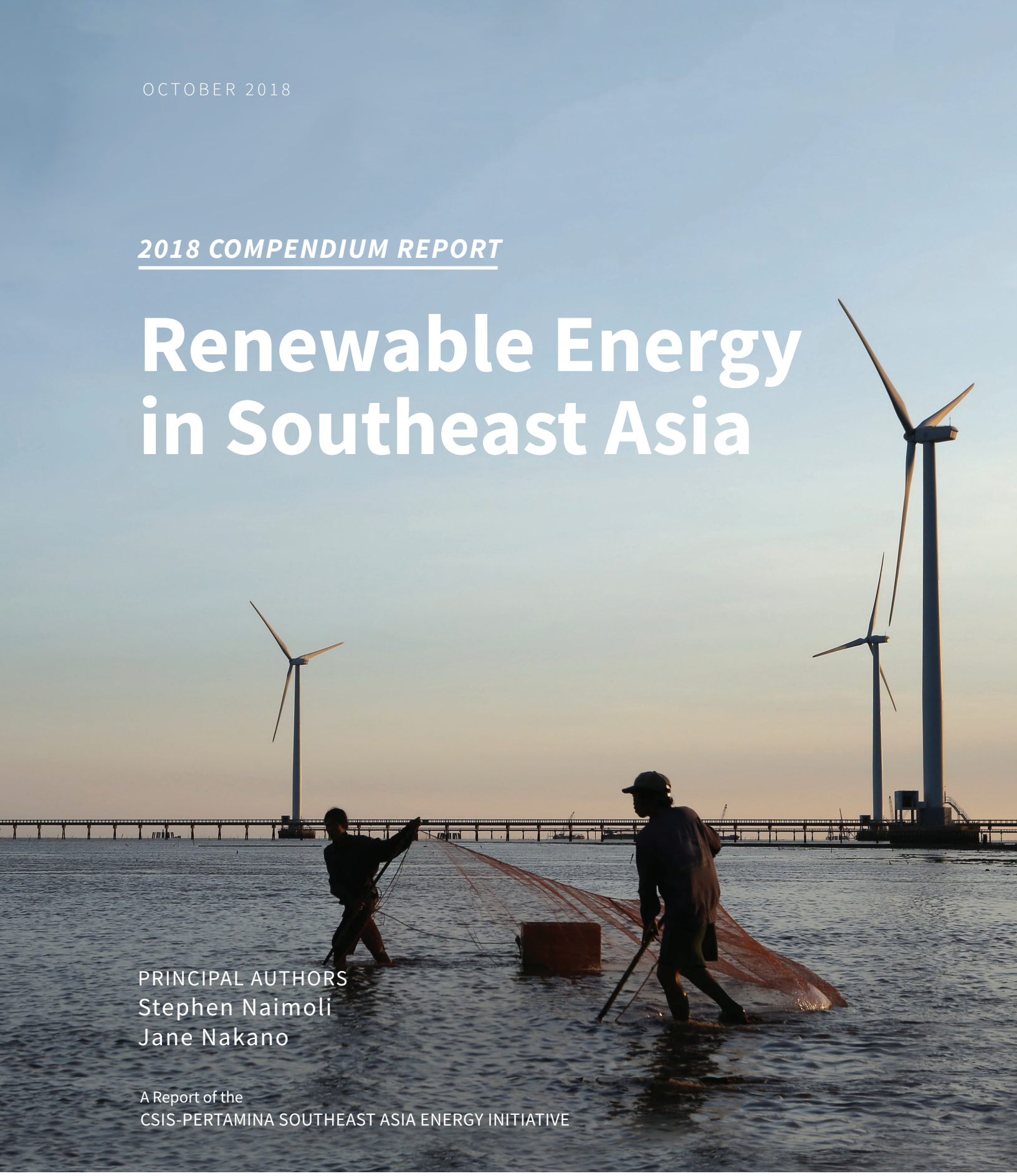
OCTOBER 2018

2018 COMPENDIUM REPORT

Renewable Energy in Southeast Asia



PRINCIPAL AUTHORS
Stephen Naimoli
Jane Nakano

A Report of the
CSIS-PERTAMINA SOUTHEAST ASIA ENERGY INITIATIVE

CSIS | CENTER FOR STRATEGIC & INTERNATIONAL STUDIES

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The series is made possible by the generous support of Pertamina.

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FOREWORD

This compendium report provides a summary of insights from a series of events held by the Center for Strategic and International Studies (CSIS) in 2018 as part of the CSIS-Pertamina Southeast Asia Energy Security Initiative. This initiative, co-directed by the CSIS Energy and National Security Program and the CSIS Southeast Asia Program, seeks to increase attention and understanding about Southeast Asia energy issues in the United States. The activities in 2018 focused specifically on the role of renewable energy in Southeast Asia and its economic, political, and security importance in the Indo-Pacific through two off-the-record roundtables, a public forum, and resulting reports.

The first roundtable was held on April 13, 2018, and explored the outlook for the region's energy mix out to 2040, the state of renewable energy in Southeast Asia, and its role in the region's energy priorities.

The second roundtable was held on June 25, 2018, and explored the role of renewable energy in providing electricity to the region's 65 million residents who lack access.

A public forum, The State of the Indo-Pacific Clean Energy Transition, was held on September 26, 2018, and focused on grid regionalization and clean energy financing in Southeast Asia.

These discussions brought together government, industry, financial, and policy experts to examine the most important energy issues affecting Southeast Asia and their broader strategic significance to regional and global energy security.

JUNE 2018

RENEWABLE ENERGY IN SOUTHEAST ASIA

Fuel Competition in the Expanding Power Market

Adobe Stock

ABOUT THE ROUNDTABLE

This report summarizes the discussion from a CSIS roundtable held on April 13, 2018, as part of the CSIS-Pertamina Southeast Asia Energy Initiative. The discussion brought together government, industry, and policy experts to explore the outlook for the region's energy mix out to 2040, the state of renewable energy in Southeast Asia, and its role in the region's energy priorities. This was the first in a series of roundtables that will be convened this year to examine the role of renewable energy in Southeast Asia and its security, economic, and political importance in the Indo-Pacific.

INTRODUCTION

NEXUS OF ECONOMIC GROWTH AND ENERGY IN SOUTHEAST ASIA

Southeast Asia is one of the fastest-growing regions in the world. The region's gross domestic product (GDP) grew 66 percent from 2006 to 2015[1] and, if all 10 countries were one economy, it would be the seventh largest in the world.[2] This growth is projected to increase, averaging just over 5 percent annually from 2018 to 2022.[3] With economic growth comes demand for energy. From 2000 to 2016, economic growth in Southeast Asia drove a 70 percent increase in primary energy demand.[4] Governments in Southeast Asia have implemented a range of policies and incentives to ensure they meet their energy demand. Renewable energy (wind, solar, geothermal, and sometimes hydro and biomass) is capturing an increasing, although not dominant, amount of attention from policymakers, investors, and the private sector as an important part of meeting this demand. Renewable energy's share of the electric power mix is driven by a range of factors—the economics of power generation, efforts to reduce greenhouse gas emissions, energy security concerns, and concerns over local air pollution.

While renewable energy is set to grow as a share of the region's energy mix, there are indications that its potential contribution is much higher than is currently on track to be realized. Renewable energy increasingly competes on an economic basis in many countries against all fuels except coal, but sometimes political and socioeconomic factors stand in the way of improving their competitiveness in specific markets. The region is also attracting a great deal of outside investor interest. Countries from around the region and ever farther afield are investing in Southeast Asia's energy sector because of the rapid growth experienced over the last decade and half, and their investment priorities, along with economics, shape their investment decisions in Southeast Asia. Energy policy and investment decisions are also being driven by the shifting nature of supply-and-demand balances in each country and the shifting domestic realities that come from becoming a net importer of specific fuels, such as in Indonesia. Many Southeast Asian countries have integrated low- or

1. Asia Matters for America, "ASEAN GDP and GDP per capita," accessed May 9, 2018, http://www.asiamattersforamerica.org/asean/data/gdppercapita.
2. Shirley Santoso, "ASEAN in the next 50 years: How the region can remake its future in manufacturing," World Economic Forum, January 5, 2018, https://www.weforum.org/agenda/2018/01/asean-50-remake-future-manufacturing-4ir.
3. Organization for Economic Cooperation and Development (OECD), *Economic Outlook for Southeast Asia, China and India 2018: Fostering Growth through Digitalisation* (Paris: OECD Publishing, 2018), https://www.oecd.org/dev/SAEO2018_Preliminary_version.pdf.
4. International Energy Agency, *World Energy Outlook Special Report: Southeast Asian Energy Outlook 2017* (Paris: OECD/IEA, 2017), https://www.iea.org/publications/freepublications/publication/WEO2017SpecialReport_SoutheastAsiaEnergyOutlook.pdf.

zero-carbon renewable energy into their energy planning efforts, and this report examines the dynamics of the power sector in Southeast Asia and how renewable energy competes with fossil fuel sources of electricity.

Regional Electricity Mix

Coal, natural gas, and hydropower are the three main sources of electricity generation in Southeast Asia, but the share of each has been shifting over time. According to the International Energy Agency, coal-fired generation grew an average of 9.8 percent per year from 2000 to 2016, and now accounts for about one-third of the electricity mix.[5] Natural gas also accounts for over one-third of generation; however, its share is declining somewhat as coal rises. Oil, once a significant source of electricity, now accounts for about 4 percent of generation, having been squeezed out by coal and natural gas. In the countries in the Lower Mekong Basin (namely, Cambodia, Laos, Myanmar, and Thailand), hydropower is a major and growing source of electricity as well. Hydro accounted for 14 percent of the region's electricity in 2016, and, given the low price of hydropower and the abundance of resources, there could be plentiful opportunities for further expansion of capacity. Other renewable energy sources, such as bioenergy, geothermal, solar, and wind, currently make up a very small part of Southeast Asia's generation mix, but resource availability and declining costs could grant them significant room to grow. Collectively, the 10 members of the Association of Southeast Asian Nations (ASEAN) have pledged to increase renewable energy's share in the region's total primary energy supply to 23 percent by 2025,[6] from 13.6 percent today,[7] and several countries have set their own targets. The Philippines, for example, have set a target of 15 gigawatts (GW) installed capacity by 2030,[8] from 4.7 GW today, and Malaysia is targeting 2,080 megawatts (MW) in 2020,[9] from 559 MW today.

KEY TAKEAWAY 1

RENEWABLE ENERGY IS SET TO GROW IN SOUTHEAST ASIA, AND THERE IS POTENTIAL FOR GROWTH BEYOND THE COUNTRIES' TARGETS

Southeast Asia's power markets are undergoing profound change as rapidly growing GDP brings significant demand for electricity. Power demand in the region is expected to continue to grow dramatically, more than doubling by 2040, and renewable energy is expected to contribute significantly to meeting this demand. The

5. Ibid.
6. ASEAN Centre for Energy, "Programme Area: Renewable Energy," accessed May 3, 2018, http://www.aseanenergy.org/programme-area/re/.
7. ASEAN Centre for Energy, *The 5th ASEAN Energy Outlook* (Jakarta: ACE, 2017), http://cloud.aseanenergy.org/s/eWoeOavzTA8JrLF.
8. Philippines Department of Energy, *Renewable Energy Plans and Programs (2011–2030)*, https://www.doe.gov.ph/sites/default/files/pdf/nrep/nrep_books_021-087_re_plans_programs.pdf.
9. Government of Malaysia, *Eleventh Malaysia Plan 2016–2020: Anchoring Growth on People* (Kuala Lumpur: Percetakan Nasional Malaysia Berhad, 2015), https://policy.asiapacificenergy.org/sites/default/files/11th%20Malaysia%20plan.pdf.

major markets of Indonesia, Malaysia, the Philippines, and Thailand are likely to see significant investments in electricity generation capacity in the next few decades if governments let economics play its role. In these countries, $430 billion is expected to be invested in power generation capacity between 2017 and 2040, with two-thirds of that investment going to renewable energy.[10] As seen in Figure 1, installed capacity in these four countries is expected to rise from about 130 GW in 2012 to 450 GW in 2040, driven largely by growth in solar photovoltaics and coal.

