology.

While the cause of the 2019/2020 meteorological drought is low rainfall, the operations of China's upstream mega-dams have compounded low water levels in the Mekong River mainstream. In April 2020, Eyes on Earth—a U.S. consultancy firm supported with funding from the U.S. Department of State—revealed that dams in China's portion of the basin have severely restricted water flow during the 2019 wet season.[92] Analysis from China State Grid indicates that this was the result of a change in dam cascade operations in 2019, when Chinese hydropower operators significantly drew reservoirs down during the dry season in order to produce hydroelectricity and then refilled them during the wet season.[93] This is normal operating procedures for hydropower projects, but an unintentional side impact was that China's upstream dams restricted water to the downstream at a time when China's actions would normally have contributed to the annual flood pulse.

The situation appears to be repeating in 2020, based on record low levels of rainfall downstream and satellite monitoring of the reservoir movements. Even after the reversal of the Tonle Sap Lake in Cambodia officially began on August 4, 2020, the volume of water in the Tonle Sap remained at record lows.[94] The Tonle Sap's annual fish catch is more than 500,000 tons, and this productivity has driven the annual reversal of the Mekong River. Record low water levels have severe repercussions for food security: fish catches in late 2019 were already down a reported 70% and 90% from averages.[95] The low water levels will also impact communities in the Mekong Delta in Vietnam again in 2020 due to drought-impacted farmland and saline intrusion.

[91] Mekong River Commission, *Hydrological Conditions in the Lower Mekong River Basin in January – July 2020,* August 2020, page 4.
[92] Alan Basist and Claude Williams, *Monitoring the Quantity of Water Flowing through the Mekong Basin through Natural (Unimpeded) Conditions,* Sustainable Infrastructure Partnership, 2020, Bangkok, page 18.
[93] China Southern Power Grid, "Incoming Water at a 13-Year High: How to Resolve the Pressure?" [original article in Mandarin Chinese: 来水创13年新高，压力如何化解], December 13, 2019, accessed September 25, 2020, at https://www.csg.cn/xwzx/2019/yxcz/201912/t20191213_306684.html; Brian Eyler and Yun Sun, "Discussing China's Dams on the Mekong," The Stimson Center, June 16, 2020, accessed September 25, 2020, at https://www.stimson.org/2020/discussing-chinas-dams-on-the-mekong/.
[94] Sao Da, "Water volume in Tonle Sap Lake at dangerous levels," *The Khmer Times*, August 21, 2020, accessed September 25, 2020, at https://www.khmertimeskh.com/50755781/water-volume-in-tonle-sap-lake-at-dangerous-levels/.
[95] Author interviews with community leaders in Kampong Phluk, Cambodia, October 6, 2019; Shashank Bengali, "'No fish': how dams and climate change are choking Asia's great lake," *Los Angeles Times,* January 20, 2020, accessed September 25, 2020, at https://www.latimes.com/world-nation/story/2020-01-20/how-climate-change-and-dams-threaten-one-of-the-worlds-great-lakes.

This period's serious drought has significant food security and environmental impacts, but it also directly impacts electricity production due to the prevalence of hydropower in the region's electricity mix. Hydropower operations in the Mekong region already face capacity factor limitations due to significant seasonal variation in the availability of water. Capacity factor is a measure of how much power a plant actually generates compared to its listed installed capacity, and for dams it depends on water availability and management. The annual average capacity factor for hydropower projects in the region is 40% - 60%, meaning that on average dams only produce 40-60% of their installed capacity.[96] This average reflects significant seasonal variation: high levels of rain swell the river and fill reservoirs during an average wet season which allows for very high capacity factors, but during the dry season the capacity factor can drop significantly lower than 40% due to low water availability.

During years of drought, the annual rainfall is often insufficient to fill reservoirs for storage dams, which limits their ability to produce electricity throughout the rest of the year. In recent years, serious droughts have caused significant drops in electricity production. In 2019, Cambodia faced months of regular power cuts because hydropower capacity suddenly dropped by 400 MW, or approximately a sixth of Cambodia's total electricity demand. Drought-related electricity production shortages pose challenges to national planners, but they also pose challenges for power plant operators who rely on the sale of electricity for revenue.

No Reservoirs, No Electricity: Cambodia's 2019 Blackouts

Hydropower is only a reliable electricity source when water is available. When there are low water levels such as those seen in times of severe drought, then hydroelectricity production can drop drastically. Few examples illustrate this as strongly as Cambodia's rolling blackouts during 2019. Starting mid-dry season in 2019, Cambodia began suffering significant water and electricity shortages. As of March 2019, Prime Minister Hun Sen announced that Cambodia's electricity production was short by 400 MW (18% of Cambodia's total installed capacity and 30% of its hydropower production) due to low levels in hydropower reservoirs.[97] The reduction in power output resulted in rotating blackouts that impacted parts of Phnom Penh for five to six hours a day.

The drought also impacted electricity production in Laos. Low levels of water in July 2019 meant that during testing, the Xayaburi Dam could only produce 40% of its installed capacity (500 MW).[98] Cities in Myanmar already face occasional electricity shortages, but in April 2019 low

[96] Mekong River Commission, *Hydropower Sector Review for the Joint Basin Planning Process*, February 2009, page 22.
[97] Phnom Penh Post, "Small vendors hit hard by nationwide blackouts," *Phnom Penh Post*, March 26, 2019, accessed September 25, 2020, at https://www.phnompenhpost.com/business/small-vendors-hit-hard-nationwide-blackouts.
[98] Pratch Rujivanarom, "Xayaburi Dam partly to blame for Mekong Basin crisis: activists," *The Nation: Thailand,* July 25, 2019, accessed September 25, 2020, at https://www.nationthailand.com/news/30373621.

hydropower productivity caused rotating blackouts in Mandalay and threatened blackouts in Yangon.[99]

Ultimately, the severe drought in 2019 raised questions over whether hydropower itself will be a reliable electricity source in the future. In Cambodia, officials have noted that the serious hydropower shortages in 2019 helped prompt a rapid diversification into renewable solar as well as new power import agreements from Thailand and Laos.[100] In Myanmar, water shortages pushed policymakers to purchase up to 2,000 MW from China Southern Power Grid to avoid future blackouts.[101]

Drought is certainly not new to the Mekong, but it has increased in regularity: the most severe drought on record before this year was only three years earlier in 2016. In late 2019, the Mekong River Commission released the first Drought Management Strategy for the region, citing the likelihood of more severe droughts in the coming 90 years due to rising temperatures, lower precipitation, and rising water demand throughout the basin.[102] The increasing commonality of drought is a serious and chronic risk to existing and future dams, particularly those planned on the mainstream of the Mekong. Due to a combination of terrain and review processes, all proposed mainstream Mekong dams in Laos and Cambodia are designed to be run-of-river dams. As a result, mainstream Mekong dams have very little storage capacity and extremely limited flexibility in responding to low rainfall or low water levels.

