

Letters from the MEKONG

MEKONG POWER SHIFT: EMERGING TRENDS
IN THE GMS POWER SECTOR

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Lower Sesan 2 Dam under construction in Cambodia.

EXECUTIVE SUMMARY

This issue brief, the fourth in Stimson’s “Letters from the Mekong” series, explores the shifting terrain for power sector development in the Greater Mekong Subregion (GMS), analyzing hydropower within the context of a broader range of emerging factors and opportunities that could lead to a transformation in the way that Mekong countries approach energy security, regional electricity trade, and sustainable development. This transition, if effectively implemented, could lead to substantive economic gains and significantly reduce ecological, socioeconomic, and political risks in the Mekong Basin.

In the coming years, new GMS hydropower projects will be competing with ever-cheaper options, including both more competitive natural gas prices as well as increasingly affordable and efficient solar and wind technologies. To provide perspective, in the United States the average cost per unit for solar and wind fell 85% and 65% respectively between 2009 and 2016. Between 2015-2016 alone, the global average price of solar dropped 13% and wind dropped 10.75%. In 2016, the record low price for solar power production was broken three times with a solar farm in Abu Dhabi taking the record in September at US\$0.0242 c/kWh. Prices for non-hydropower renewables are falling at a rate far faster than anticipated.

There is growing anecdotal evidence that GMS hydropower projects currently in the pre-feasibility study phase will be less economically competitive in the long-run. The price point of Mekong basin hydropower is changing: while authorities in Laos and Cambodia often suggest that hydropower is cheap at a price of US\$ 0.06 to 0.07 c/kWh, the reality is that new projects will likely be more expensive. Lower Sesan 2 in Cambodia sells at US\$ 0.091 c/kWh, and new projects in Laos around US\$ 0.08 c/kWh. New projects are often more remote and technically challenging, and therefore require additional transmission line buildout as well as better and more expensive mitigation due to rising standards from investors and increasing regulatory control.

Other factors suggest a coming sea change in GMS energy planning. Rising recognition of climate change impacts, Mekong countries’ commitments under the Paris Agreement, and rising environmental movements all pose a challenge to the status quo dominance of coal and hydropower. The recent suspension of hydropower projects in Myanmar, coal projects in Thailand, and nuclear projects in Vietnam are early signals that the traditional approach to energy sector planning is growing riskier. The market itself is also changing as regional electricity infrastructure is slowly built out and cross-border electricity trade increases. Myanmar and China will also likely emerge as robust net power exporters in the region. Myanmar has five times the hydropower potential as Laos and could emerge as a power trade hub for both Southeast and South Asia. China’s current excess hydropower capacity in Yunnan province is more than the combined current installed hydropower capacity of the rest of the GMS, and China’s grid operators are looking for ways to export this power to GMS markets.

The region can reap substantive efficiency gains from robust power trade, but exporting excess power capacity from Yunnan to markets in Bangkok, Ho Chi Minh City, or Phnom Penh could also deliver sustainability benefits by reducing the need for future dams in the Lower Mekong in the medium and long term. Additionally, non-hydropower renewables can be plugged into the regional power market to tamp down excessive power reserve requirements persistent throughout the GMS. The promotion of energy

interdependence and GMS power trade has long been scoped by the Asian Development Bank (ADB), which estimated in 2010 that the economic and environmental benefits of regional energy integration would deliver savings of 19% of total energy consumption, approximately \$200bn. The savings resulting from interconnecting existing GMS power systems alone are estimated at \$14.3bn.¹ This study was conducted without consideration of the renewable energy revolution occurring today, which suggests even more savings and efficiency gains are within reach. New innovations in high-voltage transmission and distributed power generation could pave the way to this transition, and the ADB or China's new Asian Infrastructure Investment Bank could serve as catalytic actors bring an integrated GMS power market to light.

Our team's extensive engagement and analysis with policy-makers, project developers, investors, academic experts, and civil society groups have revealed continuously rising political risks and economic costs to traditional infrastructure approaches. Today, the renewable energy transition and regional power market development are changing the global power landscape at a rapid rate. However, few governments in the Mekong basin are seriously considering these emerging opportunities or the ways that supply and demand shifts may impact the national electricity market. National power plans continue to be built around traditional models of point-to-point production and transmission from large, centralized coal and hydropower projects. This cuts both ways; demand-centers like Thailand and Vietnam fail to recognize the potential for efficiency, emissions, and cost savings through increasing electricity trade. On the other side, countries like Laos which predicate electricity sector development on their ability to export the electricity find themselves no longer competitive against cheaper imports from China or Myanmar or against increasingly cheap renewable energy in a diversified market where supply outstrips demand.

There are significant opportunities for Mekong countries to leapfrog and ensure that future energy mixes and grid operations take advantage of emerging technologies and dynamism in the global electricity market. A transition to a more flexible approach that incorporates emerging renewable technology and innovations in power transmission models could produce more power with fewer and less impactful dams on a regional scale. Overcoming structural obstacles in energy planning--including adjustments to national legal frameworks as well as often opaque and behind-the-scenes processes for decision-making--will take time, but it is vital that GMS countries consider first-steps to support adoption of emerging technologies. Failing to consider these shifts now will lock Mekong countries into a less than optimal development path that will damage food and water security for the region and require significant adaptation costs down the road.

A SHIFTING LANDSCAPE FOR THE POWER SECTOR IN THE GREATER MEKONG SUBREGION

Energy supply and demand is a moving target in most of the fast-developing economies in the Greater Mekong Subregion (GMS), an area formed of the Mekong Basin countries of Cambodia, Laos, Myanmar, Thailand, Vietnam, and China's Yunnan and Guangxi provinces. This dynamism requires updating power plans on a semi-regular basis to consider how to respond to changes in government priorities, market shifts, and the rate and location of demand growth. All GMS countries, with the exception of Laos, have conducted formal review of their power development plans in recent years. Thailand released a new Power Development Plan in 2015 with plans for updates again in 2017-2018. Vietnam revised its Power Development Plan VII in 2016. Cambodia's Ministry of Mines and Energy aims to formally approve an updated Master Energy Plan in early 2017. Myanmar released a draft Energy Master Plan in December 2015 which is continuing to undergo updates and revisions. China has most recently updated its plans and goals in its 2015 Five Year Plan.

However, many of the assumptions underpinning these recent plans are questionable and subject to change. For instance, most mainland Southeast Asian planners assume the coal, wind, and solar prices will not significantly change in the coming years. Also, GMS countries including China plan to expand coal fire, hydropower, and nuclear capacity despite mounting public resistance over safety risks and environmental impacts. Finally, most GMS countries assume climate change will not significantly impact the power sector in the near to medium term.

Globally, the metrics used to determine optimal energy mixes and inform energy planning are changing in response to significant and rapid advances in technology, production costs, and growing accounting of the value of environmental and social externalities. This in turn has led to a drop in the costs for non-hydropower renewables as compared to hydropower and traditional fossil fuels. However, the subsidization of power markets, a lack of human and technical capacity for long-term planning, and tensions between national plans and local interests stymie the ability of most GMS governments to adapt to changing circumstances. GMS countries are missing significant opportunities and cost savings by failing to account for such changes in their planning processes and continue to pursue outdated development pathways for their power sectors.

GMS countries appear to be overlooking four major trends in their current power planning processes:

1. **Globally, the price of non-hydropower renewables is dropping more quickly than anticipated, making these sources of power generation more competitive than traditional resources like large-scale hydropower and fossil fuels.** Globally, solar and wind prices reached record-setting lows in 2016. In the United States, prices for solar and wind dropped approximately 85% and 66% respectively since 2009.² China's economy of scale and significant investments in and export of solar and wind technologies have played key roles in the sudden price drop. This global price drop has made solar and wind the most competitive new power source in some locations, and many estimates predict that rates could drop an additional 59% through 2025, making solar and wind the

cheapest option in many markets globally.³ If rates continue to drop as predicted, investor interest and market share of solar and wind production will likely increase considerably, particularly in countries that utilize competitive pricing as determining factors for building new power plants. This could disrupt current energy mix predictions and plans in the GMS, where countries by and large utilize historical pricing data to consider various scenarios.

2. **GMS countries which once were net power importers or power neutral, namely China, Myanmar, and even Cambodia, will likely shift to net-exporters as they significantly increase domestic capacity.** China has historically been a net-importer of power, which drove Chinese investment in hydropower projects in Myanmar and northern Laos. Over the last decade, a wave of domestic investment in hydropower, solar, wind, and nuclear has erased the need for power imports from abroad. The shift is so drastic that much of the recently built power capacity in China's southwestern provinces is already underutilized due to grid congestion and competition between localities.⁴ China's state owned power distributors are exploring the possibility of exporting overcapacity to demand centers in Southeast Asia.⁵ While Myanmar and Cambodia will both continue to import significant amounts of electricity in the short-term due to a lack of energy infrastructure, both have the potential to build out power generation capacities which will exceed domestic needs. This is particularly true in resource rich Myanmar. These shifts, likely in the short term for China and in the long-term for Myanmar and Cambodia, will impact dynamics of regional power trade and have implications for broader regional relations.
3. **Fossil fuel and hydropower externalities such as air pollution, climate change effects, the reduction of critical environmental flows, and a range of social impacts produce political pressure, increasingly forcing changes in the type, location, and size of new power plants.** Environmentalism is on the rise globally. This is reflected through countries' commitments to emissions reductions under the Paris Agreement, but equally impactful are the private sector's reductions in response to cost savings and increasing domestic political pressure in many countries to address air, water, and soil pollution. Governments in the GMS are facing constraints from both sources. All of them have agreed to reduce emissions from a business-as-usual scenario under Nationally Determined Contributions (NDCs) for the Paris Agreement, with most committing to raise the amount of renewable energy in their portfolios. Domestic protests against environmentally risky projects are also on the rise, and hydropower and coal have faced increasing public pushback throughout the region. The suspension of hydropower projects in Myanmar, coal projects in Thailand, and nuclear projects in Vietnam are case studies for what happens when externalities are not considered. In the long-run, public pushback against individual projects will likely alter the overall energy mix.
4. **Innovations in energy transmission and distributed grid structures are disrupting traditional infrastructure and utilities models, both globally and in the GMS.** Ultra-high voltage lines improve the efficiency of long-distance transmission when power sources are located far from demand centers, improving the economics behind long-distance transmission and regional electricity trading. This supports the traditional utilities model, but at the same time smart grid



Electricity transmission lines in Laos.

technology has become relatively economical and offers significant improvements on supply-demand management on a real-time scale. Smart-metering also supports distributed generation such as rooftop solar, which can be used not only in urban areas to feed into the grid and meet local demand but also facilitate the build-out of micro-grids in areas far from existing transmission infrastructure. The evolution of smart metering and battery storage is disrupting the existing transmission model and will eventually replace traditional hub-and-spoke transmission and distribution mechanisms and lead to a more interconnected, flexible grid with long-distance transmission helping to meet demand in high-load centers.

Eventually, the region will recognize and begin to react to these emerging trends. However, current developments in the Mekong basin hydropower sector make exploration of these opportunities more necessary and time-sensitive. Stimson's previous research demonstrates that the rate at which agreements are signed for new hydropower projects in the Mekong basin is slowing due to rising costs and risks. However, the existing trajectory for damming the Lower Mekong mainstream and tributaries in Laos and Cambodia will likely severely increase risks to food and water security in the region at large.⁶

In November 2016 the government of Laos officially notified the Mekong River Commission (MRC) of their plans for the Pak Beng Dam, which will be the third project on the mainstream of the lower Mekong when construction begins.⁷ In 2017, the controversial Lower Sesan 2 Dam—built in Cambodia on a critical Mekong tributary—will come online. The Lower Sesan 2 is predicted to reduce the volume of migratory fish in the Mekong basin by 9.3% alone.⁸ While Cambodia's Ministry of Mines and Energy has yet to move forward with a formal Memorandum of Understanding, the well-connected Royal Group has been given tentative approval by Prime Minister Hun Sen's cabinet to do feasibility studies for the Stung Treng and Sambor project, proposed projects for the mainstream of the Mekong in Cambodia.⁹ While neither is likely to move ahead before 2020, both are predicted to have devastating impacts on Mekong fisheries and sediment distribution due to their proximity to Cambodia's Tonle Sap lake and Vietnam's Mekong Delta.¹⁰

Within this context, incorporation of these broader energy sector trends into existing planning processes could transition the region away from path dependency on damaging hydropower and toward a more sustainable and energy secure future.

GMS POWER PROFILES

This section briefly profiles the current power mix, drivers of current plans, and challenges to the status quo for power planning in each GMS country. The first profile is of Laos, which seeks to become the “Battery of Southeast Asia” through exporting hydro-power to neighboring countries. Despite policies supporting the buildout for export, we conclude Laos’s export potential could be crowded out by China, the second country profiled, which increasingly is setting its sights on exporting overcapacity from Yunnan to demand centers in Southeast Asia. Next are Myanmar and Cambodia, which have relatively low levels of installed capacity and unmet demand but could transition into net energy exporters in the long term given their wealth of energy resources. Last are profiles of Thailand and Vietnam, which already have high levels of electrification but face rising demand and limited domestically available resources, making them net power importers for the foreseeable future.



GMS Crossborder Power Transmission. Asian Development Bank. *Greater Mekong Subregion Atlas of the Environment (2nd Edition)*.

Lao PDR

CURRENT POWER MIX

Laos has a wealth of power generation resources, with an estimated 18 GW of technically exploitable hydropower potential, 8.8 GW of solar potential, and 2.8 GW of high quality wind potential. The country has also begun to tap into its relatively low level of coal reserves, with a 1,878 MW coal plant already developed in Hong Sa and additional plants under discussion. However, in 2016 the amount of installed capacity was only 6,258.95 MW, with plans to start construction of 55 more hydropower, biomass, and coal projects by 2020 that will produce an additional 4,130 MW.¹¹

Despite the abundance of potential power generating resources, electricity consumption is still quite limited, making up only 12% of the total national energy consumption. This is largely due to its low level of economic development and accompanying low demand levels. Approximately 23% of Laos's 7.1 million people live below the government-identified poverty line and the current level

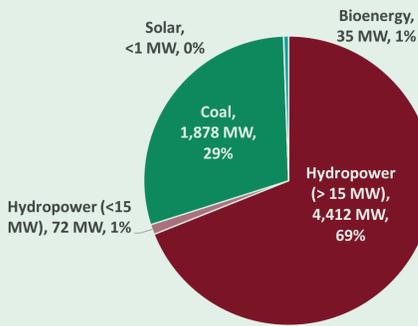
of industrial development is limited by Lao's geography and low productivity levels.¹² Laos has made rapid progress on household electrification rates rising from approximately 15% household electrification in 1995 to 87% in 2015, putting it on track to meet the goal of 90% electrification by 2020.¹³ However, in rural areas electricity is still quite limited and often erratic, and biomass sources of wood and charcoal are still used for approximately 69% of the country's total energy consumption.

As of 2013, the country's per-capita annual electricity consumption was 500 kWh/year.¹⁴ Compared to per-capita electricity usage of 1,306 kWh in Vietnam, 2,472 in Thailand, and 3,762 in China, Laos's consumption is magnitudes lower than most of its neighbors.¹⁵ Laos remains one of the world's fastest developing economies, with an average growth above 7% over the last decade, and has significant potential for growth in both domestic household and industrial electricity consumption rates. Even accounting for projected 8 to 10% annual electricity demand growth, Laos has more than enough power resources to meet domestic demand and export its surplus.¹⁶

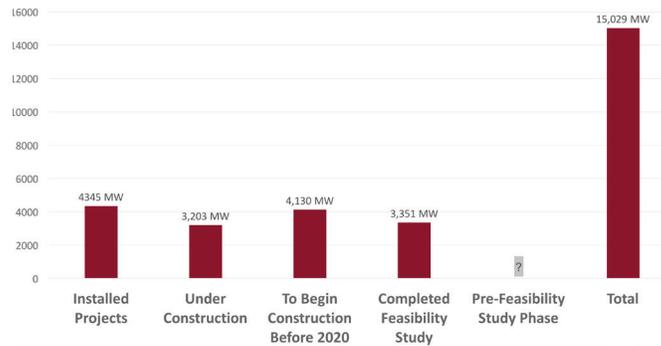
PLANS FOR THE FUTURE

A stated goal of the government of Laos is to reduce poverty and graduate from Least Developed Country status by 2020. The rapid development of hydropower has therefore been driven not by domestic needs but rather by the government's plan to promote national development through the sale of hydro-electricity to consumer markets in neighboring countries. From the beginning of national electrification in the 1970s, most electricity produced in Laos was for export. Even in 1992, 75-80% of the total electricity generated in Laos—at the time only 212 MW—was being exported to the Thai grid.¹⁷ Power export revenues have contributed significantly to the build-out to Laos's production capacity of 6,218 MW by the close of 2016.¹⁸ As of 2017, the government of Laos has signed bilateral MOUs to supply 9,000 MW of electricity to Thailand by 2025, 5,000 MW to Vietnam by 2030, and 1,500 MW to Cambodia by 2025.¹⁹ If Laos does not shift from its business as usual model, most of this power will be generated from more than one hundred large-scale dams in Laos's portion of the Mekong basin. Currently Laos has constructed roughly 30% of its potential hydropower capacity.

Lao PDR On-Grid Electricity Production by Type in 2015



Data on total installed capacity as of 2016 drawn from list of projects on Lao PDR Ministry of Energy and Mines site, updated June 30, 2016, downloadable at http://www.laoenergy.la/download_free.php. Information on solar and bio-energy is taken from the 8th Five Year Plan, p. 20 - 21.

Summary Data for Lao Dams (>15 MW)

Ministry of Planning and Investment of Lao PDR, 8th Five-Year National Socio-Economic Development Plan (2016-2020), p. 20-21. Note that the Plan appears to include Hongsa Lignite Power Plant and two bioenergy plants alongside the hydro—the figure for this chart subtracts those three projects.

CHALLENGES AND POTENTIAL SHIFTS

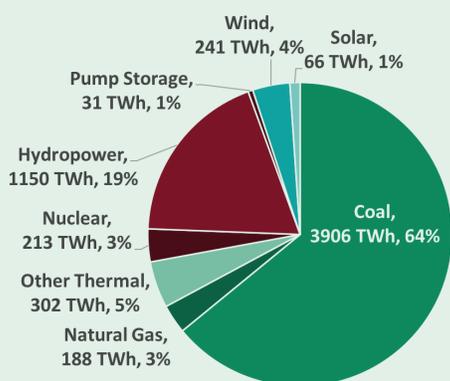
Laos faces two related energy challenges. First, a lack of available financial resources largely leaves Laos at the mercy of investor interest in individual projects. Most projects follow the build-own-operate-transfer (BOOT) model, under which Laos gains initial benefits through land concessions, taxes, and a small share of export revenues, but projects are owned and managed for between 25 and 30 years by the investor, during which time the profits go to the owners. Project ownership will transfer to Laos after the concession ends, by which time the dam may require extensive refurbishing and maintenance. Power purchase agreements with neighboring countries are the vehicle through which investors can ensure profitability, and the price and profit margin are key factors in deciding which projects move forward. In most cases, projects are large power plants which send the vast majority of power directly across the border to Thailand.