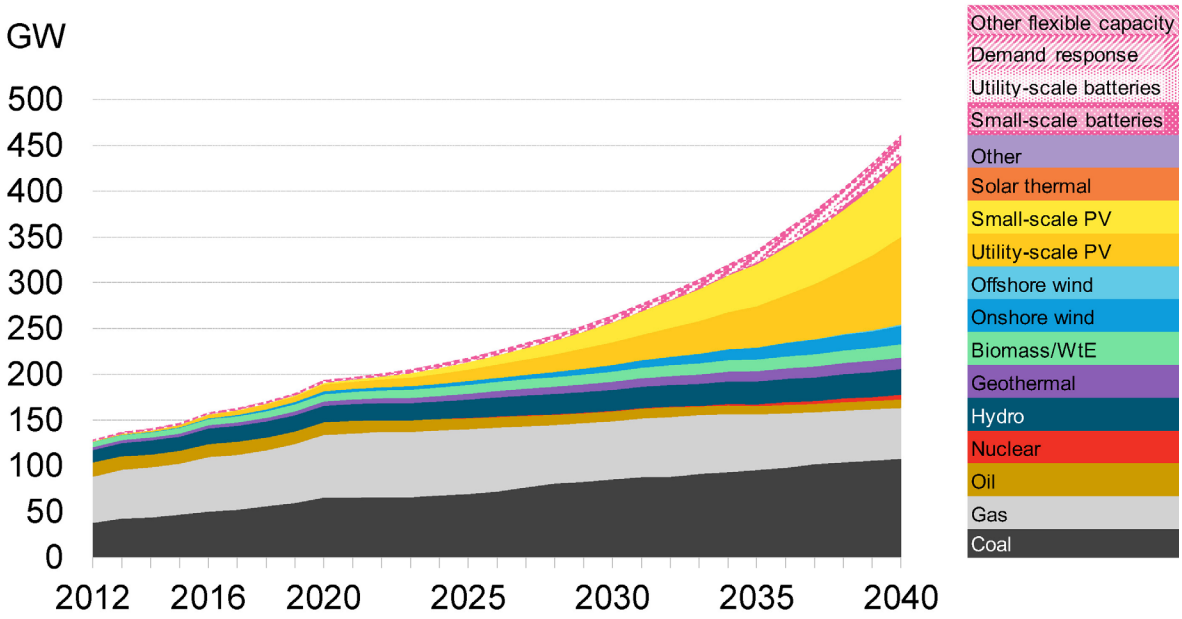

Figure 1: Cumulative installed capacity across Thailand, Indonesia, Malaysia and Philippines by technology.
Source: Bloomberg New Energy Finance.

In terms of output, Figure 2 shows that the fuel mix in 2040 is forecast to comprise coal at 45 percent and renewables at 40 percent while the remainder is expected to come predominantly from natural gas and a small volume of nuclear energy. Of the various renewable energy sources, solar dominates in this forecast, followed by wind. Biomass, geothermal, and hydro are each expected to make up a smaller share of renewable energy generation in the region. Meanwhile, coal remains the largest single fuel source, soaring from about 250 terawatt-hours (TWh) in 2018 to about 600 TWh in 2040 because it is cheap and abundant in the region.

Several of the Southeast Asian nations have committed to renewable energy targets over the next few decades. These targets are driven by commitments agreed to in the Paris Agreement, concerns about energy security, and efforts to reduce local air pollution. Analysis from Bloomberg New Energy Finance shows that for three of the major markets of Thailand, Malaysia, and the Philippines, current goals can be strengthened based on the cost competitiveness of renewables. Thailand, the region's largest solar market, has set a renewable energy target of 20 percent of generation by 2036, from 8 percent today.[11] This target can be more than doubled—the country can generate

10. Bloomberg New Energy Finance, *New Energy Outlook 2017* (New York: BNEF, 2017).
11. Thai Ministry of Energy, *Thailand Power Development Plan 2015–2036* (Ministry of Energy, 2015), https://www.egat.co.th/en/images/about-egat/PDP2015_Eng.pdf.

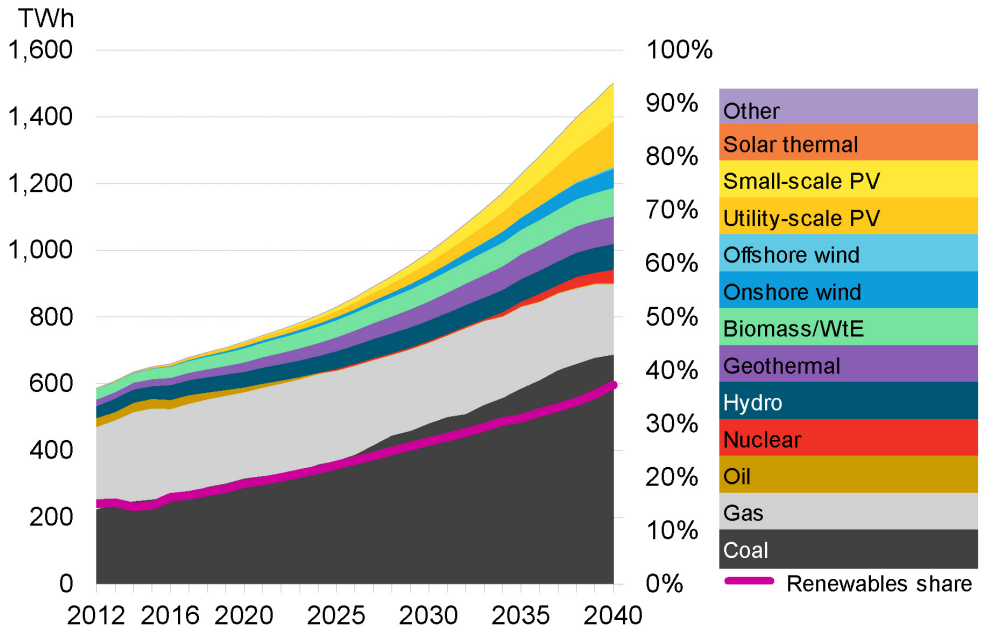

Figure 2: Electricity generation, by technology

Source: Bloomberg New Energy Finance.

over 40 percent of its electricity from renewables if the government continues to exploit the country's high solar potential along with wind and biomass. Malaysia's target calls for 10 percent of generation by 2040, from 7 percent today,[12] but it can reach over 25 percent by meeting its potential for solar power. The target set by the Philippines is closer to its capability. The country calls for 35 percent by 2030, from 25 percent today,[13] and it can reach closer to 40 percent by minimizing delays in regulatory clearance and increasing wind and solar penetration. Meanwhile, Indonesia is the only major Southeast Asian market that may have overestimated its potential. The country has a target of 23 percent by 2025, from 11 percent today,[14] but it may fall slightly short because developers are deterred by low renewable energy feed-in tariffs.[15]

As the regional economies strive to ascertain the role that renewable energy resources may play in meeting future electricity requirements, properly estimating demand becomes essential. As developing countries transition from manufacturing-based economies to a more service-based economy, they tend to use energy more efficiently. As a result, power demand forecasts that assume lower efficiency can overestimate demand growth. There is already some evidence of this occurring

12. Suruhanjaya Tenaga (Energy Commission), *Peninsular Malaysia Electricity Supply Outlook 2017* (Putrajaya: Energy Commission, 2017), https://www.st.gov.my/index.php/en/download-page/category/106-outlook?download=649:peninsular-malaysia-electricity-supply-industry-outlook-2017.
13. Republic of the Philippines Department of Energy, "Power Generation Mix," accessed May 10, 2018, https://www.doe.gov.ph/energy-resources?q=energy-resources/powermix.
14. International Energy Agency, "Indonesia: Electricity and Heat for 2015," accessed May 8, 2018, https://www.iea.org/statistics/statisticssearch/report/?country=INDONESIA&product=electricityandheat&year=2015.
15. Satya Hangga Yudha Widya Putra, "Can Indonesia Reach 23% Renewable Energy By 2025?," *GlobeAsia*, July 7, 2017, http://www.globeasia.com/columnists/can-indonesia-reach-23-renewable-energy-2025/.

in Southeast Asia. In 2016, Indonesia's 10-year Electricity Supply Business Plan (abbreviated as RUPTL) called for 76 GW of new capacity additions from 2016 to 2025, assuming an 8.3 percent of annual electricity growth. When demand growth came in at only 7 percent in 2017, the updated plan revised the 2018–2027 capacity target down to 56 GW based on a revised, assumed growth rate of 6.86 percent.[16] This may even be too high. Analysis from Bloomberg New Energy Finance shows that Indonesia's demand growth could be met with 30 GW of additional capacity between 2016 and 2026—less than half of what the government's plan called for in 2016.[17]

KEY TAKEAWAY 2

CLIMATE CHANGE IS AN IMPORTANT ISSUE FOR THE REGION BUT NOT NECESSARILY THE PREDOMINANT DRIVER OF RENEWABLE ENERGY GROWTH

The negative effects of climate change are likely to have an outsized impact on Southeast Asia, whose low-lying major cities and abundance of agricultural activity along coasts and floodplains will make it particularly vulnerable to rising sea levels, increased heat-related deaths, and extreme weather events.[18] As a major source of climate-forcing greenhouse gas (GHG) emissions, the power sector is an important place to look for solutions to mitigate the effects of climate change. The Southeast Asian nations have formed a working group on climate change,[19] and many nations have pledged to cut GHG emissions, including Indonesia—which has pledged to cut emissions by 29 percent from a business-as-usual scenario by 2030[20]—and Singapore, which has pledged to cut emissions per dollar of GDP by 36 percent from 2005 levels by 2030.[21] Many Southeast Asian countries have integrated low- or zero-carbon renewable energy into their energy planning efforts, but climate change may not be the dominant force driving these plans. The adoption of renewables in Southeast Asia does seem to be driven in part by international pressure to reduce GHG emissions, but supply diversity and concerns over air pollution are much more visible factors.

In 2016, nearly every country in the world agreed to set goals to limit global temperature rise to under 2 degrees Celsius, with an aspirational target of 1.5 degrees.

16. Viriya P. Singgih, "PLN puts 22,000 MW power plant projects on hold," *The Jakarta Post*, March 14, 2018, http://www.thejakartapost.com/news/2018/03/14/pln-puts-22000-mw-power-plant-projects-on-hold.html.
17. BNEF, *New Energy Outlook 2017.*
18. Asian Development Bank, *Southeast Asia and the Economics of Global Climate Stabilization* (Manila: ADB, 2015), https://www.adb.org/sites/default/files/publication/178615/sea-economics-global-climate-stabilization.pdf.
19. ASEAN Cooperation on Environment, "ASEAN Cooperation on Climate Change," accessed May 9, 2018, https://environment.asean.org/asean-working-group-on-climate-change/.
20. Republic of Indonesia, *First Nationally Determined Contribution* (2016), http://www4.unfccc.int/ndcregistry/PublishedDocuments/Indonesia%20First/First%20NDC%20Indonesia_submitted%20to%20UNFCCC%20Set_November%20%202016.pdf.
21. National Climate Change Secretariat, *Singapore's Climate Action Plan: Take Action Today, For a Carbon-Efficient Singapore* (Singapore: National Climate Change Secretariat, 2016), https://sustainabledevelopment.un.org/content/documents/1545Climate_Action_Plan_Publication_Part_1.pdf.

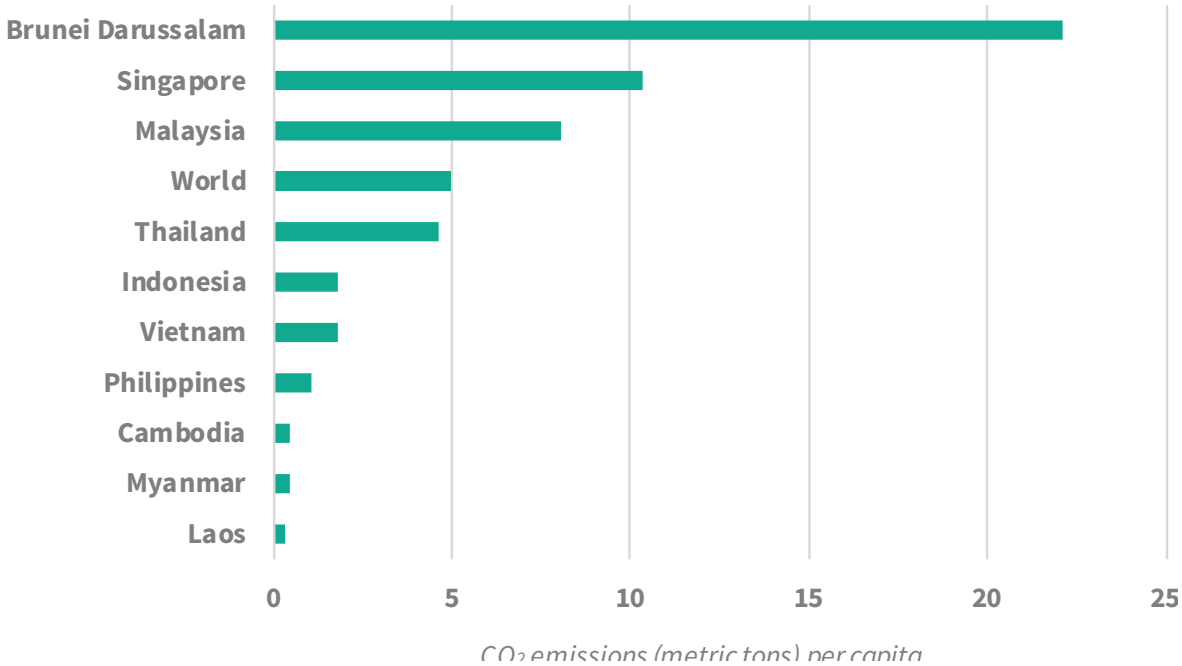

Figure 3: CO_2 emissions per capita in ASEAN nations and world average
Source: World Bank.