While drought is a more widespread and regular threat to the reliability of hydroelectricity, the converse situation of intense rainfall also poses challenges to hydropower operation and safety. When extreme rainfall events occur then dam operators need to contend with the opposite challenge: rather than having too little water in the reservoir, they have to avoid a situation where there is too much water and the level rises above the dam's storage capacity. There have been numerous instances of dam overflows or failures in recent years. The most tragic of these was the collapse of a saddle dam for the Xe Pian - Xe Namnoy hydropower project in 2018, which caused massive flooding and led to the displacement of approximately 7,000 people due to damage to their homes and killed at least 49 people.[103] While such dam failure is the result of many factors—including construction quality control failures—extreme weather events can act as precipitating events. Dam collapse impacts are most profoundly felt by affected communities

[99] Zarni Mann, "Scheduled power outages for Myanmar's major cities," *The Irrawaddy*, April 29, 2019, accessed September 25, 2020, at https://www.irrawaddy.com/news/burma/scheduled-power-outages-myanmars-major-cities.html.
[100] Thou Vireak, "No power shortages next dry season, says energy minister," *The Phnom Penh Post,* January 21, 2020, accessed September 25, 2020, at https://www.phnompenhpost.com/business/no-power-shortages-next-dry-season-says-energy-minister.
[101] Nan Lwin, "Gov't to buy electricity from China to cover shortfall," *The Irrawaddy*, May 14, 2019, accssed September 25, 2020 at https://www.irrawaddy.com/news/burma/govt-buy-electricity-china-cover-shortfall.html.
[102] Mekong River Commission, *Drought Management Strategy for the Lower Mekong Basin 2020 – 2025,* November 2019, page ii.
[103] International Rivers, Mekong Watch, and Inclusive Development International, *The Xe Pian – Xe Namnoy Dam Disaster: Situation Update Two Years On,* July 2020.

but can result in the delay of available power as with Xe Pian – Xe Namnoy or even the loss of power production if damage is sufficiently severe.

Energy plans to date have treated hydropower as an ever-reliable baseload supply, but the challenges in 2019 should raise questions about overdependence on hydropower in Laos and Myanmar just as they did for policymakers in Cambodia. Further buildout of hydroelectric dams in the region must consider the risks to production and reliability that these recent and increasingly common droughts and extreme weather events have revealed. Policymakers should account for these increasing uncertainties and risk to hydroelectricity production when considering investment options.

4.2 COVID Impacts

Southeast Asia was the first region outside China to experience COVID infections. Thailand reported the first international case on January 14, 2020, and by the end of January 2020 six of 10 ASEAN members were reporting cases.[104] While a widespread outbreak has thus far been avoided, the economic situation has severely impacted the region. Exports are down severely; tourism has dropped sharply; a collapse in oil prices has impacted regional export markets; and domestic demand has dropped due to lockdowns. [105] As a whole, Southeast Asia's GDP contracted 4% in 2020.[106]

As a result of economic disruption and physical lockdowns, 2020 saw a global decline in energy demand of 4%, and Southeast Asia's overall electricity demand dropped approximately 3%.[107] This is a massive shift from business as usual, particularly for developing countries where electricity demand often hits double digits as in Southeast Asia. The health, economic, and energy sector impacts vary by country, but here is a snapshot as of late 2020 when this paper was initially written:

- **Cambodia** has been spared a health crisis from coronavirus, with only 275 recorded cases as of September 25, 2020.[108] However, the ADB estimates that Cambodia's GDP growth rate will contract 4% in 2020. Cambodia's manufacturing and export industry has been

[104] Courtney Weatherby, "COVID-19 in Southeast Asia: outreak delayed, but developing," The Stimson Center, March 24, 2020, accessed September 25, 2020, at https://www.stimson.org/2020/covid-19-in-southeast-asia-outbreak-delayed-but-developing/.
[105] Amy Searight, "The Economic Toll of Covid-19 on Southeast Asia: Recession Looms as Growth Prospects Dim," CSIS, April 14, 2020, accessed September 25, 2020, at https://www.csis.org/analysis/economic-toll-covid-19-southeast-asia-recession-looms-growth-prospects-dim.
[106] The final figure for 2020 is taken from Asian Development Bank (ADB), *Asian Development Outlook 2021: Financing a Green and Inclusive Recovery,* April 2021, page xxii. All following economic growth/contraction figures for individual countries in this section come from Asian Development Bank, *Asian Development Outlook Supplement: Paths Diverge in Recovery from the Pandemic,* December 2020, page 7. The Cambodia, Lao PDR, and Myanmar figures are taken from *Asian Development Outlook 2020 Update: Wellness in Worrying Times,* September 2020, page 25.
[107] International Energy Agency, *Global Energy Review 2021: Assessing the effects of economic recoveries on global energy demand and Co_2 emissions in 2021,* IEA, April 2021, pages 6 and 9.
[108] All figures for coronavirus caseloads taken from the COVID-19 Dashboard by the Center for Systems Science and Engineering at Johns Hopkins University, updated 9/25/2020 at 4:23 PM EST.

severely impacted, as has its tourism industry starting in the second quarter of the year. As of June 2020, the Electricity Authority of Cambodia projected a 20% decline in electricity demand, primarily due to low industrial consumption.[109] This is a significant change from business-as-usual in previous years, when Cambodia's electricity demand usually grew by approximately 20% annually, and reflects the severe impact that the pandemic is having on Cambodia's manufacturing sector. The government has taken steps to reduce power bills for key economic sectors in order to try and help companies stay afloat during the recession.[110] While the decreased demand has allowed Cambodia to avoid power shortages due to the ongoing drought, but at the cost of approximately 130 companies closing down and another 69 factories suspending work due to the recession.[111] Electricity demand will likely rebound as the economy does, but the damage to companies and the workforce will require time to repair.