This has led to a second challenge. Reliance on the BOOT model has not allowed the government to plan national electricity production goals or transmission build-out in a strategic manner. Because the government relies on investor interest to drive development and investors are primarily interested in projects for export, the government has limited ability to prioritize projects and coordinate development. Thus far, the government of Laos has not developed an integrated power development plan that strategically lays out goals and targets for total electricity production and energy mix. The focus on exports has also prevented buildout of a strong and flexible national grid, as most large projects feed power directly across the border to Thailand rather than supporting domestic needs. Equally important, concerns over the ability of non-hydro renewable energy to ensure that Laos can reliably meet its export commitments have prejudiced planners towards technologies with tested track records like large-scale coal and hydropower projects rather than wind and solar projects, despite the fact that these sources are increasingly economical.

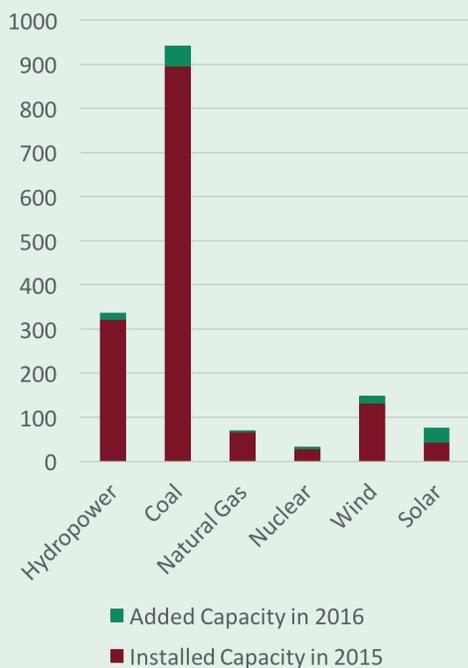
The terms of power supply contracts are still being negotiated. Permanent Secretary Daovong Phonekeo of the Ministry of Energy and Mines indicates that—price permitting—the future supply for export would likely be a mix of inputs that includes wind, solar, and coal as well as hydropower.²⁰ Off-grid solar is already common in rural villages, and the government of Laos has a 10 MW commercial-scale pilot solar project under construction with an additional 90 MW of potential solar project in the works.²¹ A Thai investment firm has already started construction on a planned 600 MW wind plant in three southern provinces.²² If these investments prove profitable, solar and wind will likely take off quickly.

China

China Power Consumption in 2016



China Installed Generating Capacity in GW



Data taken from Simon Goess. "Power statistics China 2016: Huge growth of renewables amidst thermal-based generation." CEE News. February 9, 2017. <http://ceenews.info/en/power-statistics-china-2016-huge-growth-of-renewables-amidst-thermal-based-generation/>.

CURRENT POWER MIX

China is the world's largest producer and consumer of electricity. In 2016 China's total installed capacity grew to 1646 GW, compared to the US installed capacity of just over 1000 GW.²³ China already has the world's largest installed capacity in coal (920 GW), hydropower (332 GW), wind (149 GW), and solar (77 GW). As China's economy transitions from a thirty-year high-growth phase to a slower and more sustainable model, energy demand growth is slowing. China has achieved significant gains in energy efficiency, mostly resulting from state-directed policy initiatives that are restructuring the economy away from investment-led growth. To illustrate, China's economy is projected to grow at 5% between 2015 and 2035, but overall energy demand growth will fall below 3%.²⁴ Complementary to this trend, China's energy intensity is in sharp decline and almost on par with developed countries. Because of impressive gains delivered by a significant expansion of domestically-produced solar, wind, and hydropower, China no longer relies on importing power from neighboring countries. As China transitions away from an overreliance on coal-fired power to further expansion of renewable energy resources, it still faces underlying structural challenges to usher in more efficient utilization of its renewable capacity.

PLANS FOR THE FUTURE

China is the world's largest producer, importer, and consumer of coal and will continue to hold these titles throughout most of the 21st century. This also makes China the world's largest current and future carbon emitter. In response to deteriorating air quality pervading most of the country and China's growing carbon footprint, the Chinese government has policies in place to support a long-term transition towards renewable energy and has stepped up as a global leader in efforts to curb climate emissions. China's major commitment in this context is to peak its greenhouse gas emissions by 2030, which will require substituting renewables for some of the additional coal that would otherwise be built under a business as usual scenario. Achieving that peak at a sooner date is dependent on how quickly the Chinese economy can restructure, emerging innovations in renewable technology, and the ability of China to better integrate those innovations into its power market. China's 13th five year plan targets coal's share of total energy consumption will fall from 68% in 2015 to just under 60% in 2020.²⁵

China's energy consumption will double between 2015 and 2040 from 5500 TWh to 11,000 TWh respectively.²⁶ Wind, so-

lar, nuclear, and gas fire power will each have a five-fold increase of capacity during this period. Hydropower could nearly double to 540 GW, but increasingly recognized environmental and social risks will likely curb this growth. However, coal capacity too will grow: China's 13th five-year plan requires construction of an increase of an additional 90 GW coal capacity between 2015 and 2020 bringing the total installed coal capacity to 1100 GW.

Renewables will occupy the most significant chunk of this energy expansion. China invested more than \$100bn in renewable energy (including large hydropower) between 2014 and 2016. In 2016 alone China added 64 GW of renewable energy: 12 GW of hydropower, 18 GW of wind, and 34 GW of solar. To put this into perspective, no mainland Southeast Asian country currently has a total installed capacity of 64 GW. Impressively, 25% of China's energy consumption came from renewables in 2016: most from hydropower, 4% from wind, and approximately 1% from solar.²⁷

CHALLENGES AND POTENTIAL SHIFTS

Despite the impressive buildup of China's power resources, much of China's existing capacity is underutilized. Wind is currently curtailed at a national average rate of 15%.²⁸ Yunnan exports much of its hydropower to Guangzhou through world class ultra-high voltage transmission lines, but in 2015 Yunnan's hydropower fleet wasted 95 TWh of electricity due to a lack of demand. For context, this is nearly as much as the total hydropower consumption of mainland Southeast Asia at 105 TWh.²⁹ China's current feed-in tariff structure, guaranteed operating hours for coal plants, provincial-level authority in determining dispatch priorities, and the lack of a spot power market to immediately match excess capacity with buyers discourages the dispatch of renewable energy.³⁰ 2016 energy sector reforms and pilot programs modelled in northern China to better integrate renewables suggest that overcoming these structural difficulties is only a matter of time.³¹

Grid congestion and inter-provincial competition also curb utilization of Yunnan's power. In China's developed coastal zone, provincial decision-making authorities strongly favor power produced locally over that imported from other provinces. Coal fire plants in Guangzhou employ far more workers than dams in China's southwest, and these jobs are important for meeting local employment needs. Coal is also widely viewed as the most reliable source of power generation. Renewables are intermittent, and even hydropower is subject to seasonal fluctuations. Nuclear plants currently under construction in local coastal areas will compete with far-flung hydropower in the future and will similarly receive prioritization from local consumption markets. As a result, grid operators and hydropower developers are looking for ways to export excess capacity to markets abroad and have set their sights on the GMS power market.

China's hydropower developers have long viewed the rivers of mainland Southeast Asia as potential power sources to feed China's growing economy. However, since supply currently outstrips domestic power demand in southwest China, these developers now seek to export their expertise and China's excess capacity in steel and other commodities to build dams abroad. The same can be said for Chinese expertise in coal, nuclear, solar, and wind projects. Regional frameworks such as the Belt and Road Initiative and the Lancang-Mekong Cooperation Mechanism promote Chinese investment in mainland Southeast Asia's energy sector. At the same time China's debt exposure means banks increasingly favor loans to commercially viable projects and more stringently assess project risk. The current perception among Chinese energy firms is that the number of commercially viable hydropower investment projects in mainland Southeast Asia is limited.³²

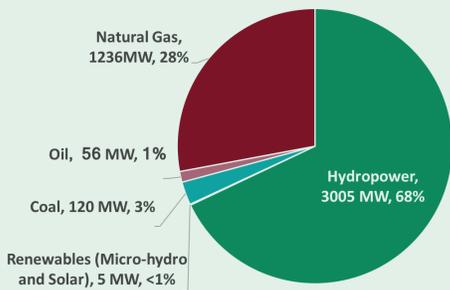
Myanmar

CURRENT POWER MIX

Myanmar's level of electrification is the lowest in the region, and only approximately 30% of its 53 million people have reliable access to electricity.³³ The vast majority of Myanmar's total energy consumption in 2015—approximately 62%—was provided by biomass (fuelwood and charcoal), with electricity providing only 6.7%.³⁴ The primary reason for this is not a lack of resources but rather a lack of investment and transmission connectivity. Myanmar has approximately 100,000 MW of potential hydropower resources, 4,000 MW of wind potential, several thousand MW of commercial-scale solar PV potential (estimates start around 40 TWh/year), and significant on and offshore oil and gas reserves.³⁵

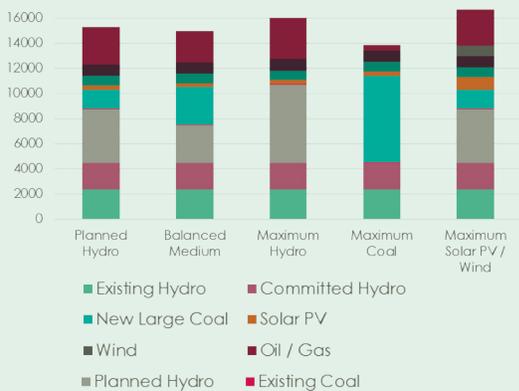
Long-term political and economic instability caused by ethnic conflict, military coups, the nationalization of private industry, and Western sanctions has historically heightened the risk of doing business and effectively limited foreign direct investment in domestic generation and transmission. Prior to 2011, Myanmar's authoritarian regime viewed rural electrification as a low priority, so most access is concentrated in urban areas where elites live. As of 2014, Myanmar's installed capacity was only 4,422 MW and dominated by hydropower and supplemented by natural gas, coal, and oil.³⁶ Some of this is exported directly across the border to Thailand and China, and due to the region's monsoon climate, much of the hydropower is only available seasonally. As a result, regular shortages during peak load times cause frequent blackouts even as electricity consumption is limited to 2500 MW a day.³⁷ To compensate, many rural households rely on diesel generators, and even urban areas use diesel as a backup.

Myanmar's Installed Capacity By Type (2014) Amount (in MW)



Nam, Cham, and Haili, p. 9

Myanmar's Installed Capacity in 2030 by Scenario



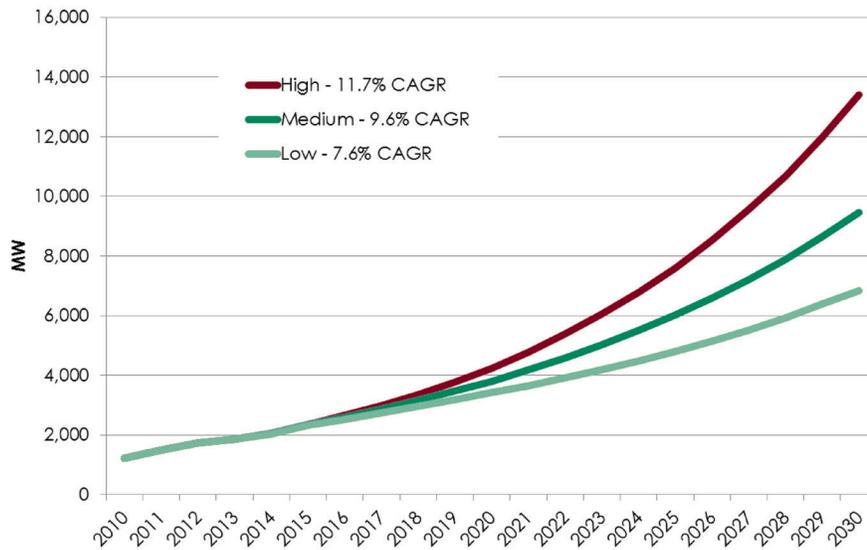
Myanmar Energy Master Plan, p. 494.

PLANS FOR THE FUTURE

Myanmar's electricity demand rose 15% annually from 2009 to 2014, and high growth rates are anticipated to continue into the future.³⁸ Myanmar's Energy Master Plan includes three potential trajectories for energy demand growth: low, medium, and high, with high growth predictions estimating that demand could almost double to 4,500 MW by 2020 and rise to 13,410 MW by 2030.³⁹ Much of the demand growth will be due to rising living standards in urban areas, but power grid expansion into rural areas will also play a key role. Myanmar has set an ambitious target of universal electricity access by 2030, through both expansion of the national grid and provision of off-grid solutions to remote areas.

As of 2015, the government's Energy Master Plan explored five different scenarios for meeting electricity needs: a base scenario, which includes all existing and committed projects with heavy coal buildout after 2026 and indicates Myanmar's current trajectory; a balanced scenario, which seeks to eliminate some proposed hydropower and replace it

Myanmar On-Grid Electricity Demand Forecast to 2030



Myanmar Energy Master Plan, p. 630.

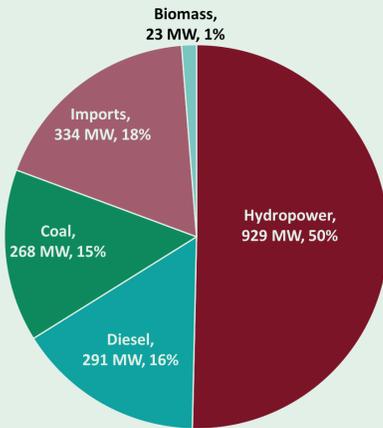
with solar PV and coal plants; and then three scenarios which respectively maximize hydropower, coal, and solar PV/wind.⁴⁰ The initial report indicated the balanced scenario is optimal across a range of criteria including CO₂ emissions, levelized cost of electricity,⁴¹ diversity of resources, and risk.⁴²

It is not yet clear which development pathway Myanmar will pursue, as these plans have undergone ongoing edits since the initial report was produced in 2015. No final public report has been released, and public debate over the merits of various options have continued. At the same time, numerous contracts have been signed to address short-term demand via fast deployment of solar, including a 150 MW plant, a 220 MW plant, and a potential 300 MW plant.⁴³ If power export is prioritized in addition to rural electrification, Myanmar could leverage its abundant power producing resources to become a significant power exporter to both Southeast Asian and South Asian markets.

CHALLENGES AND POTENTIAL SHIFTS

Myanmar's new democratically elected government led by the National League for Democracy is facing dual pressures to rapidly address gaps in the generation capacity while also dealing with controversy over many proposed hydropower and coal projects previously developed under the military junta without adequate consultation with affected communities or consideration of social and environmental impacts.⁴⁴ The government plans for regulatory changes that would increase opportunity for private-sector and foreign investment in the power sector and require reassessment of the regional and national master energy plans.⁴⁵ And Myanmar has various plans from which to draw reference: its Energy Master Plan appears to be the most comprehensive, but the Japan International Cooperation Agency (JICA) also supported an alternative analysis that recommended pursuing "clean" coal-fired power plants,⁴⁶ and there is an ongoing Strategic Environmental Assessment to support a national hydropower plan in coordination with the International Finance Corporation. With the final plans still undetermined, Myanmar appears well situated to change course, but it is unclear whether Myanmar's bureaucracy can effectively respond to high-level policy shifts in a timely manner.

Cambodia Energy Mix in 2014



Data taken from Energy Development Department, Ministry of Mines and Energy. "Electricity Data Collection." Presentation in Paris, France, March 2, 2016. Slide 5. <https://www.iea.org/media/training/alumni/escmarch2016/Cambodia.pdf>.

Cambodia

CURRENT POWER MIX

Like Laos and Myanmar, Cambodia has struggled to meet basic electricity needs. Power sector development was first stymied by internal conflict during the Khmer Rouge era, and later, governance and transparency issues have limited investment from many international and multinational development banks. Cambodia's installed capacity at the end of 2014 was only 1,511 MW, supplied largely from hydropower (929 MW), diesel (291 MW), and coal (268 MW).⁴⁷ Its potential energy resources are significantly higher with an estimated 10,000 MW of hydropower potential, and early studies indicate technically exploitable solar potential of 10.8 TWh/year and 65 GW of wind potential.⁴⁸ However, only approximately 58% of an estimated 15 million Cambodian citizens have secure access to electricity, with access concentrated in urban areas.⁴⁹ Electricity prices in Cambodia rank among the region's highest. Through 2012, urban residents paid up to US\$0.25 c/kWh in Phnom Penh and rural residents paid up to US\$0.80 c/kWh.⁵⁰ Reasons behind the high prices are numerous, but one factor is a high reliance on imported diesel fuel, which are taxed at one of the highest rates in the GMS. Electricity demand has been rising 20% annually since 2010, putting pressure on the government to build out supply and lower prices to make electricity more affordable.⁵¹

As of 2017, 1500 MW was distributed through the national grid which links 19 of 25 provinces. Provinces and villages that remain unconnected largely rely on micro-grids and imported diesel.⁵² Cambodia's domestic generation largely comes from eight hydropower dams operating and providing a stable and relatively affordable baseload, along with thermal coal power plants and diesel generators.⁵³ The addition of new hydropower plants is bringing the price of electricity down, but in 2016 Cambodia still relied on the import of 416 MW from its neighbors with 135 MW from Thailand, 277 MW from Vietnam, and 4 MW from Laos.⁵⁴

PLANS FOR THE FUTURE

Apart from the downward impacts on price, many policy-makers view the current level of imports—between 22 to 26 %, depending on which figures are referenced—as undesirable given concerns over energy insecurity and the high level of dependency on neighbors. These concerns have pushed many decision-makers to prefer domestic hydropower over imports from neighbors, despite its widely recognized impacts on Cambodia's fisheries.⁵⁵ The completion of the 400MW Lower Sesan 2 dam is a case in point, as many experts find that the dam could reduce Mekong migratory fish stocks by 9.3%.⁵⁶

CHALLENGES AND POTENTIAL SHIFTS

Cambodia's Ministry of Mines and Energy seeks to decrease net imports to 20% by 2020, primarily through the addition of new hydropower and coal plants into the grid.⁵⁷



Floating village on the Tonle Sap Lake in Cambodia, powered by rooftop solar panels.