Although some countries have historically contributed more climate-forcing GHG emissions than others, the international consensus became that every country has a part to play. As shown in Figure 3, carbon emissions per capita in most Southeast Asian countries are lower than the world average. However, every Southeast Asian country has submitted a Nationally Determined Contribution to the Paris Agreement. It appears that although Southeast Asian countries are not contributing significantly to climate change, they are keenly aware of the issue and wish to have a seat at the table in international climate negotiations.

Southeast Asian nations are also concerned about relying on too few sources of electricity to power their economies. Thailand's most recent Power Development Plan, for example, cites a need to meet increasing demand while reducing dependence on any one individual fuel to balance energy security concerns.[22] Vietnam's director of renewable energy in the Ministry of Industry and Trade has cited similar reasons, laying out the country's strategic goals of decreasing dependence on fossil fuels and strengthening energy security.[23] In this sense, energy security is conceptualized as remaining resilient should a country experience supply shortages or interruptions, but as this report discusses later, the region also sees it as a need to increase reliance on domestic, rather than foreign, supply.

While climate change poses clear long-term risks to Southeast Asia, the effects of air pollution are much more immediate and easily identifiable. As seen in Figure 4, air quality in most Southeast Asian countries is in the "moderate" category as rated by the U.S. Environmental Protection Agency's Air Quality Index—better than the

22. Thai Ministry of Energy, *Thailand Power Development Plan 2015–2036.*
23. Pham Trong Thuc, "Vietnam Renewable Energy development project to 2030 with outlook to 2050," Presentation, http://www.vn.undp.org/content/dam/vietnam/docs/Publications/Mr%20Thuc.pdf.

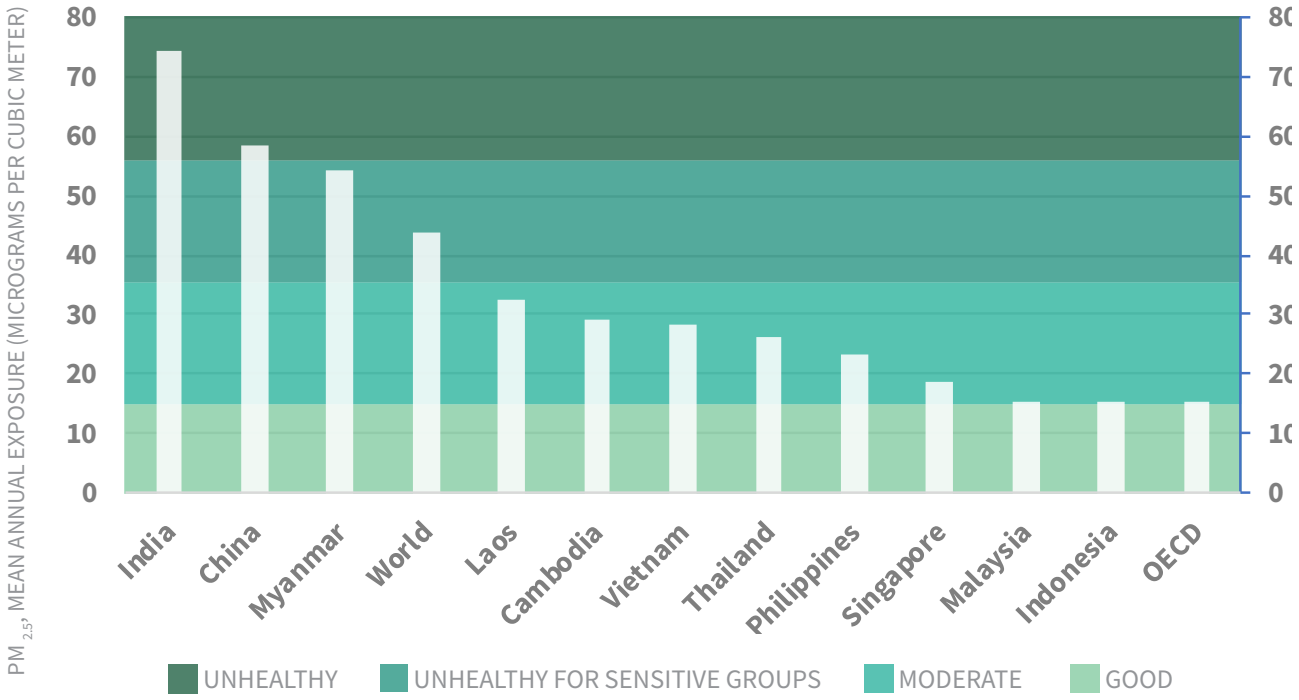

Figure 4: 2015 Mean Annual Exposure to Air Pollution ($PM_{2.5}$) in Southeast Asia and selected countries
Source: World Bank and U.S. Environmental Protection Agency.

world average, but still behind the average in high-income countries (with the exception of Myanmar, which has higher pollution than the world average).

Local air quality[24] can vary widely from national averages—for example, as seen in the figure above, the average annual $PM_{2.5}$ exposure in Indonesia is 15 µg/m³. In Jakarta, however, the average annual $PM_{2.5}$ exposure in 2015 was 40 µg/m³, four times the World Health Organization's air quality guideline.[25] In Hanoi, average $PM_{2.5}$ concentration was even higher at 42.6 µg/m³ in 2017.[26] While the International Energy Agency predicts a slight decline in $PM_{2.5}$ emissions by 2040, they expect that a significant buildout of new coal plants in the region will increase emissions of other air pollutants such as NO_x and SO_2, which will contribute to 300,000 premature deaths in 2040.[27] Unlike traditional fossil fuel-based power generation, renewable energy generation emits little to no air pollution,[28] so many countries see renewable energy as an option to prevent the worsening of air quality.

24. Particulate matter less than 2.5 micrometers (µg) in diameter, abbreviated as PM2.5, can be inhaled deep into the lungs and penetrate directly into the bloodstream, potentially exacerbating heart or lung diseases, respiratory issues, or heart conditions. PM2.5 is emitted directly from sources such as fires and construction sites and is also formed in the atmosphere with the reaction of pollutants such as SO2 and NOx, which are emitted from combustion in power plants or automobiles (U.S. Environmental Protection Agency, "Particulate Matter (PM) Basics," accessed May 29, 2018, https://www.epa.gov/pm-pollution/particulate-matter-pm-basics).
25. Erica Petrofsky, "Health Organizations, Help Indonesia Kick the Coal Habit," International Institute for Sustainable Development, September 18, 2017, http://www.iisd.org/gsi/subsidy-watch-blog/health-organizations-help-indonesia-kick-coal-habit.
26. Nguyen Thi Anh Thu and Lars Blume, *Air Quality Report: Air quality in Vietnam in 2017* (Hanoi: Green Innovation and Development Centre, 2018), http://en.greenidvietnam.org.vn/view-document/5af-836ca5cd7e87c49ee7e52.
27. International Energy Agency, *World Energy Outlook Special Report.*
28. Union of Concerned Scientists, "Benefits of Renewable Energy Use," accessed May 22, 2018, https://www.ucsusa.org/clean-energy/renewable-energy/public-benefits-of-renewable-power.

KEY TAKEAWAY 3

THE SOUTHEAST ASIAN ELECTRICITY SECTOR IS A MAJOR FOCUS FOR FOREIGN INVESTMENT

Expansion of regional electricity needs presents a significant opportunity for foreign investment. According to the International Energy Agency, modernizing the regional electricity infrastructure requires US$1.2 trillion of investment between now and 2040.[29] A pathway in line with the Paris Agreement and the United Nations Sustainable Development Agenda would require an extra $300 billion and greater investment in renewables than in fossil fuels or in transmission and distribution assets. Several countries around the region are leading investors in Southeast Asia. China sees a clear opportunity to shape the development of Southeast Asia and plans to direct a significant resource toward the ASEAN member countries. Since 2003, China has invested US$138 billion in power generation worldwide, $66 billion of which has been in Southeast Asia.[30] Chinese investments in the Southeast Asian energy sector include those in renewable energy. For example, China's sovereign fund CIC Investment Corporation is a partner in the acquisition of Singapore-based renewable energy developer Equis Energy,[31] and various other Chinese corporations are also investing in individual renewable projects in the region.[32]

Japan also sees an opportunity in Southeast Asia. The Japan Bank for International Cooperation and the Japan International Cooperation Agency have collectively invested over $1.5 billion in renewable energy, such as hydro, wind, and solar projects, in Southeast Asia since 2009.[33] Moreover, South Korea has also joined its East Asian neighbors in showing an interest in Southeast Asia. The Export-Import Bank of Korea invested $150 million in renewables in Southeast Asia from 2009–2016.[34] South Korean President Moon Jae-in announced the New Southern Policy in 2017, pledging to increase cooperation with ASEAN nations in sectors including energy and transportation.[35] Private Korean investors have also shown an interest in developing

29. IEA, *World Energy Outlook Special Report.*
30. BNEF, "Chinese Power Companies' Global Investment Strategies," https://www.bnef.com/core/insights/17879.
31. Anshuman Daga, "U.S. fund, CIC snap up Equis Energy for $3.7 billion in bet on renewables," Reuters, October 24, 2017, https://www.reuters.com/article/us-equis-m-a-globalinfra/u-s-fund-cic-snap-up-equis-energy-for-3-7-billion-in-bet-on-renewables-idUSKBN1CU053.
32. Tim Buckley and Simon Nicholas, *China's Global Renewable Energy Expansion: How the World's Second-Biggest National Economy Is Positioned to Lead the World in Clean-Power Investment* (IEEFA, 2017), http://ieefa.org/wp-content/uploads/2017/01/Chinas-Global-Renewable-Energy-Expansion_January-2017.pdf.
33. International Renewable Energy Agency, *Renewable Energy Market Analysis: Southeast Asia* (Abu Dhabi: IRENA, 2018), https://irena.org/-/media/Files/IRENA/Agency/Publication/2018/Jan/IRENA_Market_Southeast_Asia_2018.pdf.
34. Ibid.
35. Sohn JiAe, "President Moon unveils New Southern Policy for ASEAN," *Korea.net*, November 10, 2017, http://www.korea.net/NewsFocus/policies/view?articleId=151092.

wind and solar projects in Vietnam, and the Korean minister of trade, industry, and energy has indicated that the two countries could cooperate in developing renewable energy.[36]

Investment interests come from outside Asia, too. For example, the United States has made a significant commitment to the region's renewable energy development. The Overseas Private Investment Corporation invested over $400 million from 2009 to 2016, and the U.S. Agency for International Development is expected to guide $750 million into Southeast Asia for renewable energy over the next five years.[37] In Europe, Germany's development organization GIZ has partnered with the ASEAN Centre for Energy to improve cooperation within the region to better integrate renewable energy and France's Agence Française de Développement has invested $540 million in renewables in Southeast Asia.[38]

Furthermore, multilateral banks play a role in facilitating renewables deployment in the region. For example, the World Bank and the International Finance Corporation have collectively invested over $2 billion in Southeast Asian renewable energy since 2009 and the Asian Development Bank has invested over $1 billion.[39]

While renewable energy is beginning to attract foreign investment, coal appears to be a major focus for foreign investment, particularly from China, Japan, and South Korea. Although China is investing in renewable energy and cutting its coal use at home, it is increasingly investing in coal-fired power projects in other countries. Nguyen Tuan Anh, of Vietnam's Ministry of Planning and Investment, has indicated that Chinese investors are primarily interested in coal projects.[40] Like China, much of Japan's infrastructure investments in the region are coal projects as well.[41] These three countries participated in 18 coal projects in Indonesia between 2010 and 2017.[42] Coal financing is not only coming from outside Southeast Asia. Singapore's top three banks, DBS Bank, Oversea-Chinese Banking Corporation, and United Overseas Bank, provided financing for 21 coal projects between 2012 and 2018, over half of which were coal-fired power plants and most of which were in Vietnam and Indonesia.[43]

36. Vietnam News Agency, "Vietnam, RoK partner in power, renewable energy development," *VietnamPlus*, February 2, 2018, https://en.vietnamplus.vn/vietnam-rok-partner-in-power-renewable-energy-development/126026.vnp.
37. IRENA, *Renewable Energy Market Analysis.*
38. Ibid.
39. Ibid.
40. Lili Pike, "Is the Belt and Road compatible with Paris?," *China Dialogue*, December 12, 2017, https://www.chinadialogue.net/article/show/single/en/10284-Is-the-Belt-and-Road-compatible-with-Paris-.
41. Nicholas Leong, "ASEAN could face a crisis over its appetite for coal," *Global Risk Insights*, February 27, 2018, https://globalriskinsights.com/2018/02/asean-coal-energy-environment/.
42. Ibid.
43. David Fogarty, "Singapore banks DBS, OCBC and UOB funding coal projects despite climate risks: Study," *The Straits Times*, January 20, 2018, https://www.straitstimes.com/asia/se-asia/singapore-banks-dbs-ocbc-and-uob-funding-coal-projects-despite-climate-risks-study.