- **Laos** has only 23 recorded cases of the coronavirus, due in part to the government's early closure of the national borders in March to avoid a health crisis and likely also in part to low capacity to identify and track cases. However, the economy is still facing a 2.5% contraction in 2020 largely due to the devastation of the tourism industry and drop in remittances from overseas workers.[112] This has stressed Laos's ability to service debt. In June, Moody's downgraded Laos's rating due to material probability of default.[113] The electricity sector appears to be set for restructuring as a result of this economic turmoil: on September 1, Electricite du Laos signed an agreement with China Southern Power Grid Co. in a deal which reportedly gives majority control to China Southern Power Grid.[114] This new deal may allow better negotiations on price with neighbors, but the shareholding split has not been announced and it's unclear how this will impact cash flow from electricity sales to the government of Laos.
- **Myanmar** kept confirmed cases of COVID-19 low until late August—but cases began rapidly rising and averaged over 1,000 cases a day from early October to mid-December with more than 177,000 people infected and 2,484 deaths. This second wave outbreak is

[109] Thou Vireak, "EAC: no power shortage this year," *The Phnom Penh Post,* June 24, 2020, accessed September 25, 2020 at https://www.phnompenhpost.com/business/eac-no-power-shortage-year.

[110] JETRO Phnom Penh, "Unofficial Translation: Prakas on promulgating the exemption and incentive plan for industrial, agricultural, commercial, and service electricity consumers from June until October 2020, Ministry of Mines and Energy," May 19, 2020, at https://www.jetro.go.jp/ext_images/world/covid-19/asia/pdf/kh_en_20200519.pdf.

[111] May Kunmakara, "Kingdom's electricity demand retreates on Covid-induced economic shocks," *The Phnom Penh Post,* November 8, 2020, at https://www.phnompenhpost.com/business/kingdoms-electricity-demand-retreats-covid-induced-economic-shocks.

[112] Michael Hart, "Unscathed by COVID-19, Laos Gambles on Megaprojects to Revive Its Economy," *World Politics Review*, August 19, 2020, accessed September 25, 2020, at https://www.worldpoliticsreview.com/articles/28999/for-laos-dams-and-other-megaprojects-are-still-the-answer-to-economic-woes.

[113] Moody's Investors Service, "Rating Action: Moody's downgrades laos's rating to Caa2, outlook changed to negative," August 14, 2020, accessed September 25, 2020 at https://www.moodys.com/research/Moodys-downgrades-Laoss-rating-to-Caa2-outlook-changed-to-negative--PR_429248.

[114] Keith Zhai, "Chinese firm to run Lao electric grid," *Bangkok Post,* September 4, 2020, accessed September 25, 2020, at https://www.bangkokpost.com/business/1980027/chinese-firm-to-run-lao-electric-grid.

still ongoing and likely to strain Myanmar's healthcare system, which was among the least prepared for the pandemic due to financial and capacity constraints. Surveys indicate that 75% of rural households and 84% of urban households reported loss of income or employment in 2020.[115] The economy was severely impacted due to declines in tourism, remittances from international family and workers, and natural gas price collapses.[116] Prior to this second wave infection, Myanmar was projected to have GDP growth of 1.8% in 2020 and rebound to 6% in 2021. However, the continued economic stressors will bear watching—agricultural exports have recovered, but manufacturing dropped 4.4% in 2020 and there are concerns about FDI in 2021.[117]

- **Thailand** has among the Mekong countries been most severely economically impacted by the coronavirus, and the ADB estimates that it will experience an economic contraction of 7.8% in 2020. Despite early exposure and multiple waves of infection, Thailand has to date managed to contain spread to 5,716 cases and 60 deaths. However, the lockdowns required to do so involved banning commercial flights and closing most non-essential businesses. Commercial demand dropped 10% and manufacturing dropped significantly in 2020, but one unintended side effect of the lockdowns was that household electricity use rose.[118] Household bills for many families increased significantly due to higher than usual electricity use at home. The significant concern led the government to announce relief measures.[119] Thailand's Energy Policy and Planning Office reported a 3% year-on-year decline in total electricity demand for 2020.[120] The drop in electricity demand has prompted EGAT to reconsider future investments and move to reduce the reserve power capacity generation.[121]
- **Vietnam** has been internationally lauded for taking early and decisive action to shutter borders and block the spread of coronavirus domestically. Despite early cases and multiple waves of mostly imported infections, Vietnam has had only 1,420 cases of coronavirus and 35 deaths domestically. As a result, Vietnam is projected to see GDP growth of 2.3% in 2020—lower than expected, but not a contraction unlike most of its neighbors and Asia as a whole. The coronavirus has impacted demand, with 2020's

[115] International Food Policy Research Institute and Michigan State University, "Impacts of COVID-19 on Myanamr's Agri-Food System," IFPRI Myanmar, October 2020, page 8, at https://reliefweb.int/report/myanmar/impacts-covid-19-myanmars-agri-food-system-evidence-base-and-policy-implications.

[116] Jayendu De, Sanaa Nadeem, "Six charts on Myanmar's economy in the time of COVID-19," International Monetary Fund, July 7, 2020, at https://www.imf.org/en/News/Articles/2020/07/07/na70720-myanmars-economy-in-the-time-of-covid19-six-charts.

[117] Thiha Ko Ko, "Myanmar's economic growth to recover but FDI under threat: ADB," *Myanmar Times*, September 16, 2020, at https://www.mmtimes.com/news/myanmars-economic-growth-recover-fdi-under-threat-adb.html.

[118] The Nation, "Egat reviews its investments in line with covid-19 fallout," *The Nation Thailand*, May 11, 2020, accessed September 25, 2020, at https://www.nationthailand.com/business/30387534.

[119] "In the time of Covid-19," *The Bangkok Post*, April 24, 2020, accessed September 25, 2020, at https://www.bangkokpost.com/life/social-and-lifestyle/1906730/in-the-time-of-covid-19.

[120] Energy Policy and Planning Office, "Electricity Consumption for the Whole Country (Classified By Sector)", Ministry of Energy, accessible from http://www.eppo.go.th/index.php/en/en-energystatistics/electricity-statistic.

[121] Yuthana Praiwan, "Egat reining in power reserves," *The Bangkok Post*, August 20, 2020, accessed September 25, 2020, at https://www.bangkokpost.com/business/1971303/egat-reining-in-power-reserves.

average electricity demand growth estimated around 2%, compared against rates usually closer to 10%.[122] Notably, sixty percent of the listed hydropower companies in Vietnam saw profits decline in 2020 and thirty percent saw losses.[123] A number of dam operators indicated that this was the result of a dual hit from drought, which compressed the capacity that individual dams could produce, and stalling demand.[124]

The situation is still deeply uncertain. At the time of publication in mid-2021, Southeast Asia appears to be in a new wave of coronavirus infections which is significantly more severe than the initial waves in 2020 and many countries are reinstituting lockdowns in an effort to contain the spread of new variants of the disease.