Cambodia has not released an updated master energy plan, although one is currently under development by a Japanese consultant which estimates demand through 2030 and various supply options. Our discussions reveal that the new master plan is largely an aggregation of already proposed coal projects and large hydropower dams including the controversial Sambor and Strung Treng on the Mekong mainstream, with the addition of natural gas projects starting in 2026.⁵⁸ High global reserves and low prices make coal imports relatively easy to obtain leaving Cambodia's domestic coal reserves largely untapped. As a result, energy planners prefer importing coal to importing electricity from neighbors because it is less likely to be held hostage if political differences with suppliers arise.

The new draft master plan will be an important step forward in Cambodia's national electricity planning once it has been approved by the government—however, the plan notably does not include non-hydro renewable technologies as providing a substantial contribution into the national grid. Cambodia's wind potential is minimal, but solar potential is quite high at an estimated 8100 MW.⁵⁹ Various government officials indicate their support for renewable energy sources, particularly as solar has proven to be cost effective in micro-grids and is significantly less impactful than hydropower and coal. However, conversations with policy-makers revealed significant and widespread concerns about how intermittent solar would operate when integrated into the national grid. Solar's historically high price is also a serious concern for most policy-makers, as the government will only approve investments in new power projects that can deliver a price of less than US\$ 0.10 c/kwh for consumers.⁶⁰

Thailand

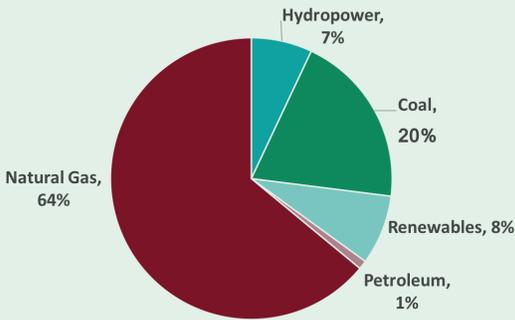
CURRENT POWER MIX

Thailand's middle income development status is reflected through its power sector in two ways: its electrical generation and distribution system is by far the most built-out in mainland Southeast Asia, and per capita electricity consumption is the highest in the Lower Mekong region. Like most developing countries, electricity use is locational—households in urban Bangkok use twice as much electricity as households elsewhere in Thailand, and the proliferation of energy inefficient shopping malls and detached housing means that the Bangkok metro area consumes approximately 40% of Thailand's total demand.⁶¹ Most of that electricity is currently supplied by Thailand's domestic natural gas reserves. As of 2014, 64% of Thailand's total power was generated using natural gas, 20% was generated by coal thermal plants, 8% was renewable energy (including large hydropower), 7% was imported hydro-power from Laos, and 1% was diesel and fuel oil.⁶²

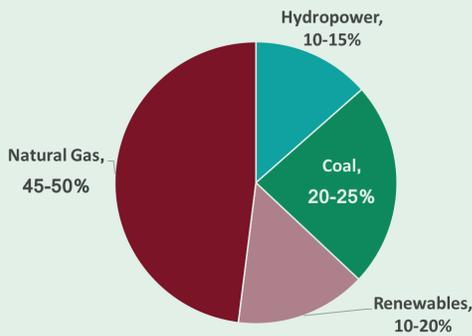
PLANS FOR THE FUTURE

However, Thailand's natural gas reserves are expected to diminish significantly by 2030, and this is pushing planners to diversify away from natural gas. Thailand still has domestic hydropower potential, but resettlement requirements and environmental impacts make building more dams highly controversial and unpopular. The strength of civil society and environmental protection regulations in Thailand has prevented additional hydropower development for decades, forcing the Electrical Generating Authority of Thailand (EGAT)—which acts as the sole purchaser of electricity, an investor in electricity projects, and negotiator of power purchase agreements with individual power producers—to consider alternatives. EGAT has identified four goals that it is pursuing in the Power Development Plan 2015-2036 (PDP 2015): to raise the percentage of electricity supply of "clean" coal, largely through the construction of new plants in southern Thailand; to increase imports—mainly hydropower—from neighboring Laos and Myanmar to 20%; to increase non-hydropower renewables; and to introduce nuclear electricity into the grid.⁶³ EGAT announced in April 2017 that it would overhaul its investment strategy and diversify into more renewable energy in the future, but details of this update remain unclear.⁶⁴

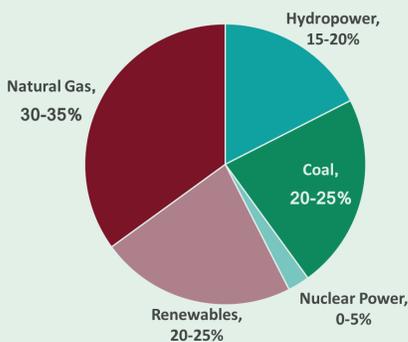
Thailand's Energy Mix in 2014



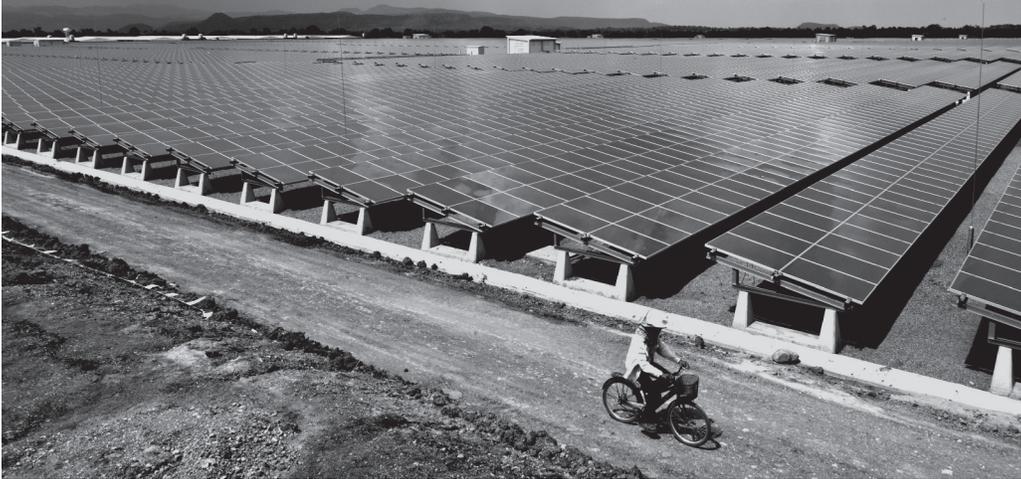
Thailand's Energy Mix in 2026



Thailand's Energy Mix in 2036



All energy mix data taken from Thailand's PDP 2015, p. 2-1.



Lopburi Solar Farm in Thailand.

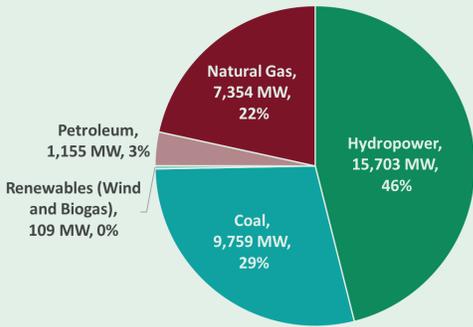
CHALLENGES AND POTENTIAL SHIFTS

The PDP 2015 assumes almost a doubling of necessary capacity from 37,612 MW in 2014 to 70,355 MW in 2036,⁶⁵ but it is unclear whether this excessive buildout is necessary. Although Thailand's energy planning is among the highest-quality in the region, EGAT has a history of over-estimating the country's power reserve targets. The reserve margins in the 2015 Power Development Plan range between 25% to 39% higher than projected demand,⁶⁶ and this is significantly higher than the international standard range of 15% to 20%. High reserve margins are ostensibly due to concerns over risks of pipeline closures, but many analysts tie it to EGAT's conflicts of interest. EGAT officials often also serve on the board of private power companies, and EGAT's cost-plus organizational model ensures that the utilities firm will receive a fixed rate of return on any new investments and allows EGAT to pass costs on to the consumer.⁶⁷ This model was useful when Thailand was initially building out energy infrastructure, but today it incentivizes overcapacity.

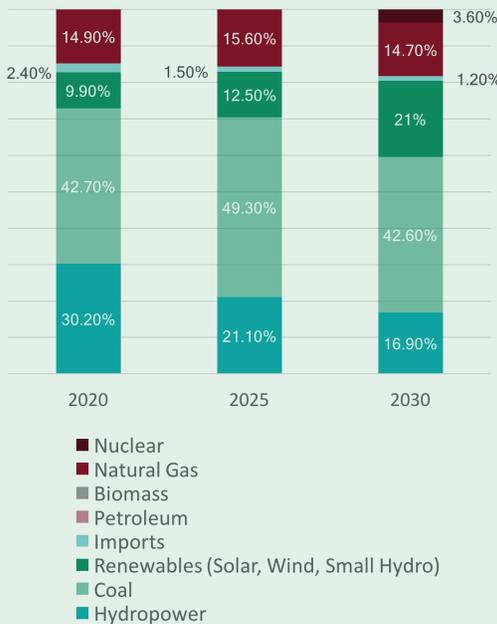
Apart from the bureaucratic structure which promotes over-investment in power reserves, two other factors may lead to inflated demand and overcapacity. First, energy demand estimates are closely tied to economic growth forecasts. PDP 2015 assumes an average rate of 3.95% economic growth through 2036. This is higher than Thailand's average growth rate of 3.5% per annum during from 2005 to 2015.⁶⁸ Thailand's government has prioritized boosting economic growth rate as a priority in order to escape the middle-income trap, but until political uncertainty surrounding current military government junta and the future of Thai democracy under the new king has dissipated, it is unlikely that the growth rates will rise to anticipated levels. This could lead to over-projection and therefore overcapacity. Second, energy efficiency gains should play a significant role in reducing Thailand's future energy consumption. Thailand has a relatively high energy intensity rate for a middle-income country, and major studies have identified that the introduction of energy efficient technology will deliver savings between 9 and 27 % of total energy consumption compared to a business-as-usual scenario.⁶⁹ The Thai government has recognized these potential gains and has committed to an energy intensity reduction of 30% from 2010 base levels by 2036.⁷⁰ If Thailand stringently implements energy savings measures, overall energy demand through 2036 will significantly diminish.

Vietnam

Installed Capacity in Vietnam by Type (2014)



Vietnam Energy Mix by Fuel Source



The energy data for 2014 is taken from WWF, *Vietnam Power Sector Vision*, p. 16. Projected data is taken from GIZ's translation of the Socialist Republic of Vietnam, "DECISION on the Approval of the Revised National Power Development Master Plan for the 2011-2020 Period with the Vision to 2030's," March 18, 2016, p. 4 - 5, at <http://gizenergy.org.vn/media/app/media/PDF-Docs/Legal-Documents/PDP%207%20revised%20Decision%20428-QD-TTg%20dated%2018%20March%202016-ENG.pdf>

CURRENT POWER MIX

In terms of sheer amount of additional capacity that will be built through 2036, Vietnam is a clear leader among its peers in Southeast Asia. As of 2014, Vietnam's total installed capacity was 33,964 MW,⁷¹ and this is estimated to increase to more than threefold over the next fifteen years to 129,500 MW in 2030. Vietnam's steady demand increase of 10-12% per year over the last decade—primarily due to increased industrial development and rising living standards for its more than 90 million citizens—has put significant pressure on its electricity supply and national grid.⁷² Vietnamese power planners assume a rate of annual growth that will slowly drop from 11 to 7.5 % in coming decades.⁷³ These estimates are based largely on economic growth trajectories, which appear not to fully account for the additional demand load potentially derived from trade deals such as the Regional Comprehensive Economic Plan, a redefined or resurrected version of the Trans-Pacific Partnership, or a partial absorption of China and Thailand's higher wage manufacturing sector.

Vietnam's current energy mix is dominated by installed hydropower, which accounted for approximately 42% of Vietnam's total installed capacity as of 2014.⁷⁴ Coal and natural gas follow, with 31.6% and 20.8% of capacity respectively. These sources are regionally split: hydropower is centered in the north and central highlands regions, with coal providing backup in both regions. Southern Vietnam's electricity market is dominated by natural gas. This energy mix is anticipated to change significantly in coming years since further large-scale hydropower development within Vietnam's border is unlikely, and concerns over how drought impacts the viability of small hydropower limit the additional buildout of small-scale hydropower.

PLANS FOR THE FUTURE

As Vietnam's electricity demand skyrockets in coming decades, planners anticipate that coal will rise as the dominant player in the market. Vietnam's revised Power Development Plan VII—which was released in 2016—indicates that coal's market share will grow to 42.7% by 2020, 49.7% by 2025, and stabilize at 42.7% in 2030.⁷⁵ At the same time, renewable investments will also grow. As a percentage of installed capacity, wind, solar, and biomass—which only made up approximately 0.1% of Vietnam's electricity supply in 2014—will rise to 9.9% in 2020, 12.5% in 2025, and hit a target of 21% by 2030.⁷⁶ The baseline for this sector is negligible, and the revised PDP VII

indicates some consensus within the government that renewable friendly policies will be needed to support this buildout. Hydropower and natural gas will drop in percentage of supply, although the overall amount of installed capacity for both will continue to rise through 2030.

CHALLENGES AND POTENTIAL SHIFTS

Vietnam's revised PDP VII focuses on meeting demand growth with domestic resources and fails to fully account for regional trade opportunities. For example, power imports, primarily from Laos, are included but only ever meet 2.4% of Vietnam's demand in 2020 before falling to 1.2% by 2030. Power imports by 2030 will reach an estimated 1,554 MW. This does not match numbers cited in Vietnam's current power trade Memorandum of Understanding (MOU) with Laos, which details 1,000 MW of imports to Vietnam by 2020, 3,000 MW by 2025, and 5,000 MW by 2030.⁷⁷ The implementation of this MOU is contingent upon price negotiations and signing of power purchase agreements, but it is notable that the increased imports are not accounted for in the revised PDP VII.

Since PDP VII was released, the National Assembly of Vietnam suspended two nuclear power plants slated for completion by 2030.⁷⁸ The shuttering of nuclear development was economically motivated, with planners indicating that the estimated \$18 billion price-tag made nuclear less competitive than alternative options such as wind or solar. Additionally, the concern for safety as expressed both by the public and the elite was likely equally important. Whatever the motivation, with nuclear off the drawing board, it is unclear which sources will replace the projected nuclear supply of 4,000 MW.

Reducing consumer subsidies on electricity is widely discussed in Vietnam as an inevitability, so pricing will likely play an important deciding factor regarding how energy trade plays into Vietnam's energy portfolio through 2030. The cost of electricity produced by adding domestic coal thermal plants is likely to rise above US\$ 0.09 c/kWh by 2020 given the need to import coal and build in improved environmental mitigation to reduce carbon emissions. This would not only make imports of hydropower from Laos affordable at US\$ 0.06-0.07 c/kWh, but could also support electricity produced by solar generation, which currently averages US\$ 0.072 c/kWh in Vietnam.⁷⁹

Given the growing role of private investors in Vietnam energy sector and Vietnam Electricity's (EVN) mandate to make a profit, low solar prices may bring about an earlier than anticipated shift towards renewables that is not accounted for in the PDP. A key factor is whether Vietnam's policies towards solar power will support large-scale investment. Until April 2017, Vietnam had no net-metering policy or a feed-in tariff.⁸⁰ Both of these have been instituted, but there are still many questions about how the government will implement them and whether there will be policy changes when the current directive comes under review in 2019.

EMERGING TRENDS AND OPPORTUNITIES FOR ENERGY PLANNERS

Renewable Energy Technologies

The national profiles highlight current states of energy planning with some consideration of future opportunities, but a number of trends are emerging which will disrupt future planning processes. Energy planners and policy makers can create opportunities from these trends now to promote a more efficient and sustainable future.

Renewable energy technologies, particularly solar and wind, are quickly becoming economically competitive alternatives to traditional sources such as fossil fuel generation and large-scale hydropower. The prices of solar and wind electricity have dropped significantly in recent years. Within the United States, the unsubsidized levelized cost of electricity per megawatt-hour dropped approximately 85% for utility-scale solar and 66% for wind between 2009 and 2016.⁸¹ These price drops make utility scale solar and wind competitive with traditional fossil fuel sources in parts of the United States, even without accounting for the social costs of externalities from fossil fuels. Within the US, utility-scale solar PPAs dropped below \$50/MWh (approximately US\$ 0.05 c/kWh) in multiple regions, comparing to an average market price of \$30-\$40/MWh.⁸² Indications are that solar will fall into this range in the coming decade.

In other parts of the world, new renewables projects reflect a similar drop in cost. PPAs signed in 2016 varied from highs of \$60/MWh for solar in India and \$80 for offshore wind in the Netherlands to record-setting lows of \$29.90/MWh in Dubai for solar and \$30/MWh in Morocco for offshore wind.⁸³ The record low price for solar fell three times in 2016, dropping from US\$ 0.0299 c/kWh from the aforementioned Dubai project in May to US\$ 0.0291 c/kWh in a project in Chile in August and then to US\$ 0.0242 c/kWh in Abu Dhabi in September.⁸⁴ Most estimates indicate that the global price of solar and wind will continue to fall in coming years due to achievements resulting from economies of scale and the rise of alternative funding frameworks currently emerging with the growing economic feasibility of these technologies.⁸⁵

These low prices have yet to reach the Mekong region. Currently, Laos's first solar plant is selling electricity at approximately US\$ 0.081 c/kWh. Cambodia's first pilot solar project estimates prices of US\$ 0.091 c/kWh. Vietnam's Bac Lieu offshore wind project sells at US\$ 0.098 c/kWh.⁸⁶ At the same time, policy-makers in these countries often seem unaware of the recent low prices seen elsewhere and—in discussing long-term plans—indicate that they strongly believe solar will remain too high-priced in the coming decades to be integrated substantively into national energy plans. For example, among Myanmar's five potential energy scenarios, only the renewables heavy option included any additional solar after 2016, and this still limited solar to 1,800 MW through 2030.⁸⁷ Weighted across a range of concerns, the “renewables heavy” option came in second due to lower scores on diversity of sources and price.⁸⁸ With consideration of recent price shifts, however, the “renewables heavy” scenario could become the most optimal.

Right: Bac Lieu Wind Farm in Vietnam.