COUNTRY FEATURE / VIETNAM

Vietnam provides an interesting case of a rapidly growing economy in the midst of energy-sector reform. Driven largely by the industrial sector, electricity demand is 1,500 kWh per capita. Demand is expected to grow 8 percent per year through 2035. At the end of 2015, power generation capacity was 38.5 GW.[44] As shown in Figure 5, the generation mix in 2015 was 36.6 percent hydro, 33.2 percent gas, 30 percent coal, and less than 1 percent oil and non-hydro renewables.[45]

Vietnam has long hoped to build nuclear generation capacity, but concerns over cost, safety, and sluggish demand canceled recent plans.[46] The country has a target of 10 percent non-hydro renewables in power generation by 2030, up from a negligible amount today. EVN, formerly known as state-owned Vietnam Electricity, owns over 60 percent of generation capacity and owns the transmission and distribution systems. In the early to mid-2000s, EVN began "partial privatization," in which the government began selling a partial stake in the state-owned enterprise.[47] This process continues today with another state-owned power producer, Vinacomin.[48] The partial privatization of EVN preceded the establishment of the Competitive Generation Market, the first phase of power sector reform in the country that allowed independent power producers to compete to sell electricity to EVN. The Wholesale Electricity Market will be implemented in 2019, and will allow new distributors to buy electricity from generators to sell to EVN's retailers. By 2023, when the country fully implements the Electricity Retail Market, new retailers will be allowed to buy power on the wholesale market and sell to consumers.

44. EVN, *Vietnam Electricity Annual Report 2016* (Hanoi: EVN, 2017), http://www.evn.com.vn/userfile/files/2017/3/AnnualReport2016.pdf.
45. IEA, "Viet Nam: Electricity and Heat for 2015," accessed May 7, 2018, https://www.iea.org/statistics/statisticssearch/report/?country=VIETNAM&product=electricityandheat&year=2015.
46. Mai Nguyen and Ho Binh Minh, "Vietnam abandons plan for first nuclear power plants," Reuters, November 22, 2016, https://www.reuters.com/article/us-vietnam-politics-nuclearpower/vietnam-abandons-plan-for-first-nuclear-power-plants-idUSKBN13H0VO.
47. Aloysius Damar Pranadi, "The History and Roadmap of Power Sector Reform in Vietnam," ASEAN Centre for Energy, April 6, 2018, http://www.aseanenergy.org/blog/the-history-and-roadmap-of-power-sector-reform-in-vietnam/.
48. Diarmaid Williams, "Vietnam to sell large power firm as part of privatization process," *Power Engineering International*, July 27, 2017, http://www.powerengineeringint.com/articles/2017/07/vietnam-to-sell-large-power-firm-as-part-of-privatization-process.html.

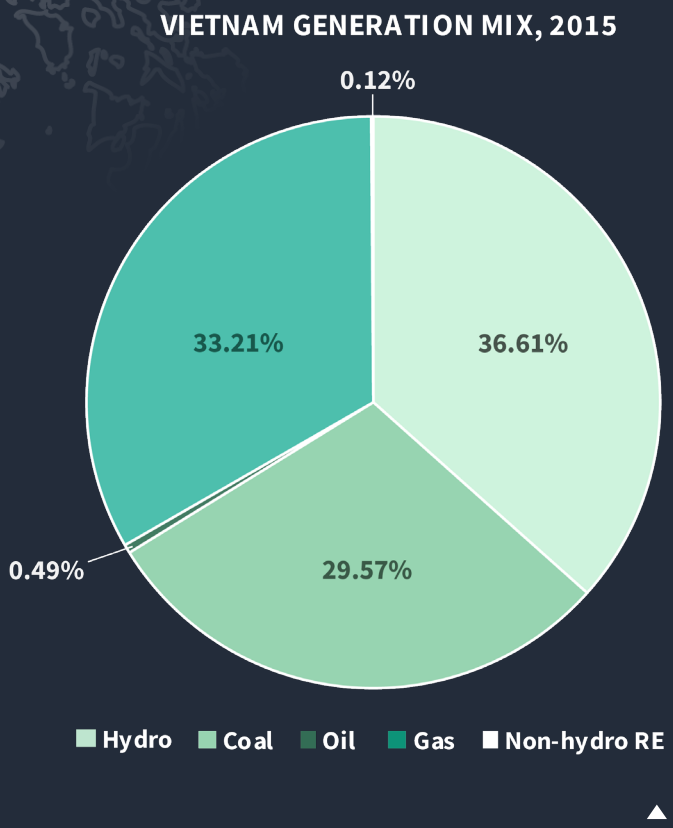

Figure 5: Electricity generation in Vietnam in 2015, by technology
Source: International Energy Agency.

There is potential for solar and offshore wind energy in Vietnam, especially along the country's southern coast. The Ministry of Industry and Trade reported in 2017 that there were 1.7 GW of solar projects proposed[49] and major international companies like Doosan of Korea and DNV GL of Norway are investing in offshore wind projects. However, there are financial issues plaguing the development of these projects, chiefly the level of the feed-in tariffs (FITs). The UN Development Programme has stated that Vietnam's FIT for wind power is too low for investors to recoup their costs. The solar power purchase agreement has been panned by international investors as nonbankable because, among other reasons, it does not guarantee compensation to generators when experiencing interruptions beyond their control.[50] The shift from the current market structure is expected to accompany an auction-based procurement process by 2021, which should create a more favorable environment for renewable energy development because competition should accelerate cost declines due to innovation and learning. Accordingly, power purchase agreements can more accurately reflect the true costs to producers and change as costs come down. In addition to financial issues, identifying land for development can be more difficult due to high population density.

49. Tom Kenning, "PV Talk: Vietnam received 'overwhelming response' to solar FiT, says MOIT official," *PV Tech*, September 13, 2017, https://www.pv-tech.org/interviews/pv-talk-vietnam-received-overwhelming-repsonse-to-solar-fit-says-moit-offic.
50. Giles T. Cooper et al., "Vietnam plays a calculated game of risk with new solar PPA," Duane Morris Vietnam, October 3, 2017, https://blogs.duanemorris.com/vietnam/2017/10/03/vietnam-plays-a-calculated-game-of-risk-with-new-solar-ppa/.

KEY TAKEAWAY 4

SHIFTING EXPORTING AND IMPORTING RELATIONSHIPS CAN ALTER FUEL PREFERENCE AND THUS THE REGION'S GRID MIX

Natural gas has historically played a large role in Southeast Asia's energy sector and trade. It is currently the region's largest source of electricity. Southeast Asia has more natural gas reserves than other developing regions, and historically has exported much more than it has consumed. Indonesia has the most recoverable gas reserves in Southeast Asia and is also the largest producer.[51] In Indonesia, as producers continue to explore the current recoverable reserves and domestic demand continues to grow, the country is increasingly left with resources that are difficult to develop, have high CO_2 content, and see a worsening investment environment. This has led to fuel switching from gas to another plentiful resource, which is coal. If current trends continue, gas consumption in Indonesia is expected to overtake production in the early 2020s and Indonesia may become a net importer of natural gas for the first time.

Import and export relationships are also likely to affect the use of coal. Indonesia is the world's top steam coal exporter.[52] Historically, India and China have been the largest importers of Indonesian coal, at 31 percent and 13 percent of Indonesia's exports, respectively.[53] However, both countries are attempting to shift away from imports to more domestic production.[54] If demand for Indonesian coal continues to fall over the long term, the country will likely shift its focus inward to domestic consumption. Regionally, this could put downward pressure on the price of coal, making it more attractive for fast-growing countries like the Philippines and Malaysia to choose coal over gas or renewables. If successful, this dynamic would likely change the generation mix all over the region and make ASEAN's renewable energy targets much more difficult to meet.

In many of the countries in the region, net imports of primary energy have increased from 2000 to 2015, with Vietnam's net imports becoming positive by 2015 (as shown in Figure 6).

51. World Energy Resources, "Southeast Asia & Pacific: Gas," accessed May 4, 2018, https://www.worldenergy.org/data/resources/region/southeast-asia-pacific/gas/.
52. World Coal Association, "Coal market & pricing: ASEAN's Energy Equation," accessed May 2, 2018, https://www.worldcoal.org/coal/coal-market-pricing.
53. Observatory of Economic Complexity, "OEC: Where does Indonesia export Coal Briquettes to? (2016)," accessed April 30, 2018, https://atlas.media.mit.edu/en/visualize/tree_map/hs92/export/idn/show/2701/2016/.
54. Meng Meng and Josephine Mason, "China coal imports to fall this year amid concerns about curbs," Reuters, April 10, 2018, https://www.reuters.com/article/us-china-coal-imports/china-coal-imports-to-fall-this-year-amid-concerns-about-curbs-idUSKBN1HH0SR; Clyde Russell, "India's changing coal imports show quality over quantity: Russell," Reuters, June 21, 2016, https://www.reuters.com/article/us-column-russell-coal-india-idUSKCN0Z70GI.

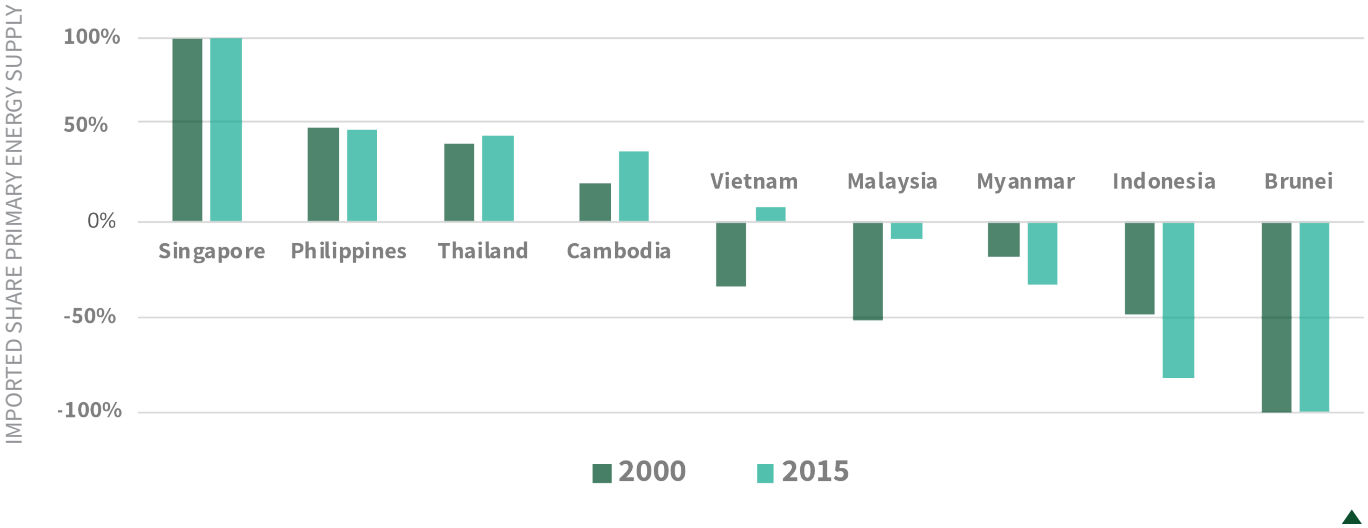

Figure 6: 2016 Net Imports of Primary Energy
Source: International Energy Agency.