While the region's long-term energy demand trajectory will recover, these disruptions have short-term impacts on energy management. For contracts where the utility has signed take-or-pay agreements, unused electricity still needs to be paid for, putting additional financial strain on utilities at a time when their income is squeezed by low demand. Even before the COVID pandemic, many utilities around ASEAN were already struggling to recover costs. With revenue dropping and expenditures remaining high due to contractual obligations, some national utilities may need to change policies. The change to ownership and management of Electricite du Laos is the combined result of long-term debt difficulty worsened by the crisis. In cases where the contracts are set up as take-and-pay where the utilities only pay if they use electricity, the sharp drop in revenue could instead pose considerable revenue issues for independent power producers.

4.3 COVID Impacts on Infrastructure

The most immediate disruptions to infrastructure from the COVID-19 pandemic have been related to workforce and supply chain issues. Many government agencies and utilities around the region have adopted quarantine and remote work plans due to concerns over infections in the first wave and again when local spread required renewed lockdowns. Previously routine communications and inspections took much longer. In-person meetings and field engagement for feasibility studies were disrupted. In Laos, all hydropower construction was put on hold starting in mid-April after a worker tested positive for the coronavirus.[125] In Vietnam, many commercial-scale renewable energy projects have faced delays due to supply chain disruptions and workforce shortages, even as small-

[122] Allen Wang and Joo Yeow Lee, "Southeast Asia's power sector continues to get battered by COVID-19," *HIS Markit*, May 4, 2020, accessed September 25, 2020, at https://ihsmarkit.com/research-analysis/southeast-asias-power-sector-continues-to-get-battered-covid-19.html.
[123] Vietnam News Agency, "Power companies face hardship in pandemic," *Vietnam Plus*, August 24, 2020, accessed September 25, 2020 at https://en.vietnamplus.vn/power-companies-face-hardship-in-pandemic/181797.vnp.
[124] Ibid.
[125] Jack Board, "Southeast Asia's hydropower boom grinds to a halt as COVID-19 stalls projects," *Channel News Asia*, April 22, 2020, accessed September 27, 2020, at https://www.channelnewsasia.com/news/asia/southeast-asia-hydropower-boom-covid-19-coronavirus-12652202.

scale residential solar deployment accelerated.[126] Globally, the International Energy Agency has identified supply chain disruptions as a challenge for projects which are currently under construction or in planning phases.[127]

One medium-term challenge which many countries in the region may face is simply disruption to new project pipelines and lockdowns impacting travel, feasibility studies, and other inputs which are key for the project development process. In Myanmar, the coronavirus response has caused delays to various hydropower projects already under construction as well as bids from new investors even as solar tenders moved forward.[128] Vietnam's early and total lockdown on international travel allowed it to manage the spread of COVID and avoid a health crisis, but it also kept some foreign companies investing in the energy sector from moving ahead with projects amid the pandemic.[129] While a short-term decline in electricity demand growth may allow for immediate flexibility, if delays continue then key power projects and infrastructure which will be needed as power demand rebounds in the medium-term may also be affected.

Economic disruptions and policy responses may also have longer-term impacts on infrastructure development. In Indonesia, national utilities have indicated that they may renegotiate contracts with independent power producers given concerns over losses linked to take-or-pay fines.[130] EGAT has indicated that in the event of a longer-economic downturn and recovery that it may put off investments in new plants, specifically those which have not yet closed on new power purchase agreements.[131]

These steps are likely necessary in the short-term for financial management and may even have benefits in terms of allowing greater consideration of alternative energy options due to delayed need for new projects. But national utilities should carefully consider the short-term financial benefits versus how this response could increase uncertainty or risk for future project investments. The take-or-pay provision which is causing economic challenges during the pandemic is an important element of managing risk for independent power producers by providing a guaranteed level of income.[132] Without the take-or-pay provision, projects wouldn't be bankable for many investors. Risk management is always a key element to attracting private investment and issues of contract default, renegotiation, or payment delays due to COVID could dissuade future investment.

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[126] Anh Minh, "Vietnam sees rooftop solar boom," *VN Express*, August 26, 2020, at https://e.vnexpress.net/news/business/industries/vietnam-sees-rooftop-solar-boom-4152437.html.
[127] NREL report page 1.
[128] Salai Tun Tun, "COVID-19 restrictions delay investors in hydropower," *The Myanmar Times*, September 7, 2020, accessed September 25, 2020 at https://www.mmtimes.com/news/covid-19-restrictions-delay-investors-hydropower.html.
[129] Tim Daiss, "Covid-19 knocking the lights out in Vietnam," *Asia Times*, March 27, 2020, accessed September 25, 2020, at https://asiatimes.com/2020/03/covid-19-knocking-the-lights-out-in-vietnam/.
[130] Alexander Richter, "PLN in Indonesia seeks to renegotiate contracts with IPPs in light of covid-19," *Think Geoenergy*, May 11, 2020, accessed September 27, 2020, at https://www.thinkgeoenergy.com/pln-in-indonesia-seeks-to-renegotiate-contracts-with-ipps-in-light-of-covid-19/.
[131] "Egat reviews its investments in line with covid-19 fallout," *The Nation Thailand,* May 11, 2020, accessed September 27, 2020, at https://www.nationthailand.com/business/30387534.
[132] NREL report page 13: https://www.nrel.gov/docs/fy20osti/76963.pdf

5. Impacts and Opportunities

The disruptions posed by the coronavirus pandemic has massively altered the short-term economic outlook for all five of the Mekong countries as explored in the previous section. The negative impacts of the recession on livelihoods and communities unfortunately may persist given the time needed to identify and scale up production of a vaccine. The recovery-time for tourism—a key part of the economy for most Mekong countries—is likely to be longer, particularly if vaccines cannot be deployed quickly. But within the context of widespread stimulus plans and post-COVID recovery plans, there are opportunities for the Mekong countries to re-align their energy plans.

Thailand has suffered the most severe economic impact in the Mekong region, and this economic crunch has prompted the Electricity Generating Authority of Thailand to commit to reducing the expensive-to-maintain electricity reserve margin from 40% to 15%.[133] This is a major change and comes after years of discussion, public debate, and critique from civil society and consumers over the slowly rising amount of excess capacity and associated costs. While this change might have eventually happened regardless of the pandemic given the clear financial benefits, the financial pressures likely sped up policy decisions to help make EGAT a more cost-efficient utility.

The Significance of Thailand Changing the Reserve Margin

In August 2020, the Electricity Generating Authority of Thailand announced plans to reduce the reserve margin from 40% to 15%.[134] This will be a significant shift in policy. The slowly growing reserve margin has been increasingly controversial in recent years. Thailand has a long history of overestimating electricity demand growth, with a 2004 review indicating that ten of the previous eleven energy forecasts had been overestimates.[135] As investment decisions in new projects are based on demand forecasts, this has led to slowly ballooning excess of power generation.