Many energy planners in the region also raised concerns about the reliability of variable sources like wind and solar and the impact of these sources on grid management. The primary mandate for energy planners in GMS countries is to expand the national electricity base to meet rising demand and to ensure adequate supply to avoid blackouts that could harm industrial growth. Ensuring steady electricity supply requires split second response to changes in demand and supply, which generally requires a fixed base load of electricity, often hydropower or thermal power plants, plus a suite of load-following power generating options which responds quickly when demand peaks. GMS energy planners generally believe that the intermittent nature of solar and wind plants makes them unable to serve as baseload without storage capacity to help firm the power supply when the sun is not shining or the wind is not blowing.⁸⁹

However, it is possible for countries still in early stages of developing electricity infrastructure—particularly Myanmar, Laos, and Cambodia—to begin building out a system that would be more flexible and better able to take advantage of emerging technologies. There are two elements to this: alternative methods of grid management and dispatch that support the integration of renewable resources, and consideration of storage technologies in long-term planning.

For countries where renewable generation is a small portion of the total capacity, electricity grids can be effectively managed through operational changes. The amount of variable renewable electricity that can be integrated into an existing and modern grid without causing stability problems is estimated by various studies at approximately 30%.⁹⁰ In the United States and Europe this has been largely manageable at minimal additional cost merely by operational changes that support system flexibility. One way to do this is to integrate existing resources and technologies such as modern weather forecasting, which supports daily planning of the energy supply around when the wind is blowing and the sun is shining. Better data on the historical performance of renewable energy sources from other case studies and pilot projects around the world helps show how these relatively new technologies actually work in the field. Most importantly, making use of smart metering and other technologies to help track changes in demand and support an immediate supply response from utilities helps manage intermittency concerns.⁹¹ Case studies from the US indicate that ramping up the renewable portion of a power portfolio to 40% or more on days where the sun is shining clearly or the wind is blowing at full strength is feasible given these management innovations.⁹²

While the United States is a developed country with ample capacity in the electricity sector, modernizing electricity infrastructure in the US requires overcoming bureaucratic hurdles associated with bringing change to long-established procedures and preferences. Mekong countries, which are still building out much of their domestic electricity infrastructure and management systems, have the opportunity to leapfrog and adopt newer methods of dispatch, smart metering practices, and forecasting tools. Applying such methods would ensure that their future grid operations will be poised to take advantage of dynamism in the electricity market. Failing to account for future shifts and relying instead on traditional methods of generation and dispatch may be cheaper in the short-term but will result in these countries facing the same difficulties of shifting operational procedures that the United States and Europe have faced – the only difference being Mekong states will likely react to these transitions at a lower level of development with fewer resources.

Today storage is still relatively expensive. Generally speaking, the inclusion of storage alongside solar PV would decrease competitiveness vis-à-vis natural gas; although in the US the price would potentially still be competitive against new coal plants.⁹³ However, a McKinsey study indicates a growing number of scenarios where storage is already a good investment alongside wind, as it only adds an additional US\$ 0.02-0.03 c/kWh which is within a competitive price range.⁹⁴ Currently pump storage is the most affordable option, as well as the most widespread, making up approximately 98% of the total installed storage capacity globally and is likely to double through 2030 as countries build storage to support climate emissions reduction goals.⁹⁵ Pump storage pairs well with intermittent sources by using excess energy to pump water into a high reservoir and then release the water through turbines during peak demand times, although it is limited by geography and may have similar impacts as traditional hydropower projects.

Setting aside the potential breakthroughs in new battery storage technologies that may come online at a more affordable price point, the price of existing storage is predicted to drop more than half through 2025.⁹⁶ Considering this alongside the continued fall of renewable prices on their own, storage will likely be more feasible within the near to medium term. This trend should be considered in long-term planning models, particularly as storage addresses existing concerns about the reliability of renewable sources that has prevented their inclusion in current plans.

Equally if not more important, effective storage can reduce the need for national planners to build out electricity supply and reserve specifically to meet anticipated annual peak demand. Predicted annual peak is often significantly higher than average daily electricity demand. For instance, Thailand's annual peak demand in 2015 was 27,346 MW on June 11 largely due to additional air conditioning use. This was approximately two to three thousand MW higher than peak demand in the cooler months from October to February, and off-peak demand is significantly lower.⁹⁷ The necessity of ensuring enough electricity capacity in the event that some plants are offline during peak time requires planners to build out reserve capacity of approximately 15% in excess of the anticipated peak, even when some or much of this capacity will go unused during the rest of the year.

Climate Change Considerations

Apart from market shifts impacting the ease of deployment for renewable technologies, growing pressures of climate change are a second trend that should drive energy planners in the Mekong countries toward non-hydropower renewables. Southeast Asia is widely recognized as one of most vulnerable to climate change. The Germanwatch Long-Term Climate Risk Index lists Myanmar, Vietnam, Thailand, and the Philippines as four of the world's top ten countries most impacted by climate variability and climatic events between 1996 and 2015.⁹⁸ Myanmar and Thailand are noted for extreme damage from specific, extremely high impact flood and cyclone events, while Vietnam and the Philippines make the list for high frequency of medium-to-high impact cyclones and other climatic events. Looking to the future, the Intergovernmental Panel on Climate Change predicts with high confidence that the frequency and intensity of heat waves, extreme rainfall events, and both floods and droughts will impact human health, security, livelihoods, and sustainable development throughout Asia.⁹⁹

Compared to other regions around the world, Southeast Asia experienced the fastest growth in carbon emission contributions between 1990 and 2010 and is on track to



Environmental gathering led by Karen women's organization in Myanmar.

become a major emitter in the future.¹⁰⁰ As Southeast Asia's energy demand skyrockets 80% through 2040, an estimated 40% of planned new capacity throughout the region will come from coal.¹⁰¹ Given the volume that energy capacity buildout will add to region's additional emissions contributions, analysis from the IEA, ADB, World Bank, and other donor countries and development organizations widely point to rapid adoption of renewables and energy efficiency technologies as key opportunities to reduce emissions from the business-as-usual scenario.¹⁰² While solar and wind technologies are not emission-less due to their construction process and supply chain, their lifetime emissions are significantly less than coal, natural gas, biomass, and (in many cases) hydropower.¹⁰³ Hydropower has traditionally been viewed as a carbon-free alternative, but studies have increasingly indicated that some hydropower projects—particularly those in tropical regions like much of mainland Southeast Asia—emit significant amounts of methane.

Within this context, all GMS countries have all made initial commitments to reduce emissions from the projected business-as-usual scenario through their National Determined Contributions (NDCs) for the Paris Agreement. China, Myanmar, Thailand, Laos, Cambodia, and Vietnam's NDCs all include an energy component.¹⁰⁴ Of these, Myanmar, Cambodia, and Laos have tied reductions to sufficient technical, human, and financial support from international donor countries and development banks, while Thailand and Vietnam indicate initial goals of 20% and 8% respectively and make additional reductions contingent upon international support.¹⁰⁵

While the NDCs are a start—and an important step for developing countries' participation in reducing emissions under previous agreements—most are relatively unambitious, and some lack any specifics to show how governments intend to implement commitments or work towards goals. There is no indication that the region—either the GMS or the ASEAN as a whole—is coordinating efforts or making concerted plans to adjust. GMS governments now acknowledge the energy sector's role in emissions, but the necessary shift to renewable energy sources and implementation of energy efficiency policies is not adequately reflected in plans. Despite some buy-in from government officials partially coming from international actors and rising domestic pressure to avoid catastrophe, change is happening at a slow pace.

Mainland Southeast Asia's Environmental Movement

The growing environmental movement in GMS countries is a third factor which could potentially push planners to reconsider traditional energy planning approaches. The predilection among planners for large, centralized power plants requires significant land usage, particularly for hydropower projects with large reservoirs that require community resettlement and have potentially severe environmental consequences. In Thailand, there is no better example of a contested hydropower project than the Pak Mun Dam. This 130 MW dam built in the early 1990s has spawned decades of protests over the resulting destruction of fisheries and the failure to fairly compensate resettled villagers.¹⁰⁶ While there has never been a real resolution to these issues, Pak Mun marked the end of domestic hydropower development in Thailand and the beginning of an era of Thai investment in hydropower abroad. This consideration was viewed as less risky given the relative control over civil society in neighboring Laos and Myanmar, but it simply shifted risk to Thailand's neighbors.

Risks to hydropower development in Laos, Myanmar, and Cambodia are now on the rise. Concerns about how large-scale development projects have benefited some elites while passing environmental and social costs to the populace at large are growing. A major factor in this perception of hydropower is the way in which benefits are shared—or not shared, in the case of many projects. In Myanmar, the political transition from a military regime to a civilian-led government opened the door to widespread public backlash against large investment projects, many negotiated under the military regime. The best-known example is the Myitsone Dam, a Chinese investment project in northern Myanmar which was suspended in 2011 after widespread protests. The Myitsone protests drew on many motivations, including concerns over environmental impacts, resettlement impacts on the Kachin ethnic minority and resulting ethnic tensions, and—most controversially—that most of the power produced would be sent to China rather than for domestic use despite electricity shortages at home. For Myanmar, Myitsone was not a singular incident. Protests over other proposed projects on the Irrawaddy and the Salween River have been numerous and continue to pose a challenge to the government's effort to quickly build out the domestic electricity sector.¹⁰⁷

In Cambodia, similar concerns related to hydropower and other development projects have been magnified by the opposition party's championship of land rights and support for halting projects which are viewed as benefiting elites at the expense of the public. The proposed Cheay Areng Dam, a 106 MW dam built in a biodiversity hotspot, attracted significant public attention as well as the Cambodia National Rescue Party's (CNRP) championship of affected locals. In February 2015 Hun Sen indicated that the project would be put on hold until at least 2018.¹⁰⁸ Public scrutiny of the Lower Sesan II project's impacts has not abated, and as the impacts to fisheries and livelihood from the proposed Sambor and Stung Treng Dams on the mainstream of the Mekong are becoming public knowledge, criticism continues to rise. Because of hydropower's unpopularity the CNRP has pledged not to approve any additional hydropower and instead incentivize solar power if it wins the 2018 national elections. This contrasts with current regime's energy plan which is heavy on hydropower and coal.¹⁰⁹ This disagreement is also sectoral—Cambodia's Ministry of Mines and Energy is pursuing the current hydro and coal heavy pathway in national planning, but various officials within the Ministry of Environment have expressed interest in alternative scenarios.

Mainland Southeast Asia's coal footprint is currently much smaller than hydropower's, but as coal is almost universally pushed by policymakers as a vital portion of the region's future energy portfolio, it has begun to attract attention over health and environment impacts. In Thailand, coal plants have long faced public pushback. Most recently, a proposed 800 MW coal power plant in Krabi province was besieged by public protests over its potential impacts on the local environment and beach tourism.¹¹⁰ On February 28, 2017 Prime Minister Prayuth Chan-Ocha halted the project and demanded EGAT to redo the project's environmental and health impact assessments. This process will take approximately two years.¹¹¹ This setback will likely require reconsideration of Thailand's power development plan, as the Krabi coal plant was intended to address anticipated shortages in southern Thailand.¹¹²

In Myanmar, despite the swiftly rising demand and the potential provision of low-rate electricity to affected communities, coal plants have received very little support from local communities given the lack of transparency in the planning process and significant

concerns over the health impacts.¹¹³ There have already been complaints about pollution from existing plants.¹¹⁴ Even Vietnam, which has stronger controls on civil society than Myanmar or Cambodia, has experienced protests over coal plant operation, and increasingly serious air pollution is becoming a political issue.¹¹⁵ Movements in these countries are likely influenced by the strong anti-air pollution sentiment and protests in China, which have grown in size and influence in recent years. Anger over the air pollution became a public phenomenon after the US Embassy began releasing air quality data measurements that showed the seriousness of the problem, in contrast to government data. The spread of public anger over a lack of control on air quality—which in China is largely due to the use of coal power plants and the rapid rise of transportation emissions from cars—has led the government to declare a “war on pollution” and take steps to cut air pollution, including moving coal plants outside city environs and even closing some coal plants with egregious records.

The increase of protests targeting specific power projects correlates to a rise in environmental concerns throughout the region, as the impacts of pollution are more broadly recognized by the public and increasingly addressed by the government. In early 2016, Myanmar published its first Environmental Impact Assessment (EIA) Procedures, which provides requirements for impact assessment transparency and public consultation.¹¹⁶ Cambodia’s Environment Minister Say Samal, who was appointed by Hun Sen in 2014 with the mandate to improve Cambodia’s environmental standards, has led a relatively consultative approach to the formation of a national environment code, holding seven public consultation meetings on the draft law and including a breakthrough clause on transboundary EIAs.¹¹⁷ While environmental standards in Vietnam have not yet undergone revision, after pollution killed an estimated 115 tons of fish along 200km of Vietnam’s coastline, a series of protests prompted a firm government response. Vietnam levied a \$500 million fine, the country’s largest ever, on the Taiwanese Formosa Steel Company for pouring untreated wastewater into the ocean.¹¹⁸ Vietnam’s Minister of Natural Resources and Environment has emphasized that the Formosa incident should drive change of environmental impact assessment and monitoring laws to prevent future incidents, and revisions are anticipated in 2018.¹¹⁹

With environmental governance protests on a clear rise, it is likely that public attention to the impacts of large infrastructure projects will continue to pose problems for new electricity infrastructure in the future. This will likely be particularly true for coal, with a clear example of what happens when pollution is not addressed early enough in reports of air, water, and soil pollution impacts coming regularly from neighboring China. As alternative renewable technologies become increasingly economic, it is harder for governments to legitimize projects with significant environmental impacts, particularly with given the rate and manners which information spreads on social media in ways that were unimaginable only a decade ago.

Challenges to a Deeper Renewable Energy Transition in the GMS

Given market shifts, growing pressure on Southeast Asian countries to cut emissions from a business-as-usual scenario, and the rise of public environmentalism, why do renewables still fail to garner due consideration from energy planners in the Greater Mekong Subregion? What prevents national and regional energy planners from fully considering renewable energy sources into long-term planning? Our engagement and

analysis has identified three primary reasons: a lack of understanding in the reliability of alternative energy technologies and the drop of global renewable prices, which translates into an unwillingness to incorporate these trends into the decision making process; a lack of bureaucratic momentum and political will to overcome legal obstacles; and financial limitations which prevent energy planners from supporting options which are relatively expensive upfront but have lifetime savings and emission reduction benefits.

When we interviewed GMS energy planners about the potential for renewables to make up a larger portion of each country's energy mix, most universally showed interest but claimed the high price of solar and wind made it prohibitively expensive. Further they mentioned that even with a price drop, reliability and grid integration were serious concerns for utility companies.¹²⁰ The speed at which prices have dropped—particularly for solar—is likely a major factor responsible for outdated pricing views held by planners. Given that their mandate is to ensure adequate electricity supply, which requires balancing demand and supply second-to-second, even when presented with information about low prices elsewhere, energy planners throughout the region tended to fall back on older data as more familiar, more accessible, and more reliable than emerging data points that set new record lows on price.

This conservatism is largely due to bureaucratic momentum and institutionalism of existing policies. Many decision-makers are enthusiastic about the concept of solar and wind, but most were educated at a time when these were fringe technologies. Most case studies of successful integration are in developed countries in Europe and the United States—there has not yet been a presentation of locally accessible case studies in the GMS that effectively illustrates efficiency gains, price drops, and operational changes to skeptical energy planners. However, some officials interviewed recognized these trends. An expert from the Ministry of Mines Institute of Renewable Energy in Laos indicated that the speed at which investor interest has ramped up for solar may be a game changer within the coming years.¹²¹ Numerous officials from Cambodia's Ministry of Environment indicated their awareness of swift changes in pricing and timeliness of early adoption of renewable technology.¹²² However, ensuring that these viewpoints are recognized within broader relevant organs and decision-making units, particularly electricity distribution and regulatory agencies of regional governments, remains a challenge.

A second major obstacle is crafting a legal framework to supports the adoption of alternative renewable projects into the grid in developing countries. Effective approaches would range from broad policies—such as setting realistic and forward-looking renewable energy targets, realistic timelines for reaching these targets, and targeting specific power types for inclusion in the future energy mix—to specific policies such as feed-in tariffs,¹²³ licensing for construction and sale, net-metering policy, and tax status for high-tech imports. Feed-in tariffs and licensing stand out as two key issues which have yet to be resolved in most Southeast Asian countries. The construction of rooftop solar—for either residential or commercial use—generally requires a legal framework allowing independent power production and the sale of excess capacity into the grid. Sorting through the legal requirements and guidelines surrounding alternative energy has remained a challenge for the region.

THE GMS RENEWABLES CHALLENGE: POLICY OBSTACLES

- Thailand has dropped a policy that supported the initial build-out of solar due to price drops, has limited PPAs available for commercial-scale solar plants on the ground, and has no net-metering scheme to support distributed generation.¹²⁴ EGAT wants a revenue analysis to be completed prior to the adoption of net-metering due to concerns about profitability of utility companies.¹²⁵
- Vietnam adopted a feed-in tariff and a policy to allow for net-metering for solar plants in April 2017, which addresses policy gaps and uncertainties that had previously deterred investment. Numerous questions remain regarding policy implementation.¹²⁶ Vietnam has a long-standing feed-in tariff for wind, but critics note the payment rate is too low, and to date, wind investment in Vietnam has been limited.¹²⁷
- Cambodia's current laws effectively prevent distributed energy sources such as rooftop solar from connecting to the grid over grid stability issues, with some exceptions in special economic zones and on large commercial buildings.¹²⁸ The government is exploring targets for non-hydropower renewable sources as total percentage of energy production but has yet to set a number.
- Myanmar currently lacks basic energy sector plans and regulations. This poses a significant challenge for investors interested in Myanmar's energy sector broadly and the renewable sector in particular. The new civilian government is still coordinating responsibilities for energy planning, implementation, and regulation among numerous organizations with overlapping mandates.¹²⁹ There is no set or standardized process for concession agreements, power purchase agreements, or procurement, nor is there agreement upon energy tariff rates moving forward.¹³⁰ A lack of baseline regulations and high regulatory uncertainty make Myanmar's energy sector a high-risk environment for investors.
- Laos currently has no feed-in tariff for on-grid solar or wind, although off-grid household solar is relatively common. The country has set a goal of 30% renewable energy supply by 2030, defined as small hydropower (comprising a majority), solar, wind, and biofuels/biomass.¹³¹

These legal difficulties are preventing a deeper renewables transition in the GMS, but pressing investor interest is targeting relevant ministries throughout the region to address these gaps. Vietnam's recent adoption of a legal framework to support solar will likely be followed by action in neighboring countries in the near term.

However, utility companies continue to put up resistance over the requirement to adapt business and operational practices to support a distributed grid model and the integration of renewables. All utilities in the Greater Mekong Subregion are state-owned enterprises and—in most cases—the sole purchaser of electricity from power generating sources. Most utilities companies in the region also invest in power projects, either through a subsidiary company such as EDL Gen in Laos or through owning shares in independent companies as EGAT does with Ratchaburi Power Company in Thailand. Given limited budgets and the relatively low bankability of many energy sector projects, these utilities are under growing pressure to ensure operational profitability. At the same time, governments also aim to keep the price of electricity relatively low for end users—or in the case of the government of Cambodia, drop the prices to a more competitive and affordable in line with neighboring countries. As a result, there is little stomach to require utilities to purchase power from relatively expensive non-hydropower renewable energy sources through feed-in tariffs or subsidization.