This trend toward reliance on foreign supply has had implications for how each country views its energy security. As nations increasingly turn to imports to meet energy needs, they become much more exposed to potentially volatile global commodity markets. With the notable exceptions of Brunei and Indonesia, most countries in Southeast Asia do not have significant fossil fuel reserves. Renewable energy provides an attractive option for energy supply diversification and as an indigenous source of energy. However, the distribution of renewable energy resources is not equal—for example, solar and bioenergy potential are relatively well-distributed, but hydro potential is significant in Cambodia, Laos, Myanmar, and Thailand,[55] geothermal potential is limited to Indonesia and the Philippines, and wind potential is highest in Indonesia, the Philippines, Thailand, and Vietnam.[56] Singapore is notable in that it has no exploitable natural resources and no hydro, wind, or geothermal potential.[57] However, it does have solar potential, which the country is beginning to exploit. Given the unequal distribution of renewable resources in the region and rising electricity demand throughout the region, the ASEAN member countries have committed to increasing interconnection of their grids with the ultimate goal of building a regional ASEAN power grid.[58] The group responsible for the management of these projects, the Heads of ASEAN Power Utilities/Authorities, says an ASEAN power grid will enhance "ASEAN energy security," conceiving of energy security as a benefit for the bloc, rather than for each individual country.

55. IRENA, *Renewable Energy Market Analysis.*
56. IEA, *World Energy Outlook Special Report.*
57. Singapore Energy Market Authority, "Renewable Energy Overview," accessed May 10, 2018, https://www.ema.gov.sg/Renewable_Energy_Overview.aspx.
58. Heads of ASEAN Power Utilities/Authorities, "The HAPUA Council Members Joint Statement 2017," September 14, 2017, http://hapua.org/main/2017/09/14/the-hapua-council-members-joint-statement-2017/.

COUNTRY FEATURE / INDONESIA

Indonesia is by far the most populous country in Southeast Asia, but with the population spread out over more than 17,000 islands, population density is low. In 2016, power generation capacity was 59 GW. As shown in Figure 7, the generation mix in 2015 was 55.8 percent coal, 25.2 percent gas, 10.7 percent renewables, and 8.4 percent oil-fired electricity.[59]

Electricity generation is dominated mostly by state-owned Perusahaan Listrik Negara (PLN), which is also the country's sole distribution company. In addition to being a major consumer of coal, Indonesia is the top steam coal exporter in the world. Projections relying solely on the changing economics of electricity generation sources show that solar could capture a significant share of the market by 2040. Starting around 2020, small-scale PV installations would grow and utility-scale would start to catch up in the 2030s. By 2040, small-scale and utility-scale PV would each take 14 percent of generation capacity.[60] However, fossil fuels are expected to remain resilient—with the exception of oil falling to 3 percent, coal would still maintain a plurality with 35 percent, and gas's share at 13 percent. Meanwhile, geothermal and hydro would be 5 percent each, biomass at 3 percent, and the rest of capacity would be made up of onshore wind, nuclear, battery storage, demand response, and other flexible capacity.[61] There are a few reasons why this scenario may not play out as projected. As mentioned earlier, if Indonesia is unable to export as much coal as it would like, it will face issues with oversupply at home and likely curtail other generation sources in favor of coal. The other main reason is the political and economic influence of coal companies. Demand growth is lagging behind GDP growth, and thus the country's state-owned coal companies are struggling financially. In an effort to boost their finances, the country has guaranteed below-market rates to generators for fuel supply and plans to actually decrease the share of renewable energy after it meets its current target in 2025—from 23 percent in 2025 to 20.4 percent in 2027.[62]

Indonesia has faced technical difficulty developing its renewable energy resources as well. Although the government instituted the renewables FIT in 2016, it has not translated into actual buildout on a significant level, largely due to a lack of experience, manufacturing, or installers in the country—a challenge that can be overcome as the existing actors build capacity and learn from experience. An additional concern, however, is a new regulation set in 2017 that replaced the FIT with a price ceiling that prioritizes low average generation costs (see takeaway #5). This may lead to much lower prices paid to renewable energy producers, reducing the attractiveness of renewable energy development.

The country also benefits from 29 GW of geothermal potential—40 percent of the world's reserves.[63] However, only 6 percent of this potential has been realized. The

59. IEA, "Indonesia: Electricity and Heat for 2015."
60. BNEF, *New Energy Outlook 2017.*
61. Ibid.
62. Basten Gokkon, "Indonesia may achieve renewables target, but still favors coal for power," *Mongabay*, March 29, 2018, https://news.mongabay.com/2018/03/indonesia-may-achieve-renewables-target-but-still-favors-coal-for-power/.
63. Alexander Richter, "Indonesia and its challenges for geothermal development, IIGCE 2017, Aug 2–4,

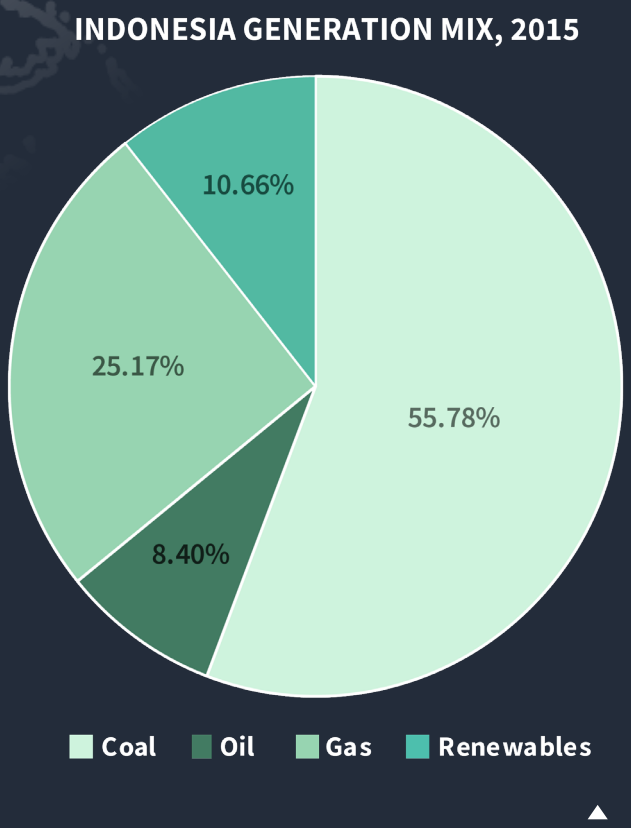

Figure 5: Electricity generation in Indonesia in 2015, by technology
Source: International Energy Agency.

government has set a goal of 6 GW of geothermal capacity by 2020 and 13.5 GW by 2040. There are various financial barriers to geothermal development that typically plague new power generation sources, such as high capital costs, lack of access to capital, and tariffs that discourage new market entrants. In addition to these financial issues, however, geothermal development in Indonesia has faced physical and permitting issues. Sixty percent of the country's geothermal reserves are located under protected forestland, in which mining is prohibited.[64] Because geothermal exploration was classified as a mining activity until 2014, this precluded geothermal development in conservation forests.[65] More fundamentally, modeling geothermal resources is difficult and there is a risk that estimated reserves will not materialize.[66] In 2017, the government revived the dormant Geothermal Fund Facility to mitigate some of the risks of geothermal exploration, with $240 million on offer.[67] Despite issues, geothermal development is moving forward in Indonesia, with the final unit of a 330 MW plant coming online in May 2018.[68]

Absent government intervention, the economics of solar and wind power will be more difficult than in other major Southeast Asian countries through 2040. Solar and wind are expected to consistently outcompete natural gas on a levelized cost of electricity (LCOE) basis starting in the next few years in Indonesia, Malaysia, the Philippines, and Thailand.[69] However, in the other three countries, either wind or solar is expected to outcompete coal in the 2020s (and both are expected to win in all three countries by 2035), but in Indonesia, coal is expected to remain cheaper through at least 2040.

2017," *ThinkGeoEnergy*, June 23, 2017, http://www.thinkgeoenergy.com/indonesia-and-its-challenges-for-geothermal-development-iigce-2017-aug-2-4-2017/.

64. Madjedi Hasan and Anton Wahjosoedibjo, "Indonesia's Geothermal Energy Development, Past and Challenges," *In Proceedings of World Geothermal Congress 2015, Melbourne, April 19–25, 2015*, https://pangea.stanford.edu/ERE/db/WGC/papers/WGC/2015/08001.pdf.
65. Rina Lee and Kim Farrar, "Indonesia relaxes regulation of the geothermal market," Simmons & Simmons Elexica, December 31, 2014, http://www.elexica.com/en/legal-topics/projects/29-indonesia-relaxes-regulation-of-the-geothermal-market.
66. Energy Research Knowledge Centre, *Overcoming Research Challenges for Geothermal Energy* (Belgium: European Union, 2013), https://setis.ec.europa.eu/energy-research/sites/default/files/library/ERKC_PB_Geothermal_ENEA.pdf.
67. Dwina Soerono, "Risk Mitigation and the Restructuring of Geothermal Funds in Indonesia," *ThinkGeoEnergy*, December 4, 2017, http://www.thinkgeoenergy.com/risk-mitigation-and-the-restructuring-of-geothermal-funds-in-indonesia/.
68. Ormat Technologies, Inc., "Sarulla Geothermal Power Plant Expands to 330 MW with Third and Final Unit Commencing Commercial Operation," News release, May 10, 2018, http://www.powermag.com/press-releases/sarulla-geothermal-power-plant-expands-to-330-mw-with-third-and-final-unit-commencing-commercial-operation/.
69. Bloomberg New Energy Finance, *New Energy Outlook 2017.*

KEY TAKEAWAY 5

SOCIOECONOMIC AND POLITICAL FACTORS CREATE BARRIERS TO RENEWABLES IN SOUTHEAST ASIA

Renewables have a potential for strong growth in Southeast Asia, but it is important to note that their growth could be hindered by a number of factors. Market structures are holding back growth for three reasons: lack of experience, unintended consequences of incentive structures, and investor risk. The markets for renewable energy in Southeast Asia are very new, and therefore local developers and utilities are not able to benefit from prior knowledge. To be sure, experience in Europe, the Americas, and Northeast Asia has driven down technology costs for developers, but the experience of project development in those regions and countries, while valuable, is not always directly transferable to these new markets. The learning curve will improve as the market matures, but in the immediate future, a lack of direct experience translates into prices higher in the region.

Ironically, another market structure issue discouraging growth in some markets is one that encouraged growth to begin with. Renewable energy deployment has been driven largely by feed-in tariffs (FITs), in which the government pays a guaranteed price to a developer for electricity delivered. In the region's more mature renewable energy markets, such as Thailand's solar market, FITs have helped encourage enough supply to jumpstart a nascent industry. However, as markets mature, FITs tend to discourage demand for projects because while innovation brings down the cost of production, FIT rates do not necessarily decrease accordingly, so electricity prices for consumers are unnecessarily high. Some Southeast Asian countries are seeking to solve this by shifting to reverse auctions, in which companies bid for the right to build projects. In other parts of the world, an increasing number of countries are switching from FITs to auctions, which has exerted downward pressure on average prices as developers compete to provide the required services at the lowest cost.[70] Auctions are much newer in Southeast Asia than in other regions, so further study is required once the region has gained more experience with the model. In the auctions that have been conducted so far, governments are seeing higher bids relative to other countries such as Chile, India, or Saudi Arabia. Part of this is simply due to developers pricing risk into their bids. When making their bids, developers include factors such as component costs, profit margins, and margins to minimize risk. Because some utilities in Southeast Asia have a history of missing payments to operators, developers are concerned about bankability. The potential remedy for this is for outside actors, perhaps multilateral development banks, to help "de-risk" investments in renewables.

Another example of market structures causing unintended consequences for renewable energy comes from Indonesia. Prior to 2017, the government paid a FIT

70. Chris Warren, "As Feed-In Tariffs Wane, Auctions Are Enabling the Next Wave of Solar Cost Improvements," Greentech Media, May 10, 2016, https://www.greentechmedia.com/articles/read/as-feed-in-tariffs-wane-auctions-are-causing-the-next-wave-of-solar-cost-im#gs.H_ilDXc.

based on the cost of production. Facing complaints from state-owned distribution company PLN that this was driving up the average cost of production, the Ministry of Energy and Mineral Resources established a new price ceiling that caps payments at or below the average price of production in a particular region.[71] While this is intended to stabilize or lower the cost of production, there are concerns that it will make progressively more renewable energy projects uneconomical as increasing low-cost coal production drives down the average price of production.[72] Aside from the market structure related challenges, a long-term challenge for the region will be ensuring the electric grid system can accommodate intermittent sources of electricity if there is a significant increase in the share of renewables in the electricity mix.