Thailand's installed capacity in 2020 currently stands at an estimated 51,390 MW.[136] Adding to this the 3,500 MW of power that has been imported from Laos in recent years, then Thailand's total available capacity rises to 54,890 MW. If peak demand in 2020 was originally estimated around 2% higher than the reported peak demand of 35,889 MW in 2019, one can calculate the excess capacity in 2020 and see that it would have reached 33%. However, that is a normal year—

[133] Yuthana Praiwan, "Egat reining in power reserves," *The Bangkok Post*, August 20, 2020, accessed September 25, 2020, at https://www.bangkokpost.com/business/1971303/egat-reining-in-power-reserves.
[134] Yuthana Praiwan, "Egat reining in power reserves," *The Bangkok Post*, August 20, 2020, accessed September 25, 2020, at https://www.bangkokpost.com/business/1971303/egat-reining-in-power-reserves.
[135] Adam Simpson and Mattjis Smits, "Transitions to energy and climate security in Thailand," Handbook of Transitions in Energy and Climate Security, edited by Robert E. Looney, pages 296-311, data on page 302.
[136] Yuthana Praiwan, "Egat reining in power reserves."

considering the significant manufacturing and commercial demand declines due to COVID, it's very likely that the excess is higher than this calculation implies.

This excess comes at a significant cost —when EGAT signs a power purchase agreement with independent power producers, it will often commit to paying something to ensure that electricity is available, even if that power is not being utilized. As the amount of overall excess power available in the system rises, so do the costs of maintaining that excess. These costs must be borne by someone, and in recent years some of this cost has been borne by the customers. This availability cost has been raised publicly in previous years as an argument against building out unnecessary fossil fuel power plants or raising power import agreements with Laos.[137] Given mounting pressures to reduce skyrocketing costs to frustrated households, EGAT's decision to decrease the reserve moving forward makes clear economic sense. It also raises questions about the need for certain power purchase agreements, such as those under discussion with mainstream Mekong dams in Laos such as Pak Beng, Luang Prabang, and Sanakham. If Thailand does not need to continue building out its capacity in the near-term, what rationale is there to move forward with expensive hydropower investments?

[137] "Renewable energy should be the focus of new power plan: expert," *The Nation Thailand*, June 24, 2018, accessed September 29, 2020, at https://www.nationthailand.com/national/30348517; Pianporn Deetes, "The hidden cost of Thailand's electricity," *Bangkok Post,* May 19, 2015, accessed September 29, 2020, at https://www.bangkokpost.com/opinion/opinion/565867/the-hidden-cost-of-thailand-electricity.

6. Recommendations

Looking to the post-COVID era, policymakers have an opportunity to rethink policies and design stimulus packages to build out a future that is more diverse, resilient, and economically and environmentally sustainable. Policymakers and development partners should consider the following recommendations in identifying paths forward:

For Policymakers:

- **Reaffirm ambitions to accelerate the energy transition as an integral part of COVID-19 recovery plans**. Renewable energy investments will not only bring clear environmental benefits both locally and globally but have knock-on effects that could support sustainable economic recovery from the COVID-19 recession. In addition to avoidance of the negative political, environmental, and social impacts from fossil fuel or large-scale hydropower projects, investment in renewable energy and energy efficiency can create twice as many jobs as investment in fossil fuels.[138] The International Renewable Energy Agency estimated that under a business as usual scenario, renewable energy could employ 1.7 million people in ASEAN by 2030 and that this would rise under a more aggressive push for renewables.[139] Renewable energy is also domestically available and can help improve energy security in the face of shocks to the global fuel system. Prioritization of renewable energy projects, electricity grid modernization, and renewable energy training programs in recovery efforts after COVID would help immediate recovery while laying a pipeline of support for the long-term energy transition.

- **As Thailand identifies a path towards carbon neutrality, it would be beneficial to plan Thailand's role as an electricity trading hub in a way that supports the region's long-term renewable energy and climate goals**. Thailand has recently begun work on a new master plan to lay out a pathway towards net-zero emissions.[140] One of the greatest benefits of a regional electricity grid is that it supports higher levels of variable renewable energy electricity projects. Broadening the geographic scope of available renewable energy resources helps to provide flexibility to work around temporary cloud cover or calm air that temporarily reduces power output in one location and balances out local short-term supply interruptions. The financial benefits of managing variable renewables across a large grid have been seen clearly in global power trading schemes, even when power markets were not designed around the integration of renewables.[141] These include

[138] Sustainable Energy for All, *The Recover Better with Sustainable Energy Guide for Southeast Asian Nations,* October 27, 2020, page 10, at https://www.seforall.org/data-and-evidence/recover-better-southeast-asia.
[139] International Renewable Energy Agency, *Renewable Energy Market Analysis: Southeast Asia,* IRENA, 2018, page 65.
[140] Yuthana Praiwan, "Zero emissions plan in progress," *Bangkok Post*, March 20, 2021, accessed June 2, 2021, at https://www.bangkokpost.com/business/2086807/zero-emissions-plan-in-progress.
[141] IEA, *Establishing Multilateral Power Trade in ASEAN,* 2019, page 66.

financial benefits like improved system efficiency, higher utilization of individual resources which might have faced curtailment in a smaller grid, and improved energy security through improving the diversity of energy supply and demand. As Thailand pursues a long-term goal of becoming an electricity hub, policymakers should plan not only for finding markets for excess power but also lay the foundation for Thailand to take advantage of higher amounts of regional variable renewable energy assets.

Because Thai and Vietnamese policymakers should consider coordinating with counterparts in Laos to explore options for a more diversified power mix which includes non-hydropower renewable energy. This would likely require adjustments to the terms of the power purchase agreements to accommodate variable renewable energy, but it would likely have financial benefits. Integrating solar or wind from Laos into the grid could also have benefits in terms of helping balance and stabilize the rising levels of renewable energy penetration coming online domestically by broadening the geographic scope of available renewable energy.

Policymakers in Laos have previously expressed interest in diversifying towards non-hydropower renewables. As early as 2017, officials from the Ministry of Energy and Mines indicated that future exports could be a mix of power depending on which projects move forward on a commercial basis.[142] More recently, policymakers from Electricite du Laos have emphasized that solar and wind could manage seasonal variations in power production and expressed interest in diversifying.[143] Laos has recently signed agreements for new non-hydropower renewable energy projects, including a 1200 MW floating solar projects on the Nam Ngum 1 Dam.[144]

While some of that electricity will be for domestic use during the dry season, Thailand is a sensible external market given that EGAT is already purchasing hydroelectricity from the Nam Ngum 1 project and has commitments to purchase future power from Laos. Initial analysis from outside experts indicates that this and other floating solar projects with backup storage could be feasible at a lower cost per kilowatt-hour than mainstream Mekong dams.[145] Modifying Thailand's PDP2018 to include non-hydropower projects in future imports from Laos would lay a forward-looking foundation for Thailand to be a sustainable and flexible electricity trading hub.