For Laos, Cambodia, and Myanmar in particular, limited finances and technical expertise within respective governments constrain national investment in their respective energy sectors. Most energy projects in these countries are funded by development aid or outside investment through the BOOT model. Under the BOOT model, a foreign investor provides upfront capital to construct the project and then own and operate the project for a contractual period, usually between twenty and thirty years, before turning it over to the state. Investor interest is typically the most significant factor in bringing projects to fruition. To date, the BOOT model has largely been applied to hydropower and coal projects as the lack of policy guidance and regulation for the alternative technologies discussed above has dissuaded investment in the solar and wind sectors. Despite growing investor interest, access to financial backing is still quite limited at the local level.

REGIONAL ENERGY TRADE: ENERGY INTERDEPENDENCE AS A SUSTAINABLE PATHWAY TO ENERGY SECURITY

Most GMS countries define energy security in terms of energy independence and seek to achieve some degree of self-sufficiency and local control of electricity production through burning fossil fuels and prioritizing large-scale hydropower development. However, the externalities created by this traditional development pathway are significant. Carbon emissions from GMS countries continue to rise and large-scale hydropower projects, especially dams built on the Mekong mainstream, cut off critical stocks of environmental flows such as migratory fish and sediment distribution. Hydropower impacts on Cambodia's fisheries sector and Vietnam's agricultural sector could potentially put these countries on the brink of a food security or economic crisis and upset regional security. Countries' efforts to minimize reliance on cross-border power trade in order to independently meet national needs is leading to an excessive buildout of power capacity on the regional scale. It is becoming increasingly clear that the pursuit of energy independence as a pathway to energy security is not a sustainable long-term strategy.

The definition of energy security for GMS economies moves on a continuum from a state of energy autarky for less developed states to a greater focus in more developed states on diversifying energy sources, through both energy trade and direct investment in energy infrastructure in neighboring countries. Less developed countries states such as Cambodia, Laos, and Myanmar seek to maximize domestic power generating capacities and minimize power imports to avoid over-reliance on stronger neighbors like Thailand, Vietnam, and China. This process traditionally was facilitated by concessionary loans from MDBs but is now tipping toward BOOT model public-private partnerships which offer limited opportunities for coordination across projects and across sectors. More developed states like Thailand and Vietnam, which face domestic limitations in building out controversial and increasingly expensive fossil fuel and hydropower projects, look outward to power their increasing demand needs, mostly through promoting the construction of new hydropower and coal projects across their borders. Thai developers are actively building coal thermal plants and hydropower dams in Laos and Myanmar that export power back to meet domestic demand needs. Vietnamese companies have set their sights set on building dams in Laos for the same purpose. These relatively wealthier economies are equipped with the currency resources to pay for these cross-border investments.

The GMS is currently endowed with an asymmetry of power resources that, if more efficiently distributed, could promote energy interdependence as a new paradigm in energy security while at the same time bolster regional security. Coordinated cross-border power trade would sit at the center of this new paradigm. To be sure the trade of hydroelectricity is already impacting regional dynamics, but the robust deployment of renewable energy technologies such as wind and solar could reduce the amount of hydropower needed for regional trade and therefore effectively reduce the number of future dams in critical river basins like the Mekong, Irrawaddy, and Salween. Further, access to reliable power sources abroad could tamp down over-inflated energy reserve requirements and reduce the need to build out domestic capacity constructed solely to meet infrequent periods of peak demand. In other words, energy interdependence promoted through cross-border power trade is a way to do more with less.

A NEW ENERGY INTERDEPENDENCE PARADIGM

To reach higher rates of sustainability and economic efficiency sustainability, regional power trade should be predicated on producing the following outcomes:

1. **Reduce domestic energy reserve requirements.** The lack of regional transmission and cross-border power trade agreements is an important factor that drives energy reserve requirements in the GMS above the global average of 15%. For instance, Thailand's energy reserve is consistently set around 40% and Vietnam's is at 30% due to concerns about reliability. Ensuring access to excess electricity from neighboring countries during peak demand times would address concerns of reliability and diversify the energy mix, reducing the need for high domestic reserve capacity.
2. **Create a level playing field for electricity prices throughout the region.** Power trade allows for countries to compete in power production capacities. Countries like Laos, Cambodia, and Myanmar, with high potential in wind, solar, and hydropower can utilize these endowments to develop a competitive advantage and drop the average cost of power sold from their grids. This would both drive policy innovation in countries which currently have inefficient transmission and costly electricity prices as well as support market-based decision making. This creates growth opportunities in those countries and benefits end users across the region, particularly in countries like Cambodia which currently pay higher than average prices per kilowatt-hour.
3. **Better link energy rich regions to high demand load centers.** Innovative advancement in ultra-high voltage transmission lines can now efficiently transfer power from remote production centers to centers of high demand more than a thousand kilometers away. This opens options for power in China and Myanmar to be sold to GMS power markets as far away as Bangkok and Ho Chi Minh City. Also, power transmission can take advantage of seasonal peak variations such as sending power during the early winter months from warmer southern Laos to colder northern Vietnam as well as daily variations that impact renewables, for instance when the sun is shining in Myanmar but not in Vietnam.
4. **Decrease the carbon footprint in the GMS.** If carefully designed around sustainability goals, regional power trade allows countries to take advantage of non-fossil fuel endowments throughout the region to electrify. This both diversifies individual countries' energy mixes as well as permits some of the most damaging projects to be replaced, which delivers a significant reduction of environmental risk. Countries could reduce their reliance on importing coal and natural gas from outside the region and replace it with imported sustainable hydropower, solar, or wind. Equally important, electrification shifts energy use away from fuelwood, which is highly inefficient and polluting.
5. **Build flexibility for the future.** Along with the rise in electricity access and demand is an opportunity to better manage the way that the populations in the GMS will utilize electricity in the future. The rise in living standards, shift from fuelwood towards electrical appliances, and shift to electric transportation mean that electricity will make up increasingly larger portions of total energy consumption. Accounting for demand-side management, vehicle-to-grid transmission and energy storage, and smart and micro-grid technologies in plans now will lead to an energy sector that is more flexible and responsive to continued innovation and change in the way that the populace uses electricity.

As discussed previously in this report, a lack of political will and inadequate legal framework discourage a shift toward energy interdependence in the GMS. Additionally, the current underdeveloped state of domestic power grid development in countries like Laos, Cambodia, and Myanmar hinders effective transmission and trade across borders. However, disruptive processes such as the falling global price in non-hydropower renewables, new innovations in ultra-high voltage transmission and distributive grid technologies, and rising climate change concerns will likely push countries toward energy interdependence in the future.

The following section discusses how individual GMS countries can benefit from regional power trade and shifting to a new paradigm of energy interdependence.

LAOS

Laos is already well positioned to play a significant role in regional power trade as it currently exports power to each GMS country. However, the over-development of hydropower resources will come at a significant environmental cost to Laos and downstream countries. Laos has only built out about 30% of its planned hydropower capacity, so it is not too late to shift to an energy plan that promotes non-hydropower renewables as a significant portion of the future energy export mix. Supplementing hydropower exports with non-hydro renewables would augment Laos's export capacity during the dry season and provide new income streams to assist with economic development.

Further, Laos can capitalize on its landlocked location in the middle of mainland Southeast Asia as not just the "Battery of Southeast Asia" but also a "land-linked" conduit that could deliver power from China and Myanmar to markets in Vietnam and Thailand. Wheeling China's excess power capacity through Laos can happen as soon as transmission lines are built to facilitate regional power trade. China's hydropower is sold at \$.04/kwh where Laos sells power to Thailand and Vietnam at around \$.06/kwh.¹³² If Laos had a flexible and interconnected national energy grid, it could benefit economically from the wheeling costs and at the same time greatly reduce downstream risk by building fewer dams. This orientation will also deliver benefit long into the future when Myanmar, which has a considerably higher endowment of power generation resources, transitions to a net power exporter.

CHINA

China wastes significant amounts of energy each year. As mentioned previously, curtailed hydropower capacity in Yunnan province alone in 2016 was greater than the total installed hydropower capacity of mainland Southeast Asia. Yet, China continues to build mega-dams in southwest China. It already has plans for thirteen more dams on the Mekong which would bring total Upper Mekong hydropower capacity to 30 GW. With further buildout on Yunnan's major rivers, total hydropower capacity in Yunnan province could exceed 100 GW. Given the current excess capacity in hydropower and an expressed policy shift to promote nuclear power, hydropower development in China's southwest could significantly be scaled back. At the same time, China's state-owned Southern Grid could target existing excess capacity toward load centers in Southeast Asia. China possesses the financial resources and political will to build out a transmission system to facilitate power trade with other GMS countries. However, this is no easy task given rising anti-Chinese sentiment in mainland Southeast Asia. Particularly, China needs to repair relations with Myanmar, potential major market for power im-

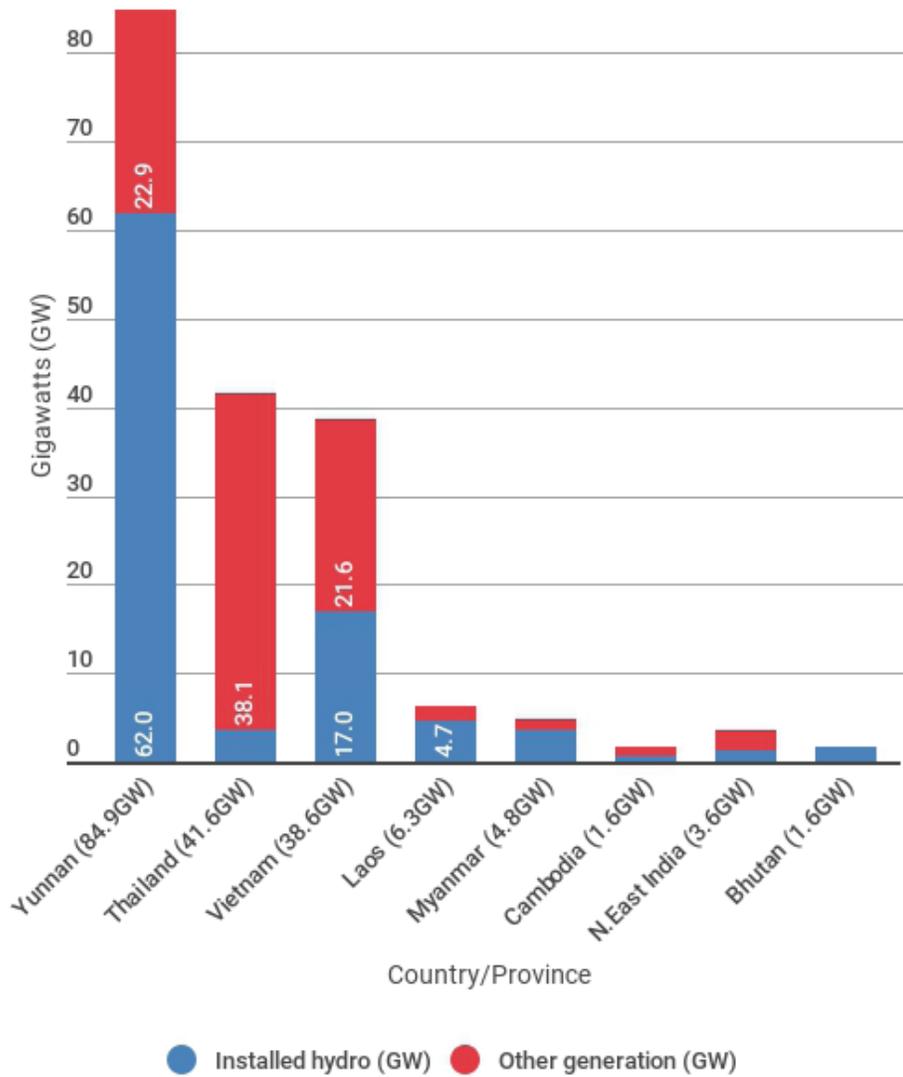


Chart from Magee and Hennig.

ports from Yunnan. Vietnam also has prickly relations with its northern neighbor and would not likely voluntarily choose to be over-reliant on China to help meet its rising energy demand. Establishing a GMS energy pooling mechanism and utilizing Laos as a centralized wheeler of power could help depoliticize this issue.

Herein lies an opportunity for China to emphasize the sustainability benefits of regional power trade: Laos, Cambodia, and Myanmar could forgo significant hydropower build-out and save critical environmental flows in their rivers that are a major source of food security for their populations. The preservation of these environmental flows such as

fish migration and sediment distribution would bring significant net economic benefit and significantly reduce ecological risk. Further, purchasing power from China's upstream dams could help regulate the Mekong downstream by providing consistent water flow during the dry season to irrigate agricultural zones as far as the Mekong Delta. With China's dams often offline because they cannot sell electricity domestically, the dry season water flow to the downstream Mekong has dropped and is subject to erratic fluctuations related to the sporadic use of Upper Mekong dams. Purchasing power from Yunnan would ensure regular dam operation and support water management downstream.

MYANMAR

Myanmar sits at the center of a power trade nexus not only with Southeast Asia but with South Asia to its west. Myanmar is currently not a major power exporter, but its wealth of resources and the significant demand in neighboring India and Bangladesh open the door to exports in the long-term once local demand has been met. Since much of Myanmar's power production potential exists in its periphery, MDBs and private investors in transmission could develop micro-grids and sub-national grids on the periphery that would both meet local needs as well as support eventual incorporation into a national grid system. Short term power purchases from Laos and China could help pad out energy needs on the periphery as Myanmar builds out its own power production and transmission system. Any cross border power would pass through many of the ethnic states which have historically not been controlled by the national government and therefore have not fully been integrated into the national infrastructure. Cross-border trade would therefore help develop areas unreached by Myanmar's inchoate national grid, provide stability to reduce conflict in armed autonomous states, and meet rural electrification targets. More importantly, this would forgo a need to buildout a traditional hub and spoke transmission and distribution system emanating from Yangon. Such an approach will assist with long term energy planning and an eventual transition to net power exporter. In a few decades the amount of excess capacity in Myanmar could easily dwarf Laos's contributions to regional trade.

VIETNAM

Vietnam stands to gain the most by reorienting its power imports away from the overseas purchase of coal towards developing its own renewable resources and increasing its direct purchase of power from neighbors. Particularly, negotiating a significant increase of power from Laos and Cambodia will give Vietnam significant leverage over how Laos and Cambodia build out future energy capacity namely promoting investment in non-hydro renewables and siting smaller-scale dams in less impactful parts of the basin. Currently Vietnam holds little leverage over Laos and Cambodia to influence hydropower buildout. Such a strategy would meet increasing domestic demand and could result in a significant reduction of environmental and social risk in the region, as many stakeholders in Vietnam would be reluctant to purchase power from sources that have substantially negative economic and environmental impacts on the Mekong Delta's agricultural economy. This strategy would also reward Laos and Cambodia with income to fund the sustainable buildout of their power sector: through terms listed in cross-border power agreements, Vietnam can prioritize specific hydropower projects that are known to be less impactful as well as non-hydropower renewable energy. Vietnam can deliver further economic and ecological benefits to its Delta by importing power from China and can help drive the policy conversation toward a regional power pool mechanism.

CAMBODIA

Similar to Vietnam, Cambodia could gain leverage over future energy buildout in Laos by prioritizing the purchase from non-mainstream dams and non-hydropower energy from Laos and signaling interest in purchasing power from China. Phnom Penh might feel like a long way from Yunnan's rivers, but Yunnan currently transmits hydropower through 800kv ultra high voltage DC lines 1500 kilometers to Guangzhou.¹³³ Phnom Penh is also 1500 kilometers from Yunnan's rivers. This would reduce pressure on Cambodia's own buildout of hydropower on the Mekong river system, which would be devastating to fisheries productivity in Cambodia's Tonle Sap lake. Importing electricity from Laos could also meet rural electrification targets and drop electricity prices in northern provinces more quickly than building a traditional hub and spoke transmission and distribution grid emanating from Phnom Penh. Importing more power in the short term can provide Cambodia with the time to develop its non-hydropower renewables. Eventually Cambodia could emerge as a net power exporter to meet growing electricity demand in southern Vietnam and Thailand and use its solar exports to complement hydropower trade flowing through the rest of the region.

THAILAND

As the largest economy in mainland Southeast Asia, Thailand's high demand is currently the number one driver of cross-border energy trade in the GMS. The high energy demand in Bangkok is met partially through the direct import of power from mega-dams in Laos like Xayaburi dam and Nam Theun 2 dam. As Thailand's national grid has been built out around demand in Bangkok and other urban areas, peripheral areas—even those closer to the dams in Laos—often experience brownouts and get little electricity through cross-border trade. The regularity of brownouts in the periphery in turn fuels arguments for the build-out of additional capacity and a higher energy reserve. A more sophisticated form of power transmission linkage that pairs high speed direct transmission with grid-to-grid connection should drive down Thailand's energy reserve requirement. Linking up to not just Laos, but also Cambodia and Myanmar for regional trade would also diversify source points for power generation and provide more flexibility. Thailand could also gain income from wheeling power from Laos and Myanmar to Malaysia and Singapore, an idea which has already been piloted as an ASEAN regional power trade project and will be discussed in the following section.