CONCLUSIONS AND RECOMMENDATIONS

Rapidly growing Southeast Asia is set to see a significant increase in electricity demand. It is likely that renewable energy will grow to capture some of that increase, but government policy will undoubtedly help shape what role it will play in meeting the region's energy needs. Climate change is not the main driver for renewable energy policy in these countries but pressure to take action on climate change is certainly one consideration—other salient factors are supply diversity, public health impacts, and a desire to attract new technologies, investment, and industry. The challenge of meeting rising electricity demand is attracting investment from within and without Southeast Asia, with investments ranging from coal-fired power generation assets to renewable energy. Relatedly, many countries in the region are grappling with the energy security implications of becoming net importers of energy for the first time and how that may change their energy and electricity mixes. Finally, countries seeking to develop renewable energy are dealing with various institutional and physical challenges that threaten to halt their progress.

Two major suggestions emerged from the workshop discussion. First, governments may wish to reexamine their electricity demand projections and their renewable energy targets to ensure they are delivering the optimal mix of power to their citizens. As rising demand necessitates further investments in generation capacity, it is important to ensure that electricity demand projections are reliable and that governments are building the resources that are delivering the greatest benefits to their citizens. Properly estimating demand is essential to ensure an appropriate buildout of electricity generation sources that does not impose unnecessary capital costs on citizens. Also, visions and targets for the

71. Michael Horn and Andhari Sidharta, "New Indonesian feed-in tariffs: Will renewables benefit?," DLA Piper, March 7, 2017, https://www.dlapiper.com/en/australia/insights/publications/2017/03/new-indonesian-feed-in-tariffs/.
72. Luke Devine, "Indonesian Government Puts the Squeeze on Renewable Energy Tariffs," Baker McKenzie, February 9, 2017, https://www.bakermckenzie.com/-/media/files/insight/publications/2017/02/indonesia-govt-renewable-energy-tariffs/al_indonesia_govtrenewableenergytariffs_feb2017.pdf?la=en.

electricity sector would benefit from a holistic approach to estimating financial/investment risk, environmental, climate, and trade implications of fuel choice. Reexamining country-level targets for renewable energy based on current and future projections of the economics of renewable and fossil energy would ensure that Southeast Asian countries were shaping the optimal generation mix for their citizens.

Second, policymakers in Southeast Asia would benefit from ensuring energy policies are encouraging lowest-cost investments in an individual country's market. It is important for countries to ensure their policies are correctly calibrated for their markets. Feed-in tariffs have been particularly helpful in encouraging renewable energy development. For this purpose, it is necessary to ensure that FIT payments are set high enough to encourage investment in projects. However, once a FIT has sufficiently built up the renewable energy market, governments should reevaluate the policy and ensure that it is still set at the optimal rate. As the costs of labor and raw materials decline due to experience and technological advancements, reevaluating FIT levels can ensure they are not so high as to discourage innovation and force customers to pay unnecessarily high rates for electricity. To this end, undergoing periodic review of FIT rates could ensure they are achieving all desired objectives. If a FIT is deemed no longer necessary, policymakers may wish to evaluate whether shifting to an alternative procurement method, such as reverse auctions, would achieve the most cost-efficient results. With respect to the ASEAN Power Grid projects, to better facilitate multilateral electricity trading, it would be sensible for partner countries to collectively determine the optimal structures for their integrated markets.

SEPTEMBER 2018

RENEWABLE ENERGY IN SOUTHEAST ASIA

The Role of Renewables in Achieving Universal Access to Electricity in Southeast Asia

Adobe Stock

ABOUT THE ROUNDTABLE

This report summarizes the discussion from a CSIS roundtable held on June 25, 2018, as part of the CSIS-Pertamina Southeast Asia Energy Initiative. The discussion brought together government, industry, and policy experts to explore the role of renewable energy in providing electricity to the region's 65 million residents who are currently without it. This was the second in a series of events this year examining the role of renewable energy in Southeast Asia and its security, economic, and political importance in the Indo-Pacific region.

INTRODUCTION

ELECTRIFICATION IN SOUTHEAST ASIA

Southeast Asia enjoys a high level of electrification, but the region's diversity of economic development conditions, types of resource endowment, and topographical features (e.g., mountainous areas where it is difficult and costly to build transmission infrastructure and remote small islands that require infrastructure that crosses bodies of water) still leave room for improving electricity access. According to the International Energy Agency (IEA), approximately 90 percent of Southeast Asians have access to electricity.[1] This has increased dramatically since 2000, when the agency estimated the region's electrification rate at 62 percent. As seen in Figure 1, electrification rates in 2016 ranged from 58.8 percent in Myanmar to 100 percent in Brunei, Singapore, and Thailand.[2]

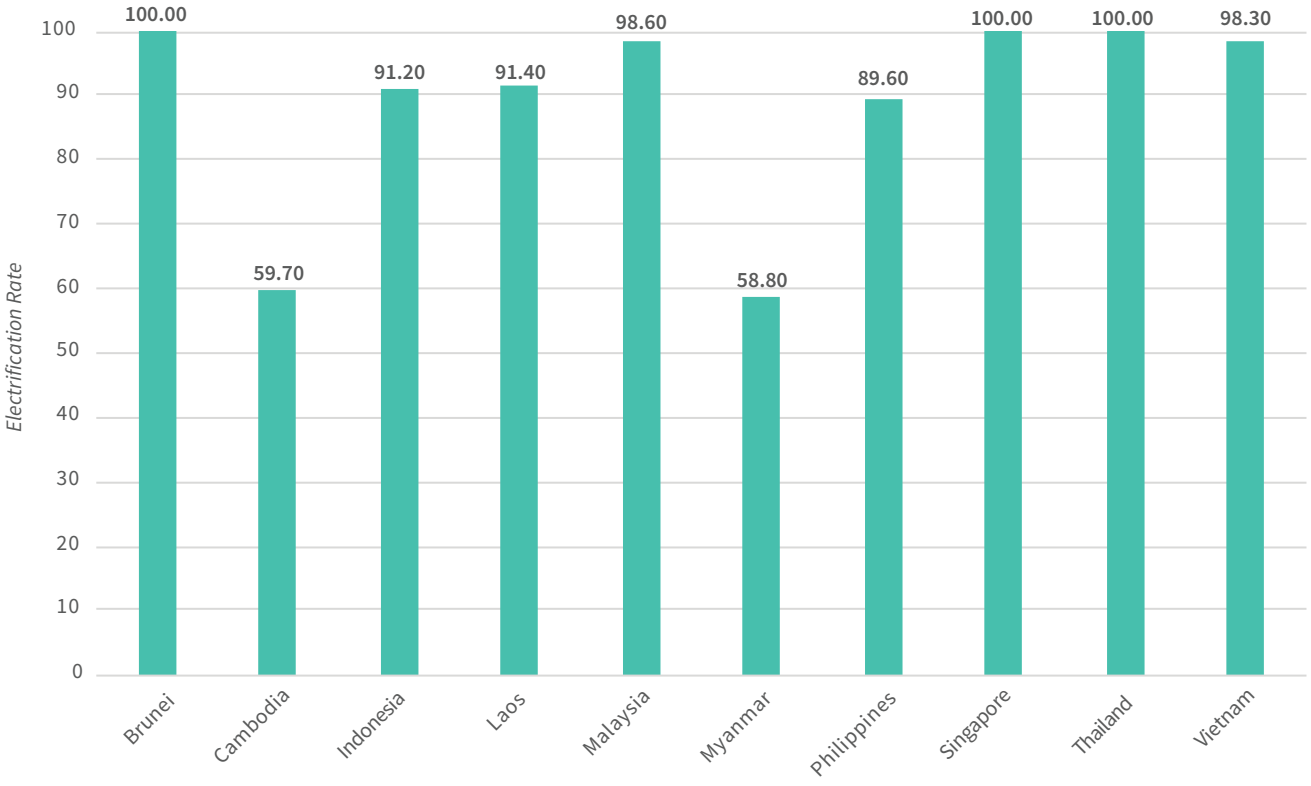

Figure 1 *National electrification rates in Southeast Asia, 2016*

Source: International Energy Agency, *Electricity Access Database* (2017), https://www.iea.org/energyaccess/database/.

1. International Energy Agency, *Southeast Asian Energy Outlook 2017*, World Energy Outlook Special Report (Paris: OECD/IEA, 2017), https://www.iea.org/publications/freepublications/publication/WEO2017SpecialReport_SoutheastAsiaEnergyOutlook.pdf.
2. International Energy Agency, *Electricity Access Database* (2017), https://www.iea.org/energyaccess/database/.

Understanding how electrification is measured and how this measurement can vary is important in efforts to ascertain the role of renewables in achieving universal electrification. This report reviews various technological, economic, policy, regulatory, and market factors, the dynamics they create in the electrification process in Southeast Asia, and the role renewables can play in achieving universal access.

KEY TAKEAWAY #1

OFFICIAL ESTIMATES OF ELECTRIFICATION ARE HIGH OVERALL, BUT THE RATE AND DEFINITION CAN VARY

While overall electrification rates in Southeast Asia are high, it is important to note that the definition of electricity access varies around the world, so regional estimates may not always be comparable. An illustrative example from outside the region is found in India. In April 2018, Prime Minister Narendra Modi announced that "every single village of India now has access to electricity."[3] Experts point out, however, that a village in India is considered "electrified" if 10 percent of its households or public buildings are connected. Therefore, 100 percent of villages being connected does not mean all households have access to electricity.

Electrification statistics may not even be consistent within countries. In Indonesia, the Ministry of Energy and Mineral Resources defines the electrification ratio as the number of households that are served by the state utility Perusahaan Listrik Negara (PLN) or by mini-grid or off-grid systems divided by the total number of households.[4] The electricity ratio reported by PLN only measures the households served by its grid or by the Super Extra Energy Efficient photovoltaic (PV) systems the company manages. The government's electrification ratio in 2013 was reported as 80.51 percent, whereas PLN's electrification ratio was 76.13 percent. International bodies such as the IEA and the World Bank also report electrification ratios, collected from various sources such as government statistics and private sector and civil society estimates, and their numbers do not always match.

Unless otherwise noted, this report uses electrification rates from the IEA. The IEA defines electricity access as having a grid, mini-grid, or off-grid connection capable of powering at least several light bulbs, task lighting, phone charging, and a radio.[5]

3. Huizhong Wu, "India Says 100% of Villages Have Electricity. Millions of People Remain in the Dark," *CNN Money*, April 30, 2018, https://money.cnn.com/2018/04/30/news/india/india-electricity-villages-modi/index.html.
4. Asian Development Bank, *Achieving Universal Electricity Access in Indonesia* (Manila: ADB, 2016), https://www.adb.org/sites/default/files/publication/182314/achieving-electricity-access-ino.pdf.
5. International Energy Agency, *WEO Energy Access Outlook 2017 Methodology for Energy Access Analysis* (Paris: OECD/IEA, 2017), https://www.iea.org/media/publications/weo/EnergyAccessOutlook2017Definingandmodellingenergyaccess.pdf.