[142] Dr. Daovong PHONEKEO, Comments during Presentation at the Regional Stakeholder Forum on the Council Study and Pak Beng Hydropower Project, February 22-23, 2017.
[143] Asia News Network, "Laos's excess power sparks export drive," *The Phnom Penh Post,* September 23, 2020, accessed September 27, 2020, at https://www.phnompenhpost.com/business/laos-excess-power-sparks-export-drive.
[144] https://www.offshore-energy.biz/pda-for-new-chinese-floating-solar-project-signed/
[145] Long P. Pham, "Can Nam Ngum solar replace hydro in Laos?", *PV Magazine,* November 1, 2019, accessed September 27, 2020, at https://www.pv-magazine.com/2019/11/01/can-nam-ngum-solar-replace-mekong-hydro-in-laos/.

- **Refusing to sign new power purchase agreements for mainstream hydropower dams in Laos would have financial benefits for EGAT and manage risk for the eight Thai provinces which rely on the Mekong River's natural resources.** Thailand has not yet signed a power purchase agreement with the Luang Prabang dam in Laos.[146] Two other mainstream Mekong dams (Pak Lay and Pak Beng) appear to be on hold until power agreements are signed, and the Mekong River Commission consultations for the Sanakham dam are ongoing. All of these projects are intended markets in Thailand, but there is widespread recognition and concern from local Thai communities about the serious negative impacts on the local environment, economy, and livelihoods.[147] This has been recognized by senior officials, with Deputy Prime Minister Prawit Wongsuwon urging Thai government agencies to analyze impacts form the project and identify ways to mitigate potential impacts.[148] Avoiding mainstream dams in favor of alternative energy options would avoid the impacts on sediment, natural water flow, and fisheries altogether.

  In late 2020, public statements from Thailand indicated that for the first time the government may reconsider Thailand's role as an off taker for electricity from mainstream Mekong dams. In November 2020, Thailand's top water official Mr. Somkiat Prajamwong indicated that the Thai government might reconsider buying electricity from the Sanakham Dam and pointed to existing power reserves as part of the rationale.[149] In December 2020 Mr. Somkiat indicated that Thailand would exercise its right under the 1995 Mekong Agreement to halt the project if the government determined that construction would negatively impact Thailand.[150]

  Refusing to sign agreements for the Sanakham and delaying or refusing to sign agreements for other mainstream dam projects leaves an opening in Thailand's plans to purchase electricity from Laos. The most recent PDP 2018 includes plans for additional imports coming from Laos starting in 2025, totaling 3,500 MW by 2037.[151] In light of existing excess capacity and EGAT's announcement that it plans to reduce the reserve margin, there is little urgency to move ahead with new PPAs in the near-term. However, Thai policymakers could work with counterparts in Laos to identify alternatives to the mainstream dams that could be brought on over the coming decade to meet Thailand's needs and interests. This timeframe is feasible to consider substituting projects like the floating solar project on the Nam Ngum 1 Dam which might be more economically and politically attractive.

[146] https://www.mymekong.org/document/จดหมายชี้แจงจากการไฟฟ้า
[147] https://chinadialogue.net/en/energy/thailand-under-pressure-over-sanakham-dam/
[148] https://www.bangkokpost.com/thailand/general/1962023/agencies-told-to-find-ways-to-mitigate-laos-dam-impact
[149] Apinya Wipatayotin, "Govt warns over Lao dam plan," *The Bangkok Post*, November 25, 2020, at https://www.bangkokpost.com/thailand/general/2025023/govt-warns-over-lao-dam-plan.
[150] Apinya Wipatayotin, "Thai govt threatens to veto new Lao dam," *The Bangkok Post*, December 12, 2020, at https://www.bangkokpost.com/thailand/general/2034151/thai-govt-threatens-to-veto-new-lao-dam.
[151] Thailand Ministry of Energy, "Summary of Thailand Power Development Plan 2018-2037," Annex 2, 2.1-1, 2.1-2, and 2.1-3.

- **Prioritize investment towards modernization of the national and regional electricity grid to ensure successful integration of renewable energy.** Investment in new power generation has continuously attracted support from the private sector, but transmission infrastructure needs to be modernized and upgraded in order to support both the new power generation capacity broadly and in particular to incorporate higher levels of renewable energy. The rapid deployment of solar in Vietnam is a great leap forward, but the curtailment of projects due to a lack of sufficient transmission capacity and challenges illuminates the challenges for investors when power generation investment is not matched by parallel investments in transmission and distribution networks. As Thailand and other neighboring countries expand variable renewable energy generation, care should be taken to ensure that the transmission network receives additional priority support to ensure that power generation capacity is not wasted.

  Transmission and grid modernization are also necessary to support higher levels of electricity trade. The sections of this report on electricity trade between Thailand, Malaysia, and Singapore point to the limitations of the existing transmission and interconnection network. Installing higher-rated transmission lines and interconnections will be necessary to support higher levels of electricity trade. Transmission lines transfer electrons and are therefore fuel agnostic, and so further investments in transmission should be matched by soft-side investments in improvements to dispatch, load demand forecasting, and consideration of renewable energy certifications into the electricity trading process.

- **Setting more ambitious official targets and supportive policies for alternative renewable energy technologies in Laos and Myanmar will help both countries diversify smoothly away from overreliance on hydropower and position the Mekong for a more resilient energy future.** Compared to Thailand and Vietnam, Cambodia, Laos, and Myanmar currently all have relatively high dependency on hydropower and relatively low official targets for alternative renewable energy technologies like solar, wind, and biomass. The challenges of depending on hydropower became clear in 2019 due to unreliability during the drought, and Cambodian policymakers have recently stated their intent to bring solar up to 20% of installed capacity by the early-2020s as a result of shocks during the drought. Although this is a new target, Cambodia appears to be on track. Both Laos and Myanmar have increasingly deployed off-grid household-level solar systems to improve electricity access in rural communities,[152] but the national governments have been slow to pursue official policies and targets for grid-connected solar due in part to

[152] World Bank, "Turning on the Lights for 450,000 People in Rural Myanmar," World Bank, July 8, 2020, accessed September 30, 2020, at https://www.worldbank.org/en/news/press-release/2020/07/08/turning-on-the-lights-for-450000-people-in-rural-myanmar.

bureaucratic resistance to unfamiliar technologies and perceptions of uncompetitive costs associated with renewable energy. Despite significant solar potential—approximately 8,000 MW in Laos and up to 35,000 MW in Myanmar—neither country has yet developed significant utility-scale solar resources.