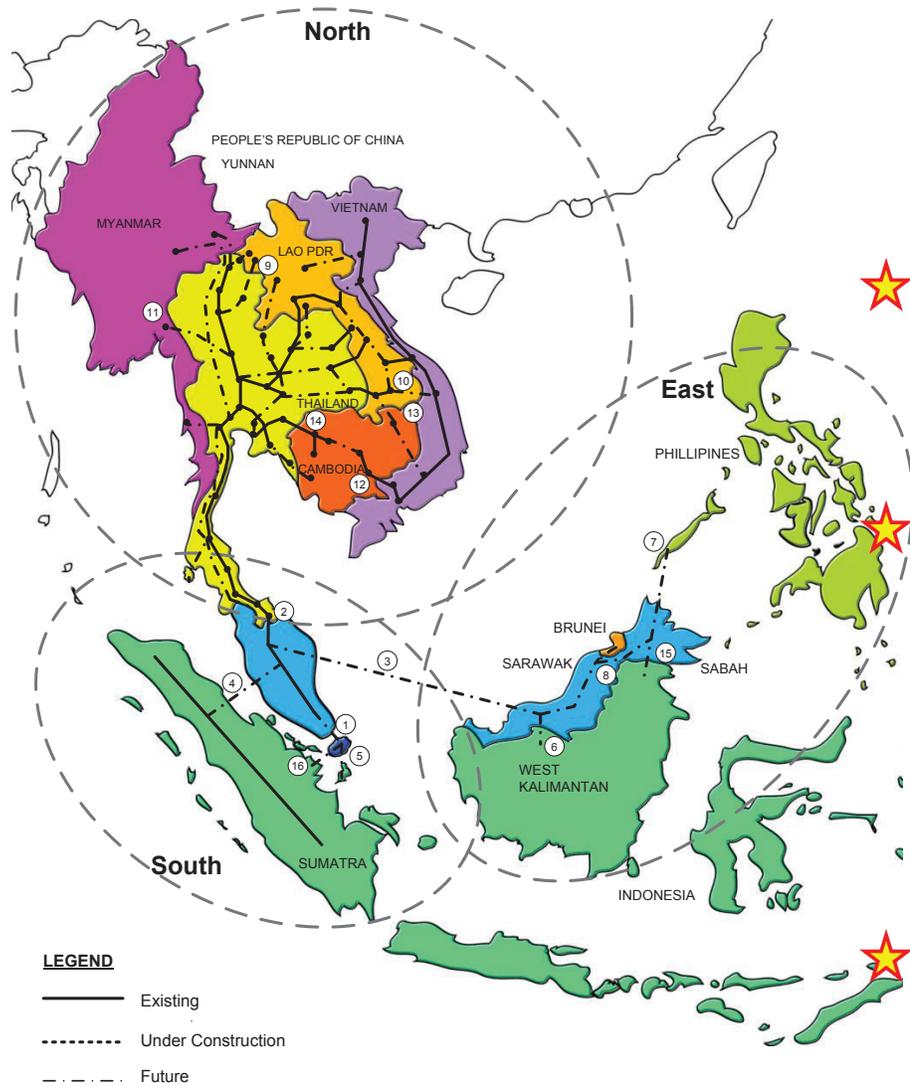
REGIONAL POWER TRADE MODALITIES

A broader vision for coordinated power trade among GMS countries and throughout ASEAN is not a new idea. For the last decade, the Asian Development Bank has considered the GMS as an area naturally endowed with resources and growing demand zones suitable for regional power trade. Further, in 2014, ASEAN endorsed an action plan for energy trade which prioritizes an ASEAN Power Grid as a key project. Also, in 2016, the China-led Asian Infrastructure Investment Bank (AIIB) initiated rounds of consultation for an energy sector strategy that promotes transmission and distribution linkages between China and Southeast Asia. Most analysts believe a regional power trade architecture will eventually rise within the region, but which countries will lead the way? Will sustainability considerations and non-hydropower renewables be central to the priorities of implementers? And will the architecture be built out in a coordinated effort that utilizes emerging technologies and considers sustainability concerns or will it be constructed in a piecemeal manner?

The promotion of regional power trade has been a key component of the ADB's Greater Mekong Subregion program's energy sector since the mid-1990s. The ADB's gradualist approach to regional power and energy integration at large is supported by conducting studies which demonstrate power trade benefits, convening working groups such as the Regional Power Trade Coordination Committee (RPTCC), and highlighting investment opportunities in individual transmission and distribution projects as part of its regional investment profile. Its grand vision is to create a fully integrated GMS power market managed by a Regional Power Coordination Center. A 2010 ADB study estimated that the economic and environmental benefits of regional energy integration would deliver energy sector savings amounting to 19% of total energy consumption, approximately \$200bn. The savings from interconnecting GMS power systems alone are estimated at \$14.3bn.¹³⁴ Most savings in this study were modelled on the benefits of offsetting coal production with hydropower. The incorporation of efficiency increases, future prices of non-hydropower renewables, and transmission innovations into an updated plan would likely demonstrate even greater savings. Equally important, a regional energy network could also support the replacement of coal and the most damaging hydropower projects with non-hydropower renewables as well as support optimization of the food-water-energy nexus tradeoffs on a basin-wide scale.

However, the ADB's gradualist approach has run into obstacles. GMS countries have difficulty meeting high environmental and social standards and turn to other forms of financing. In 2015, the ADB noted that many existing interconnection and direct transmission projects were outside its investment profile and being built by public private partnerships or bilateral agreements between countries. Instead of being oriented toward regional market integration—an orientation the ADB could facilitate—most new cross-border transmission projects directly link export oriented power plants to load centers. As previously noted, Bangkok receives a disproportionate bulk of this transmission. Further, despite working on streamlining power integration for decades, most GMS countries have yet to harmonize regulations and standards. Without such harmonization, the economic gains of trade are unachievable. Further, GMS countries have not reached consensus on the location of the GMS Regional Power Coordination Center.¹³⁵

Interconnection Projects of ASEAN Power Grid



LEGEND

- Existing
- - - - Under Construction
- · · · Future

<ul style="list-style-type: none"> 1) P.Malaysia - Singapore (New) 2) Thailand - P.Malaysia <ul style="list-style-type: none"> • Sadao - Bukit Keteri • Khlong Ngae - Gurun • Su Ngai Kolok - Rantau Panjang • Khlong Ngae - Gurun (2nd Phase, 300MW) 3) Sarawak - P. Malaysia 4) P.Malaysia - Sumatra 5) Batam - Singapore 6) Sarawak - West Kalimantan 7) Philippines - Sabah 8) Sarawak - Sabah - Brunei <ul style="list-style-type: none"> • Sarawak - Sabah • Sabah - Brunei • Sarawak - Brunei 	<p>Earliest COD</p> <ul style="list-style-type: none"> post 2020 Existing Existing TBC TBC 2025 2020 2020 2015 2020 2020 2020 2017 post 2020 post 2020 2018 	<ul style="list-style-type: none"> 9) Thailand - Lao PDR <ul style="list-style-type: none"> • Roi Et 2 - Nam Theun 2 Existing • Sakon Nakhon 2 - Thakhek - Then Hinboun (Exp.) Existing • Mae Moh 3 - Nan - Hong Sa 2015 • Udon Thani 3- Nabong (converted to 500KV) 2019 • Ubon Ratchathani 3 - Pakse - Xe Pian Xe Namnoy 2019 • Khon Kaen 4 - Loei 2 - Xayaburi 2019 • Nakhon Phanom - Thakhek 2015 • Thailand - Lao PDR (New) 2019-2023 10) Lao PDR - Vietnam 2016-TBC 11) Thailand - Myanmar 2018-2026 12) Vietnam - Cambodia (New) TBC 13) Lao PDR - Cambodia 2017 14) Thailand - Cambodia (New) post 2020 15) East Sabah - East Kalimantan post 2020 16) Singapore - Sumatra post 2020
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★ Priority Projects

ASEAN Center for Energy. ASEAN Plan of Action for Energy Cooperation (APAEC) 2016-2025. 2015. Page 18.

The challenge of linking Laos to the rest of the region serves as a case study for the ADB's difficulties in promoting a regional power trade market. For instance, in 2016, a new \$43mn interconnection¹³⁶ between Attapeu province in Laos to Gia Lai province in Vietnam was completed by Vietnam Electricity (EVN) after more than a decade of unsuccessful application to the ADB resulted in zero financing due to the inability to meet standards. This transmission project was part of a broader \$274mn ADB project which would deliver more robust interconnections between Vietnam and Laos.¹³⁷ Stimson's publications have previously discussed the ADB's prioritization of a \$400mn 500kv trunk line that would run the entire length of Laos.¹³⁸ The ADB has ranked this project as its top power project for its 2013-2022 GMS investment pipeline. This trunk line could also effectively link Laos to the rest of the region and serve as the backbone of a regional power distribution system. However, the Lao government has not signaled interest citing the need to electrify rural areas over the building of a trunk line. In all likelihood, Lao line agencies are too busy serving the needs of individual hydropower projects to envision the economic and sustainability benefits of a national grid with regional connections.

In 2014 after ASEAN energy ministers endorsed the ASEAN Plan of Action for Energy Cooperation (APAEC), the Jakarta based ASEAN Centre for Energy began to convene mid-level energy officials to scope out an ASEAN Power Grid.¹³⁹ This framework is broader than the ADB's GMS plan and encompasses all ten ASEAN countries. The plan ASEAN Power Grid is divided into three regions (East: Philippines, Indonesia, Malaysia; South: Thailand, Malaysia, Singapore, Indonesia, and a north region composed of all GMS countries).

ASEAN countries have agreed to setting up at least one multi-lateral interconnection by 2018, but the only existing agreement for a multilateral connection is a 2015 bilateral MOU for the export of 100MW of power from Laos to Singapore via Thailand and Malaysia.¹⁴⁰ If successful, this multilateral agreement could serve as a case study to drive the future development of the ASEAN Power Grid, but progress is slow. Thailand is stalling on tax and wheeling costs negotiations despite the ability to gain considerable profit from moving power between Laos and Malaysia: Lao hydropower sells around 6-8 cents/kwh and Singapore's end users purchase power at rates around 20 cents/kwh. A contributing factor to the pause is the challenge of linking up Laos's state-controlled power agencies to more market oriented counterparts in Thailand, Malaysia, and Singapore.

China has expressed the most interest in providing financing for ASEAN grid connections. Provided that Chinese investors deploy state of the art technology, meet best practices on environmental standards, and coordinate with other investors to consider regional needs and optimization of energy and environmental tradeoffs, there is the real potential for China to emerge as a catalytic driver of progress. Over the last three years, at China's annual Clean Energy Forum representatives from China's Southern Grid have presented studies on ASEAN power interconnections – both within ASEAN and between ASEAN and China.¹⁴¹ But working groups associated with ASEAN's energy planning processes are slow to react to this opportunity citing a lack of existing interconnections between China and mainland Southeast Asia and a lack of local capacity to manage a short-term ramping up of regional grid connections. Inevitably, some ASEAN states interpret China's enthusiasm as an attempt to offload excess capacity in

power and the steel and labor required to build transmission lines and are concerned about an over-reliance on their northern neighbor.

In 2015, the AIIB launched a consultative process for its first energy sector strategy citing the significant benefit emerging renewable technologies and efficiency gains from power trade and integration can deliver to energy sectors in the developing world. Its guiding principles are to promote energy access and security, realize energy efficiency potential, reduce carbon intensity, catalyze private capital, and promote regional connectivity and cooperation. While little is known about the future of the AIIB's approach to power sector financing, its literature states that power grid infrastructure development will be an essential component of the Bank's connectivity strategy and to promote regional cooperation. The excerpt below suggests that the AIIB's intent is to avoid traditional models of power sector development and promote non-hydropower renewable investment.

“Support for power transmission and distribution is expected to be one of the core areas for Bank interventions, alone or in association with other multilateral or bilateral institutions. The Bank proposes to support: (i) new transmission and distribution projects to increase power systems' resiliency to natural disasters, and assist member countries in “leapfrogging” to smart metering and other digital solutions to empower consumers, and manage the system efficiently; and (ii) rehabilitation and reinforcement of existing networks to increase their resiliency to natural disasters, reduce technical losses, allow smooth integration of intermittent renewable energy and improve reliability of supply.”¹⁴²

Creative leadership and broader thinking toward the opportunities lying within regional power trade can unlock significant economic benefit and transfer savings to support the development of other critical sectors. Further, by utilizing emerging renewable technologies and exporting power from the farther upstream reaches of rivers in Yunnan and Myanmar, lower Mekong countries can reap ecological gains by not having to build their own damaging large scale hydropower projects. The obstacles to creating this regional power trade infrastructure and a shift toward greater energy inter-dependence are similar to those discussed in the previous section on the renewable energy transition, but most analysts at the ADB and the ASEAN Center for Energy believe the establishment of an effective regional power market is only a matter of time. China looks poised to be a key player in this power trade push, but the question is whether the Chinese government and stakeholders like China's Southern Power Grid will adopt a traditional approach to exporting its excess power abroad in a way which stifles local development and industry, or choose to underscore the sustainability benefits of such an approach and effectively establish itself as a regional sustainability leader.

Development partners such as the United States, European Union, Japan, and Australia should mobilize resources within GMS countries to support the development of a regional grid that promotes efficiency, reduces the need for new hydropower and coal plants, and facilitates a significant expansion of non-hydropower renewables and smart-grid technology. In addition to bilateral aid and investment, they should utilize their roles as board members of the ADB, World Bank, and the AIIB to support regional sustainability and bring this new energy inter-dependence paradigm to light.

RECOMMENDATIONS

From the analysis of individual country profiles and policies within the context of global shifts and regional integration, there are three arenas in which clear changes could support better regional power trade and integration of non-hydropower renewables: national energy planning, electricity pricing and power purchase agreements, and in financing mechanisms for renewable sources. Multilateral development banks, international donors, and the private sector also play a key role in the financing and investment side of the equation, particularly when it comes to financing mechanisms and loan terms that support competitive pricing of renewables and the transmission infrastructure that will support regional energy trade. At the heart of these recommendations is a net reduction in future hydropower and coal projects to significantly reduce environmental and political risk in the Mekong basin. Within this context, we recommend that:

- **Multilateral Development Banks (MDBs) such as the Asian Development Bank, Asian Infrastructure Investment Bank, and/or World Bank should finance a GMS Sustainable Infrastructure Preparatory Facility with funding to provide upstream, master-planning support that enables alternative power mix scenario analyses and system-scale planning.** A major challenge for implementation of system-scale planning and consideration of various alternative scenarios—whether for something as large-scale as optimizing a hydropower cascade or as specific as alternate siting options for an individual power plant—is obtaining financing early enough in the process for alternatives to be fully considered. Alternative scenario analysis must be considered early in the project development process and is therefore considered too marginal for many private financiers to support. As a result, projects often only receive funding support once they have already made general decisions about location, technology type, project size, etc. Further, path dependency as promoted by the BOOT model, locks governments into a project by project build out of the power sector and discourages system-scale planning. A GMS Sustainable Infrastructure Preparatory Facility could use a rotating fund—much like the Global Infrastructure Fund—which supports system-scale analysis on a cascade, provincial, or national scale to support optimization on a larger-scale. When projects are decided upon and move forward, then the money could be paid back on a revolving basis. This support is key to help countries with limited resources move away from the current project-driven development model to one that allows for better consideration of alternative scenarios and more sustainable options.
- **MDBs, aid agencies, and private investors should prioritize solar and wind projects in developing countries for preferential loan treatment.** Like many other energy projects, solar and wind projects have relatively high upfront costs but pay back benefits over decades of operation. As emerging technologies, solar and wind lack case studies proving long-term profitability, which translates to investors as comparatively high risk and often precludes them from access to the type of preferential loan terms offered to more mature, conventional assets. Equally important, the scale of solar projects in developing countries is often relatively small. Project financing has historically been available on a robust scale for large-scale for projects, usually starting around \$50 million.¹⁴³ As a

result, small-scale renewable projects with relatively small costs and footprints are often viewed as relatively unattractive.

For both initially-announced pilot solar projects in Laos and Cambodia (previously discussed), preferential loan terms were key factors in lowering the price of electricity per kilowatt hour to a rate that would be competitive enough for a power purchase agreement with respective utilities. Access to similar types of project financing terms that 1) allow for long-term payback at relatively low-interest rates, 2) are limited recourse to help mitigate risk to parent companies, and 3) include blended financing (i.e. concessional and commercial loan mixes) from the ADB and other financial institutions will be key to support early growth of renewables in emerging economies.¹⁴⁴

- **ASEAN should identify regional standards for energy efficiency, particularly on building codes, smart-metering, and appliance requirements.** There is significant opportunity for GMS countries to reduce energy demand in coming decades through demand-side management and savings. Specifically, as countries throughout the region collectively experience urbanization and living standard rise, there is the opportunity to moderate the overall demand rise through integration of efficient technologies from the beginning. A major opportunity for this lies in adoption and implementation of building codes—with peak demand driven by air conditioning, ensuring that new buildings are better insulated and more efficient could help mitigate some of the demand growth resulting from rising living standards.

Separate from building codes, other technologies—such as smart metering to better track and manage energy use or appliance standards similar to the Energy Star system that has been utilized under previous administrations in the United States—can help promote more efficient use of electricity from the user-side. National standards in these sectors may be a necessary first step, but ASEAN would be a good platform for countries that are all experiencing shared challenges of urbanization and rapid energy demand rise to share lessons learned and potentially negotiate shared goals on energy efficiency. Given the regional economic connectivity, shared standards would potentially also support investment across borders in the construction sector.

- **In exploring transmission infrastructure opportunities to offload overcapacity from Yunnan to demand centers in Southeast Asia, Chinese development banks and the AIIB should prioritize sustainability benefits and economic savings of a regional power market.** A traditional mercantilist approach to offloading excess capacity will likely be ill-received by other GMS countries, but following through on sustainability commitments of regional power trade and supporting a center for regional power trade management located outside of China could do much to turn a regional power market from plan to reality.



Ban Na Substation in Champasak, Laos.

- Stakeholders who impact regional energy discourse--particularly technical advisors, academic experts, and the private sector—should explore benefits of a regional energy grid in terms of energy security though energy interdependence.** Currently, discussion of the GMS or ASEAN grid are both designed and discussed in terms of meeting point to point energy supply and demand by linking capacity in Laos and Myanmar to demand load centers like Bangkok, Ho Chi Minh City, and Singapore. The rise of these urban centers will remain an economic driver for transmission construction, but there are ample case studies of grid innovations elsewhere in the world—particularly in the United States and Europe—that have successfully utilized the scope and diversity of power inputs to support further development of new renewable technologies, promote grid to grid energy trade, and level out peak supply on a regional basis. These should be considered as learning opportunities for the GMS region.
- Vietnam should address uncertainties about its recently announced feed-in-tariff for solar and the vulnerability of solar PPAs to policy changes after 2019.** The government of Vietnam took an important step in April 2017 when it issued a feed-in tariff for solar power at the equivalent of US\$ 0.0935 c/kWh because the lack of a feed-in tariff had long been a barrier for potential investors.¹⁴⁵ Initial indications suggest many projects previously stalled in a holding pattern will move forward in the near future, with EVN announcing 350 MW of solar plants to move forward shortly after the FiT and PPA information was released.¹⁴⁶ The policy also supports net-metering for rooftop solar, which is another potential game-changer.

However, a number of important questions remain regarding these policies that may continue to hold back solar investment. Most importantly, the current directive is only effective through June 30, 2019, after which Vietnam’s Ministry of Industry and Trade plans to issue a new solar policy.¹⁴⁷ The uncertainty about treatment of new projects after that date may prevent projects currently in the early stages of development from moving forward, as they could potentially face different circumstances for operation and power purchase agreement after June 2019. Equally important, a lack of clarity surrounds the construction

of transmission lines, substations, meter locations, and responsibility and risk allocation for projects which are located some distance from existing transmission lines.¹⁴⁸ The cost of transmission lines is a key element in the financial viability of projects. Clearly identifying whether the developer or government take on specific responsibilities and risks may make the difference whether an individual project is deemed bankable or not.