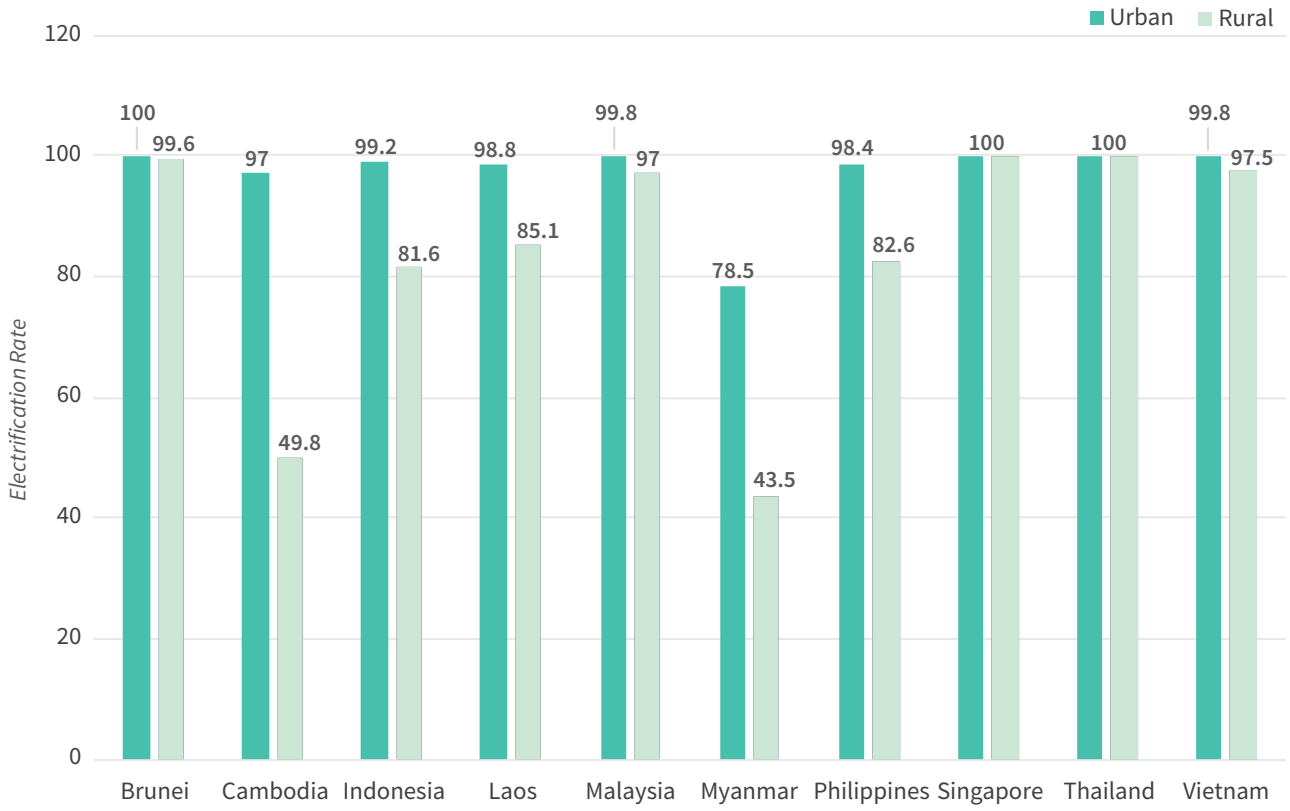

Figure 2 *Urban vs. rural electrification in Southeast Asia, 2016*

Source: International Energy Agency, *Electricity Access Database* (2017), https://www.iea.org/energyaccess/database/.

National electrification ratios also do not necessarily capture the variation between urban and rural areas. For example, in Cambodia, the electrification rate as of 2016 was 60 percent overall, 97 percent in urban areas, and 49.8 percent in rural areas (Figure 2).[6]

The Energy Sector Management Assistance Program (under the World Bank) and Sustainable Energy for All (under the United Nations) have developed a six-tier (0–5) framework that seeks to provide better granularity in measuring access to electricity.[7] The framework measures access from two perspectives: supply and services. It ranks supply in terms of the following attributes: capacity, duration, reliability, quality, affordability, legality, and health and safety. And it ranks services in terms of what households can do with the electricity they receive. For example, as shown in Table 1, tier 1 access to electricity is a daily capacity of at least 12 watt-hours (Wh), providing access to minimal lighting and some mobile phone charging for at least four hours per day. Tier 3 represents daily capacity of at least 1 kilowatt-hour (kWh), allowing for general lighting, phone charging, television, a fan, and medium-power appliances for at least eight hours per day. The highest tier, tier 5, has a daily capacity of at least 8.2 kWh, allowing for the previous services plus very-high-power appliances for at least 23 hours a day. It is

6. International Energy Agency, *Electricity Access Database.*
7. World Bank, *Beyond Connections: Energy Access Redefined* (Washington, DC: World Bank Group, 2015), https://openknowledge.worldbank.org/bitstream/handle/10986/24368/Beyond0connect0d-000technical0report.pdf.

		Tier 0	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Peak capacity Power capacity ratings *(in daily watt-hours)*			Min 12 Wh	Min 200 Wh	Min 1.0 kWh	Min 3.4 kWh	Min 8.2 kWh
Availability *(duration)*	Hours per day		Min 4 hrs	Min 4 hrs	Min 8 hrs	Min 16 hrs	Min 23 hrs
	Hours per evening		Min 1 hr	Min 2 hrs	Min 3 hrs	Min 4 hrs	Min 4 hrs
Reliability						Max 14 disruptions per week	Max 3 disruptions per week of total duration < 2 hrs
Quality						Voltage problems do not affect the use of desired appliances	
Affordability						Cost of a standard consumption package of 365 kWh/year < 5% of household income	
Legality						Bill is paid to the utility, prepaid card seller, or authorized representative	
Health & safety						Absence of past accidents and perception of high risk in the future	

Multi-tier matrix for measuring access to household electricity services						
Tier criteria	**Tier 0**	**Tier 1**	**Tier 2**	**Tier 3**	**Tier 4**	**Tier 5**
		Task lighting and phone charging	General lighting and phone charging and television and fan (if needed)	Tier 2 and any medium-power appliances	Tier 3 and any high-power appliances	Tier 2 and any very high-power appliances

Table 1 *Multi-tier matrix for measuring access to household electricity supply and services*

Source: Adapted from World Bank, *Beyond Connections: Energy Access Redefined* (Washington, DC: World Bank Group, 2015), https://openknowledge.worldbank.org/bitstream/handle/10986/24368/Beyond0connect0d000technical0report.pdf.

possible for a household to be at different tiers for supply and services depending on the availability and affordability of appliances.

KEY TAKEAWAY #2

POLICY CERTAINTY IS KEY TO ELECTRIFICATION WITH RENEWABLES

Policy certainty provides a stable environment in which to make investments in infrastructure, including grid or mini-grid infrastructure and off-grid power generation. The Energy Sector Management Assistance Program has developed the Regulatory Indicators for Sustainable Energy (RISE) to compare countries' efforts to provide energy access, energy efficiency, and renewable energy. The RISE scores of most Southeast Asian countries are shown in Table 2 (Brunei and Singapore, which have both achieved 100 percent electrification, are not measured by RISE).[8] Southeast Asian nations perform relatively well in terms of energy access, scoring an average of about 77 out of 100. Laos has the lowest score for energy access in the region, with only 46.6 out of 100. The RISE data sug-

8. World Bank, "Scores," *Regulatory Indicators for Sustainable Energy* (2017), http://rise.esmap.org/scores.

	Energy access	Energy efficiency	Renewable energy
Cambodia	70.25	21.06	34.29
Indonesia	61.49	33.88	55.00
Laos	46.60	7.78	46.14
Malaysia	100.00	51.66	68.29
Myanmar	58.54	13.26	43.00
Philippines	82.24	42.23	66.57
Thailand	100.00	62.54	59.57
Vietnam	100.00	70.58	64.14
Average	77.39	37.87	54.63

Table 2 *RISE scores for selected Southeast Asian countries*
Source: Adapted from World Bank, "Scores," *Regulatory Indicators for Sustainable Energy* (2017), http://rise.esmap.org/scores.

gest that to increase this score, the country would need to provide new support for electrification, such as offering subsidies to utilities to establish distribution systems in rural areas, specifying performance standards for new connections, and providing support for off-grid, stand-alone systems.[9] Malaysia, Thailand, and Vietnam all receive perfect scores on energy access, thanks to extensive electrification plans; solid frameworks for grid electrification, mini-grids, and stand-alone systems; and transparent and creditworthy utilities.[10]

On renewable energy, however, the region scores only 54.6. The Philippines is one of the better performers in the region, scoring 66.6, but investors are concerned about the low quality of the grid and difficulty accessing financing for renewables.[11] Vietnam scores 64.1 on renewable energy. The RISE data suggest that to increase this score, the country would need to provide new support for this effort, such as conducting a renewable energy integration study, allowing third parties to provide risk guarantees on utility payments, and guaranteeing payments to generators if the offtaker does not have the infrastructure to take their power when the project is completed.[12]

9. World Bank, "Countries: Lao PDR," *Regulatory Indicators for Sustainable Energy* (2017), http://rise.esmap.org/country/lao-pdr.
10. World Bank, "Scores," *Regulatory Indicators for Sustainable Energy* (2017), http://rise.esmap.org/.
11. Victor V. Saulon, "Philippine Renewables Outperform Regional Peers, but Policy Uncertainty Looming—BMI Research," *BusinessWorld Online*, May 9, 2017, http://bradmanrecruitment.com/philippine-renewables-outperform-regional-peers-policy-uncertainty-looming-bmi-research/.
12. World Bank, "Countries: Vietnam," *Regulatory Indicators for Sustainable Energy* (2017), http://rise.esmap.org/country/vietnam.

COUNTRY FEATURE / PHILIPPINES

The Philippines is classified as a lower middle income country by the World Bank, with a GDP of about $304 billion in 2016.[13] In 2016, grid-connected generators produced about 90.8 terawatt-hours of electricity, 48 percent of which was generated from coal. Twenty-four percent came from renewables, 22 percent from natural gas, and 6 percent from oil (Figure 3).[14]

The electrification rate in the Philippines is currently about 90 percent; the IEA forecasts that the country will reach universal electrification by 2022.[15] To that end, grid extension is expected to bring power to 14 million Filipinos, while minigrids and off-grid technology powered by wind and PV are expected to bring power to another 1.5 million in remote areas. The total investment required for universal electrification is estimated at $14 billion.[16]

A key player in rural electrification in the Philippines is the National Power Corporation, a government agency that helps electrify rural areas where the private sector deems it uneconomical to provide service. Many such areas are remote islands where grid connection is difficult. About 80 percent of the off-grid power delivered to these areas currently comes from diesel generators or power barges, which are costly and difficult to operate and maintain in remote settings. The government is attempting to incentivize diversification of energy sources by providing cash rebates to power providers who incorporate renewables like solar PV and wind.

13. World Bank, "Countries and Economies: Philippines," *World Bank Open Data* (2016), https://data.worldbank.org/country/Philippines.
14. Philippines Department of Energy, *2016 Philippine Electricity Demand–Supply Snapshot* (2017), https://www.doe.gov.ph/sites/default/files/pdf/electric_power/power_situationer/2016_power_situation.pdf.
15. International Energy Agency, *Southeast Asian Energy Outlook 2017.*
16. Ibid.

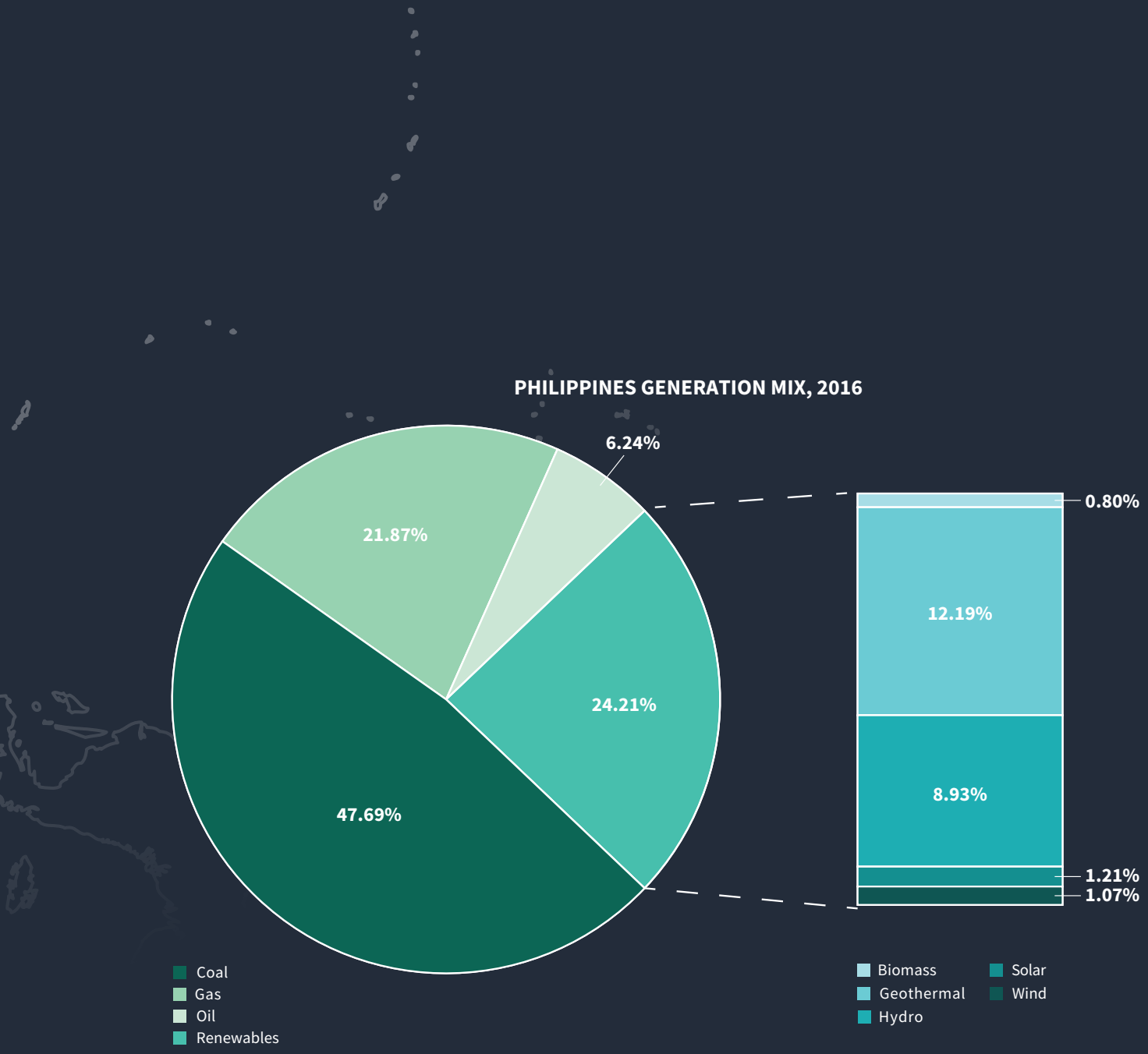

Figure 3 *Electricity generation in the Philippines in 2016, by technology*

Source: Philippines Department of Energy, *2016 Philippine Electricity Demand–Supply Snapshot* (2017), https://www.doe.gov.ph/sites/default/files/pdf/electric_power/power_situationer/2016_power_situation.pdf.