The rapid price drop of solar and wind technologies provides an opportunity for Laos and Myanmar to be more ambitious in diversifying their power mixes without paying higher costs. Both countries have pilot solar projects, and there are a series of policy and regulatory lessons that can be learned from these pilots and from successful deployment in Thailand, Vietnam, and to some degree Cambodia. This report focuses on solar given that high solar radiation makes it feasible to deploy in many locations and there are numerous successful projects in the region—but resources like wind and biomass should also be explored and given policy support considering their significant potential. In addition to setting more ambitious official targets to set a tone, officials in both countries could work to provide policy clarity in terms of standard terms for renewable energy PPAs, clarify and streamline permitting processes, reducing imports on key equipment, and identify and address other policy and regulatory obstacles identified with pilot projects.

The high level of existing and proposed hydropower in both countries makes Laos and Myanmar uniquely suited to consider floating solar and hybrid ground-mount solar/hydropower projects to attain more reliable year-round production. Large-scale projects developed elsewhere in Asia can achieve comparable prices to ground-mount solar if they are larger than 50 MW.[153] There are numerous benefits to floating solar: building on reservoirs avoids high costs and controversies over land use; floating solar panels are more efficient because of cooling from the water below; and they can use existing transmission connections from the hydropower projects.[154] Developing solar and hydropower in close coordination can also help increase the overall reliable capacity across the wet and dry seasons. These projects will be most effective when designed with hybrid operation in mind from early stages of project development instead of adding the solar component as an afterthought. Hybrid development can also be done with micro-hydropower to support mini-grids in rural areas, which would have benefits for Myanmar in terms of avoiding expensive grid buildout.

- **Policymakers in Thailand and Vietnam should consider sharing lessons-learned from integrating rooftop solar technology with neighboring countries. could be an important**

[153] Neil Ford, "Floating solar design gains drive strong growth prospects," *Reuters Events*, July 22, 2020, accessed September 30, 2020, at https://www.reutersevents.com/renewables/pv-insider/floating-solar-design-gains-drive-strong-growth-prospects.
[154] Rina Chandran, "Why floating solar panels are on the rise," World Economic Forum, February 15, 2019, accessed September 30, 2020, at https://www.weforum.org/agenda/2019/02/in-land-scarce-southeast-asia-solar-panels-float-on-water/.

way to continue promoting local resilience and recovery post-pandemic. While utility-scale solar and wind will play a major role in shifting the power mix to be more renewable, both Vietnam and Thailand are pursuing policies to support small-scale deployment of rooftop solar. Vietnam began pilot explorations of rooftop solar in 2019 and by December has deployed more than 50,000 rooftop solar projects with an installed capacity of 1,200 MW.[155] Much of the installed capacity to date is centered in southern Vietnam and is dominated by industrial rooftop solar installations.[156] Vietnam has notably adopted both a feed-in-tariff to support grid-connected rooftop solar as well as policies to support private power purchase agreements between independent generators and purchasers.

In Thailand, rooftop solar has been allowed for many years including for sale back to the grid under the very small power producer scheme, and many of the existing projects around the country are small. Though the government has set up rooftop solar targets of 100 MW, in June 2020 the Thai Minister of Energy noted that this has been reduced to 50 MW total due to limited buy-in from consumers.[157] There may be opportunities for Thailand to learn from Vietnam's relatively successful rollout, but there are clearly lessons which can be gleaned from both experiences. Regional conversation about lessons-learned in deployment of rooftop solar—particularly for industrial zones—could inform recession recovery efforts in industrial and manufacturing sectors in Cambodia and Vietnam, both of which already face strains on the grid and likelihood of supply and demand mismatch once the recession eases and electricity demand surges.

- **As Mekong countries prepare to shift toward widespread electric vehicle deployment, experimenting with demand-side management will help identify ways to manage peak demand**. There has been much written about energy efficiency and demand-side management more broadly, but this becomes increasingly important to consider given that Thailand has taken steps to incentivize electric vehicle investment and deployment. Thai policymakers anticipate significantly raising the number of EVs in Thailand to 1.2 million by 2030.[158] As the number of electric vehicles rises, Thailand will likely experience challenges of demand management. Policymakers now have an opportunity to prioritize trial zones for priority EV deployment in pandemic recovery packages in order to experiment with various demand-side management techniques to figure out how to deploy EVs in a way that does not cause sharp demand rises or disrupt grid stability. Much

[155] Vietnam News Agency, "Vietnam home to nearly 50,000 rooftop solar projects," *Vietnam Investment Review,* December 9, 2020, at https://www.vir.com.vn/vietnam-home-to-nearly-50000-rooftop-solar-projects-79212.html.
[156] PVBox Webinar, "Vietnam Rooftop Solar Market Future Landscape and COVID-19 Reactions," June 4, 2020, at https://www.pv-magazine.com/press-releases/vietnam-rooftop-solar-development-2020/.
[157] Yuthana Praiwan, "Minister seeks solar rooftop revisions," June 30, 2020, at https://www.bangkokpost.com/business/1942988/minister-seeks-solar-rooftop-revisions.
[158] Xinhua, "Thailand to have 1.2 million electric vehicles running in streets by 2030," *Xinhua*, August 18, 2020, accessed September 30, 2020, at http://www.xinhuanet.com/english/2020-08/18/c_139300269.htm.

as Thailand has done for rooftop solar pilot projects, the development of priority zones could support tracking of how EVs impact local electricity demand, household electricity rates, and impact local grid stability.

Thailand is not the only country considering electric vehicle deployment, but its policies are significantly farther along than those of its neighbors and Thailand has the benefit of a pre-existing battery and automobile manufacturing industry. Experimenting with demand-side management now could identify pathways to help manage longer-term grid impacts inside Thailand as the number of EVs rises in the coming decade. Early identification of successful policies would also be something Thailand could bring to its neighbors, which could provide Thailand with a leading role ushering in electric transportation around ASEAN. There would also be non-transport benefits: successful integration of EVs would increase electricity demand both domestically and in neighboring countries, which could help create a market to absorb some of the medium-term excess electricity that Thailand seeks to shed. Thailand's early adoption of EVs and domestic manufacturing capacity also positions it well to export EVs as a regional market develops.