- **Laos and Cambodia should both prioritize production of a Power Development Plan for 2018 that not only examines the business-as-usual scenario of proposed projects but also considers a variety of alternative economically feasible development scenarios for the coming decade.** Thailand and Vietnam both already produce and regularly revisit PDPs to adjust for cancelled plans and retired assets, shifts in pricing of renewable alternative technologies, changing demand dynamics, and other global market changes. Myanmar's preliminary PDP has not been finalized but did include comparison of alternative scenarios and exploration of how each fared on a range of factors, including cost and climate change emissions. This alternative scenario consideration will be a key enabler for policy-makers who want to quickly adjust to market changes that could impact the economic competitiveness and long-term feasibility of existing plans. This is particularly important for Laos and Cambodia given the rate of development of new projects as well as the relative dependency of both countries on the regional market for power exports from Laos and power imports into Cambodia.
- **Thailand and Vietnam should both consider climate change emissions and sustainability of energy source when signing power purchase agreements to import electricity from neighbor countries.** Currently Vietnam and Thailand prioritize imports based only on price, and do not account for carbon emissions or other environmental, social, or health impacts when investing in projects abroad and purchasing from them. As purchasers Vietnam and Thailand have a determining role regarding which projects move ahead: PPAs are the key factor which ensure a project's bankability, and most projects will not move ahead until a PPA is signed. Currently, discussions about environmental and health impacts—whether from transboundary dam impacts or local and regional air pollution impacts from coal plants such as in Hongsa, Laos—are divorced from discussions about power purchase agreements. If policymakers in Vietnam and Thailand are truly seeking a more sustainable energy sector, as both have laid out in energy planning policy documents, then impacts from foreign investment must be considered alongside domestic projects rather than as the sole responsibility of their neighbors.
- **GMS countries should consider utilizing storage to both help firm renewable electricity sources as well as store electricity for use during peak demand days during the warmer dry season, eliminating the need for some of the additional reserve capacity in the long-term.** This is a long-term recommendation given the currently low-level of renewable technology penetration in the regional energy mix, but in the storage will be a key factor in supporting the eventual adoption of a large percentage of renewables and in supporting a distributed grid network in the GMS countries. Countries should start examining the potential for pump storage and consider the price points at which battery technology would be worth the investment to make additional solar, wind, and other variable technologies.

ENDNOTES

1. Asian Development Bank. *Greater Mekong Subregion Power Trade and Interconnection: 2 Decades of Cooperation*. 2012. Page 1. <https://www.adb.org/sites/default/files/publication/29982/gms-power-trade-interconnection.pdf>.
2. Lazard. *Lazard's Levelized Cost of Electricity Analysis – Version 10.0*. December 2016. Page 10. <https://www.lazard.com/media/438038/levelized-cost-of-energy-v100.pdf>.
3. International Renewable Energy Agency (IRENA). *Press Release: Average Costs for Solar and Wind Electricity Could Fall 59% by 2025*, June 15, 2016. http://www.irena.org/News/Description.aspx?NTtype=A&mnu=cat&PriMenuID=16&CatID=84&News_ID=1452.
4. Liu Qin. “China’s hydro expansion will fail without energy market reform.” *The Third Pole*, January 13, 2017. <https://www.thethirdpole.net/2017/01/13/hydro-expansion-will-fail-without-energy-market-reform>.
5. Private conversation with local officials in Kunming, China. February 2017.
6. Ziv, G., E. Baran, I. Rodríguez-Iturbe, and S.A. Levin. “Trading-off Fish Biodiversity, Food Security and Hydropower in the Mekong River Basin.” *Proceedings of the National Academy of Sciences*, Vol.109, no. 15 (January, 2012). <http://www.pnas.org/content/109/15/5609-5614.full.pdf>; Baird, Ian G. *The Don Sahong Dam: Potential Impacts on Regional Fish Migrations, Livelihoods and Human Health*. University of Victoria, August 2009. http://www.polisproject.org/PDFs/Baird%202009_Don%20Sahong.pdf; Orr, Stuart, Jamie Pittock, Ashok Chapagain, and David Dumaresq. “Dams on the Mekong River: Lost fish protein and the implications for land and water resources.” *Global Environmental Change*, Vol. 22, Issue 4 (October 2012): 925–932. <https://doi.org/10.1016/j.gloenvcha.2012.06.002>.
7. Mekong River Commission (MRC), “Lao PDR is to undertake MRC’s prior consultation on its new hydropower development plan in Pak Beng,” November 7, 2016. <http://www.mrcmekong.org/news-and-events/news/mrc-statement-on-the-occasion-of-pdies-15th-anniversary-2/>.
8. Ziv, “Trading-off.”
9. Zsombor, Peter and Ben Sokhean. “Kith Meng Backs Plans for Three Hydropower Projects.” *The Cambodia Daily*. February 3, 2017. <https://www.cambodiadaily.com/morenews/kith-meng-backs-plans-for-three-hydropower-dams-124528/>.
10. SUSHU, Wu, Hioshi ISHIDAIRA, and Wenchao SUN. “Potential Impact of Sambor Dam Project on Interaction Between Mekong River and Tonle Sap Lake.” *Annual Journal of Hydraulic Engineering*, JSCE, Vol. 54 (February 2010).
11. Ministry of Planning and Investment of Lao PDR. *8th Five-Year National Socio-Economic Development Plan (2016-2020)*. June 2016, 20. http://www.la.one.un.org/images/publications/8th_NSEDP_2016-2020.pdf.
12. Ibid, 13.
13. Tang, Jie, Yan Li, Arun Sanghvi, and Jason Steele. *Lao PDR: Power to the People: Twenty Years of National Electrification*. World Bank. January 2012. <http://siteresources.worldbank.org/INTEAPAS-TAE/Resources/LaoPDR-PowertoPeople.pdf>; Laspho, Litthanoulouk. “Lao Rural Electrification.” Ministry of Energy and Mines presentation at SE4ALL Consultation Workshop, June 14, 2015. Slide 6. <https://www.slideshare.net/energyforall/laos-rural-electrification>.
14. Intelligent Energy Systems (IES). Mekong Economics and World Wild Fund for Nature. *Alternatives for Power Generation in the Greater Mekong Subregion: Volume 3, Power Sector Vision for the Lao People’s Democratic Republic*. March 20, 2016. 10. https://d2ouvy59p0dg6k.cloudfront.net/downloads/vol_3_ies_mke_lao_pdr_wwf_power_sector_vision_20160321_final_r4.pdf.

15. World Bank. *Electric power consumption (kWh per capita)*. 2014. <http://data.worldbank.org/indicator/EG.USE.ELEC.KH.PC>.
16. Ministry of Energy and Mines of Lao PDR. "Hydropower in Lao PDR." <http://www.poweringprogress.org/new/2-uncategorised/3-hydropower-in-lao-pdr>.
17. Savada, Andrea Matles, ed. "Energy." *Laos: A Country Study*. Washington, DC: U.S. Library of Congress. 1994. <http://countrystudies.us/laos/78.htm>.
18. Laos Ministry of Energy and Mines. *Hydropower*. Updated July 2016. http://www.laoenergy.la/download_free.php.
19. PHONEKEO, Daovong. "Pak Beng hydropower in the context of Lao development strategy and Mekong sustainable development." Presentation at the Regional Stakeholder Forum on the Council Study and Pak Beng Hydropower Project. February 22-23, 2017. <https://www.mrcmekong.org/assets/Publications/Council-Study/PPT-on-Lao-hydropower-development.pdf>.
20. Ibid.
21. Private conversation with official from the Ministry of Energy and Mines. Vientiane, Laos. February 2017.
22. Ibid.; The Nation. "IES, Denmark's Vestas to join for largest wind farm to provide low-cost energy." May 25, 2016. <http://www.nationmultimedia.com/news/business/EconomyAndTourism/30286622>.
23. Gob, Simon. "Power Statistics China 2016: Huge growth of renewables amidst thermal based generation." China Europe Energy News, February 9, 2017. <http://ceenews.info/en/power-statistics-china-2016-huge-growth-of-renewables-amidst-thermal-based-generation/>.
24. Finamore, Barbara, Asia Director, Natural Resources Defense Council. "Coal Peak or Plateau? Digging into the Climate and Water Impacts of China's Decarbonization." Presentation at the Wilson Center. March 13, 2017.
25. National Development and Reform Commission. "China's 13th Electricity Development Plan: 2016-2020." 2016. <http://www.ndrc.gov.cn/zcfb/zcfbghwb/201612/P020161222570036010274.pdf>.
26. Zhou Xizhou, Senior Director HIS Markit's Power, Gas, and Renewables Group. "Coal Peak or Plateau? Digging into the Climate and Water Impacts of China's Decarbonization." Presentation at the Wilson Center. March 13, 2017.
27. Gob, "Power Statistics China 2016."
28. Paulson Institute. "The Costs of China's Wasted Power." August 10, 2016. <http://www.paulsoninstitute.org/paulson-blog/2016/08/10/the-costs-of-chinas-wasted-wind-power/>.
29. Magee, Darrin and Thomas Hennig. "Hydropower boom in China and along Asia's rivers outpaces electricity demand." China Dialogue, April 28, 2017. <https://www.chinadialogue.net/article/show/single/en/9760-Hydropower-boom-in-China-and-along-Asia-s-rivers-outpaces-electricity-demand>.
30. Kahrl, Friedrich, Max Dupuy, and Wang Xuan. "Issues in China Power Sector Reform: Generator Dispatch Discussion Paper." The Regulatory Assistance Project. July 2016. <https://www.raponline.org/wp-content/uploads/2016/07/rap-kahrl-dupuy-wang-china-generator-dispatch-reform-july-2016.pdf>.
31. Hove, Anders and Kevin Mo. "Going for Gold: Championing Renewable Energy Integration in Jing-Jin-Ji." Paulson Institute. Accessed May 5, 2017. <http://www.paulsoninstitute.org/wp-content/uploads/2016/07/Renewable-Energy-Integration-EN.pdf>.
32. Interviews with executives from major power firms Hydrolancang, Sinohydro, and Yunnan Energy Investment Corporation. October 2016.
33. International Institute for Environment and Development. "Energy poverty in Myanmar: only 34% of the population have grid quality electricity." May 10, 2016. <https://www.iied.org/energy-poverty-myanmar-only-34-population-have-grid-quality-electricity>.

34. Intelligent Energy Systems and Myanmar International Consultants. *Myanmar Energy Master Plan 2015*. Page vi. http://www.burmalibrary.org/docs22/2015-12-Myanmar_Energy_Master_Plan.pdf.
35. Ibid, 146-148.
36. Nam, Kee-Yung, Maria Rowena Cham, and Paulo Rodelio Haili. "Power Sector Development in Myanmar: ADB Economics Working Paper Series, No. 460." Asian Development Bank, October 2015. Page 9. <https://www.adb.org/sites/default/files/publication/175801/ewp-460.pdf>.
37. Ibid, 10.
38. Ibid, 10; Kyaw Hsu Mon. "Burma's Electricity Demand Predicted to Nearly Double by 2020." The Irrawaddy, November 17, 2016. <https://www.irrawaddy.com/news/burma/burmas-electricity-demand-predicted-to-nearly-double-by-2020.html>.
39. *Myanmar Energy Master Plan*, 495.
40. Ibid, 620.
41. The levelized cost of electricity, commonly referred to as LCOE, is a key metric used by utilities to indicate the cost of electricity per kilowatt hour over the lifetime of the project. It is calculated by considering all anticipated lifetime costs—upfront capital for construction and financing, fuel, maintenance, taxes, etc.—divided by the anticipated total output over the project's lifetime. It is commonly used to compare different generation options.
42. *Myanmar Energy Master Plan*, 629.
43. Hughes, Krista. "New \$480 million solar plant project planned for Myanmar." Reuters, August 28, 2014. <http://www.reuters.com/article/us-myanmar-solar-idUSKBN0GS1JV20140828>; Mahapatra, Saurabh. "220 MW Solar Power Project Planned in Myanmar." Clean Technica. October 27, 2015. <https://cleantechnica.com/2015/10/27/220-mw-solar-power-project-planned-myanmar/>; Aung Shin. "Thai firm signs 300 MW solar deal." Myanmar Times. May 20, 2016. <http://www.mmtimes.com/index.php/business/20424-thai-firm-signs-300mw-solar-deal.html>.
44. Myint, Shwe Yee Saw and Antoni Sladkowski. "Exclusive: hungry for power, Myanmar bets on hydro in new energy plan." Reuters. September 11, 2016. <http://www.reuters.com/article/us-myanmar-energy-hydropower-idUSKCN11H0SD>.
45. Htwe, Chan Mya. "New energy master plan for Yangon." The Myanmar Times. February 3, 2017. Accessed on April 18, 2017. <http://www.mmtimes.com/index.php/national-news/24811-new-energy-master-plan-for-yangon.html>.
46. "Clean coal" is an industry term usually used for thermal coal plants which use more efficient super-critical technology and implements some form of pollution mitigation technology like carbon capture and storage or flue-gas desulfurization. Many existing coal plants in Southeast Asia utilize older sub-critical technology, so while "clean coal" would be an improvement it is still more polluting than alternative technologies.
47. Energy Development Department, Ministry of Mines and Energy. "Electricity Data Collection." Presentation in Paris, France. March 2, 2016. Slide 5. <https://www.iea.org/media/training/alumni/escmarch2016/Cambodia.pdf>.
48. Asian Development Bank. *Renewable Energy Developments and Potential in the Greater Mekong Subregion*. 2015. Pages 12, 15, and 19. <https://www.adb.org/sites/default/files/publication/161898/renewable-energy-developments-gms.pdf>.
49. Private conversation with official from Cambodia's Ministry of Mines and Energy. Phnom Penh, Cambodia. February 2017.
50. Poch, Kongchheng and Savong Tuy. "Cambodia's Electricity Sector in the Context of Regional Electricity Market Integration." In *Energy Market Integration in East Asia: Theories, Electricity Sector and Subsidies*. Edited by Wu, Y., X. Shi, and F. Kimura. 2012. ERIA Research Project Report 2011-17. Jakarta: ERIA, Page 141.

51. World Wild Fund. *Power Sector Vision: Towards 100% Renewable Electricity by 2050. Cambodia Report*. May 2016. Page 5. http://wwf.panda.org/what_we_do/where_we_work/greatermekong/our_solutions/2050powersectorvision/.
52. Private conversation with official from Cambodia’s Ministry of Mines and Energy. Phnom Penh, Cambodia. February 2017.
53. Electricity Authority of Cambodia. *Report on Power Sector of the Kingdom of Cambodia: 2015 Edition*. July 2015. Page 26. <http://eac.gov.kh/wp-content/uploads/2015/07/report-2014en.pdf>.
54. Sor, Chandara. “Put more energy into power supply, firms told.” *The Phnom Penh Post*. January 19, 2016. <http://www.phnompenhpost.com/business/put-more-energy-power-supply-firms-told>.
55. Private conversation with officials from Cambodia’s Ministry of Environment. Phnom Penh, Cambodia. October 2015.
56. Guy Ziv, et al. “Trading-off of fish biodiversity, food security, and hydropower in the Mekong River Basin.” *Proceedings of the National Academy of Social Sciences of the United States of America*. Vol. 109 No. 15. January 28, 2012. <http://www.pnas.org/content/109/15/5609.full>.
57. Private conversation with official from Cambodia’s Ministry of Mines and Energy. Phnom Penh, Cambodia. February 2017.
58. Private conversation with official from Cambodia’s Ministry of Mines and Energy. Phnom Penh, Cambodia. February 2017.; private conversation with JICA officials. Phnom Penh, Cambodia. March 2017.
59. De Ferranti, Richard, David Fullbrook, John McGinley, and Stephen Higgins. *Switching On: Cambodia’s Path to Sustainable Energy Security*. Mekong Strategic Partners. Phnom Penh, Cambodia. March 2016. Page 16.
60. Private conversation with official from Cambodia’s Ministry of Mines and Energy. Phnom Penh, Cambodia. February 2017.
61. Marks, Danny. “Laos foots the bill for power-hungry Bangkok.” *Mekong Commons*. December 11, 2014. Accessed on March 22, 2017. <http://www.mekongcommons.org/laos-foots-bill-power-hungry-bangkok/>; Baird, Ian and Noah Quastel. “Rescaling and Reordering Nature–Society Relations: The Nam Theun 2 Hydropower Dam and Laos–Thailand Electricity Networks.” *Nature and Society*, Vol 105. 2015.
62. Mr. Chavalit Pichalai. *Thailand’s Power Development Plan 2015 (PDP 2015)*. Energy Policy and Planning Office (EPPO). <http://www.renewableenergy-asia.com/Portals/0/seminar/Presentation/02-Overview%20of%20Power%20Development%20Plan%20%28PDP%202015%29.pdf>.
63. Energy Planning and Policy Office (EPPO). *Thailand Power Development Plan 2015 – 2036 (PDP 2015)*. Thailand Ministry of Energy. June 30, 2015. Page 2-1. https://www.egat.co.th/en/images/about-egat/PDP2015_Eng.pdf.
64. Yuthana Praiwan. “Egat looks to ride renewable wave.” *The Bangkok Post*, April 27, 2017. <http://www.bangkokpost.com/business/news/1239314/egat-looks-to-ride-renewable-wave>.
65. PDP2015.
66. Paritta Wangkiat. “Critics say emissions vow ‘a pipe dream’.” *Bangkok Post*. December 5, 2015. <http://www.bangkokpost.com/print/785421/>.
67. Middleton, Carl. “Sustainable Electricity Transition in Thailand and the Role of Civil Society.” *Handbook on Sustainability Transition and Sustainable Peace*. Edited by Hans Gunter Brauch, et al. Springer International Publishing, Switzerland: 837.
68. World Bank. “Thailand.” April 2017. <http://www.worldbank.org/en/country/thailand/overview>.
69. Asian Development Bank. *Energy Efficiency Developments and Potential Energy Savings in the Greater Mekong Sub region*. 2015. Page 49. <https://www.adb.org/sites/default/files/publication/161894/energy-efficiency-savings-gms.pdf>; WWF. *Thailand Power Sector Vision 2050*. May