For Development Partners:

- **The Japan – U.S. Mekong Power Partnership (JUMPP) should consider providing assistance on exploring a cross-border clean energy plan with Mekong countries in support of Thailand's stated goal of becoming an electricity hub and supporting further diversification of Laos's electricity exports to Thailand, Vietnam, and Cambodia.** The United States and Japan have both individually been active on energy issues for many years in the Mekong region through programs such as USAID Clean Power Asia and capacity-building projects for regional ministries run through the Japan International Cooperation Agency. However, in 2019 the US and Japan jointly identified regional energy integration and cross-border power trade as priority areas and founded JUMPP to provide collaborative assistance, including a particular focus on the enhanced deployment of wind, solar, and other advanced power technologies for diversification.[159] While Thailand and Laos must each make sovereign national decisions about electricity development, coordinating on how to develop alternative solar and wind projects on a regional basis could have long-term benefits for both countries. The US and Japanese national experiences managing power trade across different utilities with rising levels of renewable energy would prove useful in this context. Such activities would build on work done under the first year of JUMPP with EGAT and with regional utilities and regulators.

[159] Office of the Spokesperson, *Japan-U.S. Joint Ministerial Statement on Japan- U.S. Mekong Power Partnership (JUMPP),* U.S. Department of State, September 8, 2020, accessed September 27, 2020, at https://www.state.gov/japan-u-s-joint-ministerial-statement-on-japan-u-s-mekong-power-partnership-jumpp/.

- **The US and Japan should prioritize infrastructure funding from the U.S. Development Finance Corporation and Japan Bank for International Cooperation towards power generation and transmission projects in cross-border clean energy zones**. The Japan-U.S. Mekong Power Partnership (JUMPP) was only launched in 2019, but it has already prioritized technical assistance projects which support regional energy integration, cross-border power trade, higher deployment of advanced energy technologies, and a multi-sector nexus approach to planning which can help avoid or mitigate impacts of energy projects.[160] The opportunities identified through these technical assistance projects supporting these efforts could be used to help inform investments from Japan and the United States, as well as other like-minded development partners who prioritize the renewable energy transition and protection of environmental flows in the Mekong region. Identifying cross-border clean energy zones—such as the 3S Basin in Cambodia, Laos, and Vietnam, which has significant solar and wind potential as well as a series of planned hydropower projects—would provide priority areas for strategic investment to help support the renewable energy transition while protecting key river flows. Such a zone would fit into the JUMPP framework, could fit into the Thai-led ACMECS framework, and could act as a high-profile example of what high-quality infrastructure can look like.

- **Share lessons learned from experiences integrating utility-scale and distributed battery storage with policymakers in the Mekong region.** Apart from concerns over cost, the greatest obstacle surrounding widespread deployment of renewable energy is its variability. As the price of battery storage continues to drop, it will be crucial for international partners to share their own successes and challenges in deploying battery storage with policymakers in Southeast Asia. Sharing these case studies and policy lessons-learned will help build confidence in the technology and the grid's ability to utilize it effectively. Australia's 100 MW Hornsdale Power Reserve, which uses Tesla lithium-ion batteries, has played a key role improving grid stability and avoiding blackouts in South Australia. It saved $40 million in grid operation costs during its first year of operation,[161] and battery's critical supportive role when part of the electricity grid went down due to a massive storm has made it a commercial success only three years after its construction.[162] India has held multiple auctions for round-the-clock capacity, essentially requiring that projects incorporate battery storage or backup supply to ensure that the resulting power is dispatchable. While these contracts as written have ultimately been amended not to

[160] Office of the Spokesperson, "Japan-U.S. Joint Ministerial Statement on Japan-U.S. Mekong Power Partnership (JUMPP), U.S. Department of State, September 8, 2020, accessed September 30, 2020, at https://www.state.gov/japan-u-s-joint-ministerial-statement-on-japan-u-s-mekong-power-partnership-jumpp/.

[161] Marija Maisch, "South Australia's Tesla big battery saves $40 million in grid stabilization costs," *PV Magazine,* December 6, 2018, accessed September 30, 2020, at https://www.pv-magazine-australia.com/2018/12/06/south-australias-tesla-big-battery-saves-40-million-in-grid-stabilization-costs/.

[162] Giles Parkinson, "Tesla big battery in South Australia delivers stunning windfall profits," *Renew Economy*, September 24, 2020, accessed September 30, 2020, at https://reneweconomy.com.au/tesla-big-battery-in-south-australia-delivers-stunning-windfall-profits-77644/.

require 24-hour dispatchable power due to challenges with implementation, they are a step towards developing a hybrid solar/battery model as prices drop.[163]

Sharing details of these positive experiences as well as some of the challenges from deployment and management of battery storage globally could help Thai grid operators as they consider grid-scale storage in coming years. Battery storage is also highly valuable at the building or household level because it can store electricity from rooftop solar and reduce that unit's demand on the local electricity grid during times of peak demand.

- **Share lessons-learned with household and industrial level rooftop-solar deployment with policymakers across the Mekong region.** Thailand is one of few countries in the region which has built rooftop solar into its power plans in recent years, although critics have pointed out that incentives were not strong enough to support widespread adoption.[164] Cambodian utilities have historically disallowed it, although there have been limited allowances for industrial consumers in the last few years. Utilities around the region are understandably concerned about the impact that rooftop solar could have on the grid as well as on their revenues, given that this has posed a challenge to developed countries as well. However, strategic deployment of rooftop solar in Cambodia, Laos, and Myanmar would help ease peak demand and perhaps reduce instances of brownouts and blackouts due to electricity shortages. This is particularly true for commercial and industrial consumers, for whom rooftop solar can help to ease daytime power demand and reduce electricity bills. The Chip Mong Insee Cement Corporation is one of few companies in Cambodia to pioneer a direct power purchase rooftop solar model, partnering with Cleantech Solar to build a 9.8 MW rooftop and floating solar system to reduce operating costs, reduce carbon footprint, and ultimately improve competitiveness.[165] Numerous industrial zones in Vietnam have also deployed rooftop solar for similar reasons. Sharing case studies, successful policies, and management lessons learned from experiences deploying household or building-level in the United States, Germany, and other countries could help build a path to scale up roof-top solar deployment around the region.

[163] Nihar Gokhale, "Is India's first round-the-clock renewable energy contract really what it claims to be?" *Mongabay*, August 4, 2020, accessed June 4, 2021, at https://india.mongabay.com/2020/08/is-indias-first-round-the-clock-renewable-energy-contract-really-what-it-claims-to-be/.

[164] Yuthana Praiwan, "Minister seeks solar rooftop revisions," *The Bangkok Post,* June 30, 2020, accessed September 30, 2020, at https://www.bangkokpost.com/business/1942988/minister-seeks-solar-rooftop-revisions.

[165] "Chip Mong Insee Cement Corp opens 9.8 MW solar power plant," *Cement News*, February 26, 2019, accessed June 4, 2021, at https://www.cemnet.com/News/story/165994/chip-mong-insee-cement-corp-opens-9-8mw-solar-power-plant.html.