2016. http://wwf.panda.org/what_we_do/where_we_work/greatermekong/our_solutions/2050p_owersectorvision/.
70. Thailand Ministry of Energy's Energy and Planning Office. *Thailand Power Development Plan 2015-2036*, June 30, 2015. 32-34, http://www.egat.co.th/en/images/about-egat/PDP2015_Eng.pdf.
 71. Intelligent Energy Systems (ES). *Alternatives for Power Generation in the Greater Mekong Subregion. Volume 6: Socialist Republic of Vietnam Power Sector Scenarios*. May 2016. Page 14. http://d2ouvy59p0dg6k.cloudfront.net/downloads/ies_mke_vietnam_power_sector_vision_part_2.pdf.
 72. "Vietnam to augment power generation." Oxford Business Group. April 30, 2016. <http://www.oxfordbusinessgroup.com/news/vietnam-augment-power-generation>.
 73. Private conversation with Vietnam Electricite official. Hanoi, Vietnam. November 2016.; Doan Phac Le, *Vietnam Presentation at the Technical Meeting on Country Nuclear Power Profiles*. International Atomic Energy Association, Vienna, Austria. May 10-13, 2016. Slide 18. https://www.iaea.org/NuclearPower/Downloadable/Meetings/2016/2016-05-10-05-13-NPES/Country_pres/Vietnam_Presentation-CNPP_TM_2016.pdf.
 74. IES, *Vietnam Power Sector Scenarios*, 16.
 75. GIZ. *Decision on the Approval of the Revised National Power Development Master Plan for the 2011-2020 period, with vision to 2030 (GIZ translation for reference)*. 18 March 2016. Accessed on April 17, 2017. Page 4-5. <http://gizenergy.org.vn/media/app/media/PDF-Docs/Legal-Documents/PDP%207%20revised%20Decision%20428-QD-TTg%20dated%2018%20March%202016-ENG.pdf>.
 76. Ibid.
 77. PHONEKEO Daovong.
 78. "Vietnam ditches nuclear power plants." DW. November 10, 2016. Accessed April 17, 2017. <http://www.dw.com/en/vietnam-ditches-nuclear-power-plans/a-36338419>.
 79. Private conversation with World Bank official. Hanoi, Vietnam. March 2016.
 80. Net-metering is an important mechanism for tracking the two-way flow of electricity for homes and other buildings which have both rooftop solar and a connection to the grid. It tracks when and how much excess electricity produced by the solar panels flows into the grid and when there is not enough electricity produced locally and electricity is bought off the grid. For more information on why net-metering matters, see: Andra, Jacob. "What is Net-Metering and Why Does it Matter?" *Renewable Energy World*. November 14, 2016. <http://www.renewableenergyworld.com/ugc/articles/2016/11/11/what-is-net-metering-and-why-does-it-matter.html>.
 81. Lazard. "Lazard's Levelized Cost."
 82. Fares, Robert. "The Price of Solar is Declining to Unprecedented Lows." *Scientific American: Plugged In Blog*. August 27, 2016. <https://blogs.scientificamerican.com/plugged-in/the-price-of-solar-is-declining-to-unprecedented-lows/>.
 83. Frankfurt School - UNEP Collaborating Centre. "Global Trends in Renewable Energy Investment in 2017." *United Nations Environment Programme and Bloomberg New Energy Finance*, 2017. Page 18.
 84. Giles Parkinson. "Solar price hits record low of 2.42 c/kWh, and may fall further." *REneweconomy*, September 20, 2016. <http://reneweconomy.com.au/solar-price-hits-record-low-of-2-42ckwh-and-may-fall-further-32358/>.
 85. IRENA. *The Power to Change: Solar and Wind Cost Reduction Potential to 2025*. 2016. Page 10.; Bloomberg New Energy Finance. "Coal and gas to stay cheap, but renewables still win race on costs." June 12, 2016. <https://about.bnef.com/blog/coal-and-gas-to-stay-cheap-but-renewables-still-win-race-on-costs/>.
 86. Private conversations with an official from the Ministry of Energy and Mines in Vientiane, Laos, February 2017 and with a Ministry of Mines and Energy official in Phnom Penh, Cambodia, March

- 2017.; Ngoc Chi. "Plan to increase wind power price to be approved." Vietnam Economic Times, December 5, 2016. <http://vneconomicstimes.com/article/business/plan-to-increase-wind-power-price-to-be-approved>.
87. *Myanmar Energy Master Plan*, 632.
 88. Ibid, 629.
 89. Union of Concerned Scientists. *How Energy Storage Works*. <http://www.ucsusa.org/clean-energy/how-energy-storage-works#.WP5euFXyuUk>.
 90. Milligan, M., B. Kirby, T. Acker, M. Ahlstrom, B. Frew, M. Goggin, W. Lasher, M. Marquis, and D. Osborn. "Review and Status of Wind Integration and Transmission in the United States: Key Issues and Lessons Learned." National Renewable Energy Laboratory, March 2015. 17. <http://www.nrel.gov/docs/fy15osti/61911.pdf>.
 91. Jurgen Weiss and Bruce Tsuchida. "Integrating Renewable Energy into the Electricity Grid." the Brattle Group, June 2015. 4-5.
 92. Ibid, 11.
 93. Lazard, "Lazard's Levelized Cost." 2-3.
 94. d'Aprile, Paolo, John Newman, and Dickon Pinner. "The new economics of energy storage." McKinsey & Company. <http://www.mckinsey.com/business-functions/sustainability-and-resource-productivity/our-insights/the-new-economics-of-energy-storage#0>.
 95. John Roach. "For Storing electricity, Utilities Are Turning to Pumped Hydro." Yale Environment 360. November 24, 2015. http://e360.yale.edu/features/for_storing_electricity_utilities_are_turning_to_pumped_hydro; Sakarii Oksanen, IRENA. Presentation at World Hydropower Congress.
 96. Ibid.
 97. International Energy Association. *Thailand Electricity Security Assessment 2016*. 2016. Page 23. https://www.iea.org/publications/freepublications/publication/Partner_Country_Series_Thailand_Electricity_Security_2016_.pdf.
 98. Kreft, Sonke, Davie Eckstein, and Inga Melchior. "Global Climate Risk Index 2017." Germanwatch. November 2016. Page 6. <https://germanwatch.org/de/download/16411.pdf>.
 99. Hijioka, Y. et al. "Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change." *In Asia*. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 2014. Pages 1331-1332. https://www.ipcc.ch/pdf/assessment-report/ar5/wg2/WGIIAR5-Chap24_FINAL.pdf.
 100. Raitzer, David, et al. *Southeast Asia and the Economics of Global Climate Stabilization*. Asian Development Bank, 2015. Page 3. <https://www.adb.org/sites/default/files/publication/178615/sea-economics-global-climate-stabilization.pdf>.
 101. International Energy Agency. *Southeast Asia Energy Outlook 2015*, 2015. Page 9. https://www.iea.org/publications/freepublications/publication/WEO2015_SouthEastAsia.pdf.
 102. International Energy Agency. *Southeast Asia Outlook 2015: World Energy Outlook Special Report*. 2015. https://www.iea.org/publications/freepublications/publication/WEO2015_SouthEastAsia.pdf; Asian Development Bank. *Energy Outlook for Asia and the Pacific*, 2013. <https://www.adb.org/sites/default/files/publication/30429/energy-outlook.pdf>.
 103. Steffen Schlomer et al. "Annex III: Technology-specific Cost and Performance Parameters." Climate Change 2014: Mitigation of Climate Change, Cambridge University Press, 2014. Page 1335.; Salisbury, Clair. "Counterintuitive: Global hydropower boom will add to climate change." Mongabay, February 14, 2017. <https://news.mongabay.com/2017/02/counterintuitive-global-hydropower-boom-will-add-to-climate-change/>.

104. UNFCCC. *INDCs as communicated by Parties*. <http://www4.unfccc.int/submissions/INDC/Submission%20Pages/submissions.aspx>
105. UNFCCC. *Vietnam, INDCs as communicated by Parties*. Page 2. <http://www4.unfccc.int/ndcregistry/PublishedDocuments/Viet%20Nam%20First/VIETNAM%27S%20INDC.pdf>;
106. Philip Hirsch. "The Changing Political Dynamics of Dam Building in the Mekong." *Water Alternatives*, Vol. 3, Issue 2 (2010): Page 316.
107. Saw Yan Naing. "Environmental Advocates: Salween River is Being 'Sold Off' to China." *The Irrawaddy*, August 23, 2016. <https://www.irrawaddy.com/news/burma/environmental-advocates-salween-river-is-being-sold-off-to-china.html>.
108. May Titthara. "Don't talk about Areng." *Phnom Penh Post*, February 25, 2015. <http://www.phnompenhpost.com/dont-talk-about-areng>; Khuon Narim and Zsombor Peter. "Government Ditches Hydropower Dam for More Coal Power." *The Cambodia Daily*. February 20, 2017. <https://www.cambodiadaily.com/morenews/government-ditches-hydropower-dam-for-more-coal-power-125402/>.
109. Board, Jack. "Cambodia opposition promises to slash power prices, encourage solar energy." *Channel News Asia*. December 20, 2016. <http://www.channelnewsasia.com/news/asiapacific/cambodia-opposition-promises-to-slash-power-prices-encourage/3380920.html>.
110. The Mekong Eye. "Coal Power on the Rise: Mekong Region Digs In." February 14, 2016. <https://www.mekongeye.com/2016/02/14/coal-power-on-the-rise/>.
111. Kotani, Hiroshi. "Protests upend a coal-fired power plant in southern Thailand." *Nikkei Asian Review*. March 9, 2017. <http://asia.nikkei.com/magazine/20170309/Business/Protests-upend-a-coal-fired-power-plant-in-southern-Thailand?page=1>.
112. Yuthana Praiwan and Apornrath Phoonphongphiphat. "Krabi coal plant up in the air." *The Bangkok Post*. April 24, 2017. <http://www.bangkokpost.com/news/security/1237518/krabi-coal-plant-up-in-the-air>.
113. Yen Saning. "Mass Protest Held against Mon State Coal Plant Proposal." *The Irrawaddy*. May 5, 2015. <https://www.irrawaddy.com/news/burma/mass-protest-held-against-mon-state-coal-plant-proposal.html>; Salai Thant Zin. "Locals Campaign for Shutdown of Coal-Fired Power Plant." *The Irrawaddy*, November 4, 2016. <https://www.irrawaddy.com/news/locals-campaign-for-shutdown-of-coal-fired-power-plant.html>.
114. WWF, *Alternative Vision for Myanmar's Power Sector*, 16.
115. Binh Thuan. "Vietnam orders coal power plant to reduce pollution following 30-hour protest." *Thanh Nien News*. April 23, 2015. <http://www.thanhniennews.com/society/vietnam-orders-coal-power-plant-to-reduce-pollution-following-30hour-protest-42524.html>.
116. Htoo Thant. "New environmental impact rules released." *The Myanmar Times*, January 15, 2016. <http://www.mmtimes.com/index.php/business/18490-new-environmental-impact-rules-released.html>.
117. Interview with members of Vishnu Law Group, the private firm responsible for coordinating the draft law consultation meetings. Phnom Penh, Cambodia. October 2015.
118. Gary Sands. "Vietnam's New Leadership Tested by Environment Protests." *The Diplomat*. May 12, 2016. <http://thediplomat.com/2016/05/vietnams-new-leadership-tested-by-environment-protests/>
119. "Vietnam to tighten environmental monitoring: Deputy PM." *Vietnam Net Bridge*. July 19, 2016. <http://english.vietnamnet.vn/fms/government/160707/vietnam-to-tighten-environmental-monitoring--deputy-pm.html>.
120. Private conversations with an official from Cambodia's Ministry of Mines and Energy. Phnom Penh, Cambodia. February 2017.; Interview with official from Lao PDR's Ministry of Energy and Mines. Vientiane, Laos. February 2017.; Interview with utilities expert from Electricity Vietnam. Hanoi, Vietnam. October 2016.

121. Private conversation with official from Ministry of Energy and Mines. Vientiane, Laos. February 2017
122. Private conversation with two officials from the Ministry of Environment. Phnom Penh, Cambodia. February 2017.; Public comments in USAID. “Report recommends actions to increase Cambodia’s renewable energy use.” January 21, 2016. <https://www.usaid.gov/asia-regional/press-releases/jan-21-2016-report-recommends-actions-increase-cambodias-renewable-use>.
123. A feed-in tariff is a payment made to the producer for all electricity produced from a renewable energy source, even the amount that is locally used or otherwise not sold into the grid. It often includes an additional payment for electricity sold into the grid. This promotes both energy efficiency—because the producer makes more for electricity sold into the grid than used locally—and integration of renewables—whether commercial or household scale—into the national grid system.
124. Publicover, Brian. “Thailand offers long-term PV promise, but uncertainty over short term.” Solar Plaza. October 26, 2016. <http://www.solarplaza.com/channels/markets/11624/thailand-offers-long-term-pv-promise-uncertainty-over-short-term/>.
125. Private conversation with renewable energy policy expert. Bangkok, Thailand. March 2017.
126. Baker McKenzie. “Long-Awaited Policy for Solar Power Adopted.” April 19, 2017. <http://www.bakermckenzie.com/en/insight/publications/2017/04/long-awaited-policy/>.
127. Cuong, N.D. and Dersch, D. “Proposal of an appropriate support mechanism for wind power in Vietnam (Short Version).” GIZ, 2014. http://gizenergy.org.vn/media/app/media/PDF-Docs/Publications/Wind_Fit_Study.pdf; “Low feed-in tariffs deter wind power investors.” Vietnam Net. July 23, 2016. <http://english.vietnamnet.vn/fms/business/160761/low-feed-in-tariffs-deter-foreign-wind-power-investors.html>.
128. de Ferranti et al., 28-29.; also Business2Business Cambodia. “Opportunities and Barriers in Cambodia’s Solar Market.” February 6, 2017. <https://www.b2b-cambodia.com/articles/opportunities-and-barriers-in-cambodias-solar-market/>.
129. Myanmar Business Forum. *Power Working Group Report*. March 2017. Page 3. <http://myanmar-businessforum.org/wp-content/uploads/2017/04/MBF-Power-Working-Group-Position-Paper-March-2017-English.pdf>.
130. Ibid, 1 and 4.
131. Lao People’s Democratic Republic. *Renewable Energy Development Strategy in Lao PDR*. October 2011. Page 14. <http://www.eepmekong.org/index.php/resources/country-reports/laos/57-laos-06/file>.
132. Magee and Hennig.
133. Private conversation with Huaneng Vice President. Kunming, China. February 2016.
134. Asian Development Bank, *GMS Power Trade and Interconnection, 1*.
135. Asian Development Bank. *Summary of Proceedings: 19th Meeting of the GMS Regional Power Trade Coordination Committee (RPTCC-19)*. January 2016. <https://www.adb.org/sites/default/files/publication/178869/rptcc-19-summary-proceedings.pdf>.
136. “Pleiku’s 2 500kv transformers ready to receive power from Laos.” Nanluong News. June 16, 2016. <http://nangluongvietnam.vn/news/en/electricity/pleiku-2s-500kv-transformers-ready-to-receive-power-from-laos.html>.
137. Asian Development Bank. *Greater Mekong Sub region Economic Cooperation Program: Regional Investment Framework Pipeline of Potential Projects (2013-2022)*. December 2013. Page 30. <https://www.adb.org/sites/default/files/publication/42581/gms-rif-pipeline-potential-projects-2013-2022-june2014.pdf>.
138. Ibid.

139. Asian Development Bank. *ASEAN Plan of Action for Energy Cooperation (APAEC) 2016-2025*. ASEAN Center for Energy, 2015. <http://www.aseanenergy.org/wp-content/uploads/2015/12/HighRes-APAEC-online-version-final.pdf>.
140. “Malaysia to buy power from Laos via Thai power grid.” *Vientiane Times*. September 23, 2016. http://www.vientianetimes.org.la/FreeContent/FreeConten_Malaysia.htm.
141. Interview with a researcher from the ASEAN Center for Energy. Jakarta, Indonesia. February 2017.
142. Asian Infrastructure Investment Bank. *AiIB Energy Sector Strategy: Sustainable Energy for Asia Discussion Draft for Consultation*. January 2017. Page 17. <https://www.aiib.org/en/policies-strategies/strategies/.content/index/Energy-Strategy-Discussion-Draft.pdf>.
143. Groobey, Chris, John Pierce, Michael Faber, and Greg Broome. *Project Finance Primer for Renewable Energy and Clean Tech Projects*. Wilson Sonsini Goodrich & Rosati Corporation, August 2010. https://www.wsgr.com/PDFSearch/ctp_guide.pdf.
144. Hashizume, Shuji. *Cambodia’s First Utility-scale Solar Plant*. Asian Development Bank, February 1, 2017. http://www.climateinvestmentfunds.org/sites/default/files/knowledge-documents/srep_meeting_phnom_penh_01feb17_shuji_hashizume.pdf.
145. Kenning, Tom. “Vietnam introduces utility-scale solar FiT and rooftop net metering.” *PV Tech*. April 19, 2017. <https://www.pv-tech.org/news/vietnam-introduces-utility-scale-solar-fit-and-rooftop-net-metering>.
146. Duy Anh. “Genco 3 to build \$422 mn solar plants in Ninh Thuan.” *Vietnam Economic Times*. May 4, 2017. <http://vneconomicstimes.com/article/business/genco-3-to-build-422mn-solar-plants-in-ninh-thuan>.
147. Baker McKenzie. “Long-Awaited Policy for Solar Power Adopted.” April 19, 2017. <http://www.bakermckenzie.com/en/insight/publications/2017/04/long-awaited-policy/>.
148. *Ibid.*

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About Stimson

The Stimson Center is a nonpartisan policy research center working to solve the world's greatest threats to security and prosperity. Think of a modern global challenge: refugee flows, arms trafficking, terrorism. These threats cannot be resolved by a single government, individual, or business. Stimson's award-winning research serves as a roadmap to address borderless threats through collective action. Our formula is simple: we gather the brightest people to think beyond soundbites, create solutions, and make those solutions reality. We follow the credo of one of history's leading statesman, Henry L. Stimson in taking, "pragmatic steps toward ideal objectives." We are practical in our approach and independent in our analysis. Our innovative ideas change the world. The Stimson Southeast Asia program takes a pragmatic view of hydropower development in the region, recognizing the significant negative impacts from hydropower while also recognizing the political economy of regional development. Our team seeks to identify feasible alternatives that would lead to more sustainable outcomes than the current development trajectory.

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LETTERS FROM THE MEKONG

This is the fourth in the *Letters from the Mekong* series of issue briefs from the Mekong Policy Project, a long-term initiative at the Stimson Center that focuses on alternative solutions to transboundary environmental and food security and regional stability impacts arising from proposed hydropower dams on the mainstream and major tributaries of the Lower Mekong River. The Mekong Policy Project seeks to promote further awareness about these impacts and the need for a more coordinated development strategy among regional actors, policy-makers in riparian countries, donor governments to the MRC, and civil society actors. *Letters from the Mekong* draw from regular research trips that the Southeast Asia team makes to the region and will examine changing trends for hydropower development and perceptions among regional actors.

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