KEY TAKEAWAY #3

VARIOUS TECHNOLOGY OPTIONS EXIST FOR ELECTRIFICATION, AND THEIR USE DOES NOT NEED TO BE MUTUALLY EXCLUSIVE

The IEA defines three distinct modes of transmitting and distributing electricity: on-grid, mini-grid, and off-grid.[17] Households are connected to the grid if they are served by a distribution network, typically delivering power from large, centralized power plants. In Southeast Asia, these power plants typically generate electricity using fossil fuels, but large-scale renewable energy generation is becoming more common as costs fall.[18]

Mini-grids are small, localized grids that deliver power in a small geographic area, typically from diesel or natural gas generators or small-scale renewable energy technologies like micro hydropower generators, PV installations, wind turbines, or biomass gasification plants.[19] Mini-grids integrating solar and battery storage are also emerging as a solution for remote island communities. For example, the island communities of Merabu, Long Beliu, and Teluk Sumbang in Indonesia's East Kalimantan Province are now powered by mini-grids with a combined 1.2 megawatts (MW) of solar and 2.1 MW-hours of battery storage.[20] If a mini-grid is established in an area and then the main grid is extended to that area, they can be interconnected given adequate investment in transmission and distribution equipment. Mini-grids can be powered by one or more power sources; a study by the Frankfurt School of Finance and Management and the UN Environment Programme found that adding solar PV to diesel-only mini-grids can deliver fuel savings.[21]

Off-grid electrification refers to systems that power individual households to enable basic services like lighting, phone charging, and operating appliances. The most common systems are diesel generators and solar home systems.[22]

The IEA expects that Southeast Asia will reach universal electrification in the

17. International Energy Agency, *Energy Access Outlook 2017*, World Energy Outlook Special Report (Paris: OECD/IEA, 2017), http://www.iea.org/publications/freepublications/publication/WEO2017SpecialReport_EnergyAccessOutlook.pdf.
18. For a more in-depth discussion of on-grid power market trends in Southeast Asia, see Stephen Naimoli and Jane Nakano, *Renewable Energy in Southeast Asia: Fuel Competition in the Expanding Power Market* (Washington, DC: Center for Strategic & International Studies, 2018), https://www.csis.org/analysis/fuel-competition-expanding-power-market.
19. David Taylor, Simon Turner, Daniel Willette, and Pariphan Uawithya, *De-centralized Electricity in Africa and Southeast Asia: Issues and Solutions* (Accenture, 2015), https://assets.rockefellerfoundation.org/app/uploads/20150128205930/De-centralized-Electricity-in-Africa-and-Southeast-Asia.pdf.
20. Ilias Tsagas, "Indonesia Inaugurates Its First Three Solar Plus Storage Mini-grids," *PV Magazine*, June 14, 2018, https://www.pv-magazine.com/2018/06/14/indonesia-inaugurates-its-first-three-solar-plus-storage-mini-grids/.
21. Hirak Al-Hammad, Torsten Becker, Andrea Bode, Srishti Gupta, and Silvia Kreibiehl, *Renewable Energy in Hybrid Mini-Grids and Isolated Grids: Economic Benefits and Business Cases* (Frankfurt: Frankfurt School of Finance & Management, 2015), http://www.irena.org/-/media/Files/IRENA/Agency/Publication/2015/IRENA_FS_UNEP_Hybrid_Minigrids_2015.pdf.
22. International Energy Agency, *Southeast Asian Energy Outlook 2017.*

2030s.[23] In the IEA's New Policies Scenario, which measures the effects of current policies as well as those that have been announced but not yet implemented, more than half of the additional, access-driven power demand in Southeast Asia is expected to come from mini-grid and off-grid technologies. About 40 percent of new connections are expected to be the result of grid extension; 33 percent are expected to be mini-grids; and the remaining 27 percent are expected to be off-grid solutions. Renewable energy has a large role to play, particularly in providing mini-grid and off-grid electricity. In Indonesia, for example, the IEA expects renewables will make up more than half of new mini-grid connections and about 75 percent of new off-grid connections between 2017 and 2025.

Typically, grid extension can provide more services than off-grid technologies, allow for economic opportunities and services that require grid access, and ensure load growth for a stable grid—as long as the grid power is reliable.[24] However, this is not always feasible due to physical or economic constraints. Transmission and distribution infrastructure is expensive and becomes much more difficult to justify when it will serve fewer customers and have lower per capita use. In addition, remote populations that are far from the existing grid infrastructure, including those on small islands, would be costlier to serve with grid extension because significant new transmission and distribution infrastructure would need to be built—including long-distance transmission lines that would suffer from higher cumulative line losses and require expensive substations and distribution lines.[25]

Off-grid and mini-grid electrification, on the other hand, can be very useful for remote and/or low-density populations, although it can risk unnecessary capital expenditures if grid extension later comes to the area. Mini-grids can be built to eventually interconnect with the main grid if grid extension becomes feasible at a later date. Mini-grids whose developers are not willing to upgrade them to the proper standard for grid infrastructure risk becoming stranded assets.

Cambodia provides an illustrative example of how to successfully integrate mini-grids with the main grid. In the 1990s, diesel mini-grids emerged to supply power to rural neighborhoods in Cambodia.[26] In the early 2000s, when the state utility Electricité du Cambodge began extending the grid to these rural areas, the company incentivized mini-grid owners to upgrade their systems, interconnect with the grid, and operate as distribution franchisees. Ultimately, connecting with the main grid improved household services from tier 2 on the World Bank framework to tier 4 or 5 and lowered household rates from $0.40–1.00 per kWh to a regulated tariff of $0.12–0.20 per kWh (partially subsidized by Electricité du Cambodge).

23. Ibid.
24. Norwegian Agency for Development Cooperation, *Norwegian Development Assistance to Rural Electrification: Best Practice Guide for Planning* (Oslo: NORAD, 2009), https://www.norad.no/globalassets/import-2162015-80434-am/www.norad.no-ny/filarkiv/norwegian-development-assistance-to-rural-electrification.pdf.
25. EU Technical Assistance Facility for the Sustainable Energy for All Initiative, *Sustainable Energy Handbook Module 5.2: On-Grid Rural Electrification* (2016), https://europa.eu/capacity4dev/public-energy/document/sustainable-energy-handbook-module-52-grid-rural-electrification.
26. Bernard Tenenbaum, Chris Greacen, and Dipti Vaghela, *Mini-grids and Arrival of the Main Grid: Lessons from Cambodia, Sri Lanka, and Indonesia* (Washington, DC: World Bank Group, 2017), https://openknowledge.worldbank.org/bitstream/handle/10986/29018/121823-ESM-MiniGridsandtheArrivaloftheMainGridFINALhhav-Indonesia-PUBLIC.pdf.

KEY TAKEAWAY #4

INCREASING ELECTRICITY ACCESS REQUIRES WELL-DESIGNED POLICIES, REGULATIONS, AND MARKETS

Competition helps create an enabling environment for market participants to provide access to electricity. In Southeast Asia, Singapore and the Philippines are the only countries with competitive retail electricity markets. The other countries have single-buyer markets, in which independent power producers can generate electricity but are required to sell their electricity to the state-owned utility, which then distributes it to customers (Figure 4).[27] Vietnam is developing competitive wholesale and retail markets, which are projected to be completed by 2023.[28]

Within the competitive generation market, experts argue, well-designed auctions encourage competition that incentivizes innovation and brings down installation costs.[29] Globally, recent factors driving down costs have included improved components and growing experience in installation.[30] Auctions are new in Southeast Asia as a procurement mechanism, but they are growing in popularity—Cambodia, Indonesia, Malaysia, the Philippines, Singapore, and Thailand have all tested auctions, and Vietnam is considering implementing them starting in 2019.[31] In Thailand, a 2017 auction for 300 MW of small, hybrid renewable energy projects saw an average bid price of $0.0739 per kWh—33 percent below the ceiling price of $0.11/kWh.[32] In Malaysia, a 2017 auction for 460 MW of large-scale solar capacity saw bids ranging from $0.08 to 0.12/kWh.[33] In the Philippines, developer Solar Philippines submitted record low bids of $0.06/kWh and $0.04/kWh in 2017 and 2018 auctions, respectively—bids CEO Leandro Leviste admitted would bring low returns, but were intended to help grow the market.[34] Fourth-quarter 2017 global solar prices ranged from $0.03–0.15/kWh.[35]

27. International Renewable Energy Agency, *Renewable Energy Market Analysis: Southeast Asia* (Abu Dhabi: IRENA, 2018), https://irena.org/-/media/Files/IRENA/Agency/Publication/2018/Jan/IRENA_Market_Southeast_Asia_2018.pdf.
28. Aloysius Damar Pranadi, "The History and Roadmap of Power Sector Reform in Vietnam," ASEAN Centre for Energy, April 6, 2018, http://www.aseanenergy.org/blog/the-history-and-roadmap-of-power-sector-reform-in-vietnam/.
29. Emma Foehringer Merchant, "The Floor for Ultra-Low Solar Bids? $14 per Megawatt-Hour," *Greentech Media*, August 2, 2018, https://www.greentechmedia.com/articles/read/the-floor-for-ultra-low-solar-bids-14-per-megawatt-hour.
30. Fabian Wigand, "Designing Renewable Energy Auctions: Key Considerations for Lao PDR" (presentation, Asia Clean Energy Forum, Manila, Philippines, June 8, 2018), https://d2oc0ihd6a5bt.cloudfront.net/wp-content/uploads/sites/837/2018/06/Fabian-Wigand-Designing-Renewable-Energy-Auctions_-Key-Considerations.pdf.
31. Sopitsuda Tongsopit et al., *Designing Renewable Energy Incentives and Auctions: Lessons for ASEAN* (Bangkok: USAID Clean Power Asia, 2017), https://www.ecofys.com/files/files/re-incentivesreport-20170904-final.pdf; Aloysius Damar Pranadi, "The History and Roadmap of Power Sector Reform in Vietnam."
32. Khomgrich Tantravanich, "Case Study—Thailand: Experience from Competitive Biddings for Renewable Energy Projects in Thailand and the Recent SPP Hybrid-Firm" (presentation, Asia Clean Energy Forum, Manila, Philippines, June 8, 2018), http://usaidcleanpowerasia.aseanenergy.org/resource/case-study-thailand-experience-from-competitive-biddings-for-renewable-energy-projects-in-thailand-and-the-recent-spp-hybrid-firm/.
33. Becky Beetz, "Another 30 MW Awarded in Malaysian Solar Auction," *PV Magazine*, December 5, 2017, https://www.pv-magazine.com/2017/12/05/another-30-mw-awarded-in-malaysian-solar-auction/.
34. Emiliano Bellini, "Philippine utility Meralco receives Southeast Asia's lowest solar bid," *PV Magazine*, August 13, 2018, https://www.pv-magazine.com/2018/08/13/philippine-utility-meralco-receives-southeast-asias-lowest-solar-bid/.
35. Emma Foehringer Merchant, "IRENA: Global Renewable Energy Prices Will Be Competitive with Fossil Fuels by 2020," *Greentech Media*, January 16, 2018, https://www.greentechmedia.com/articles/

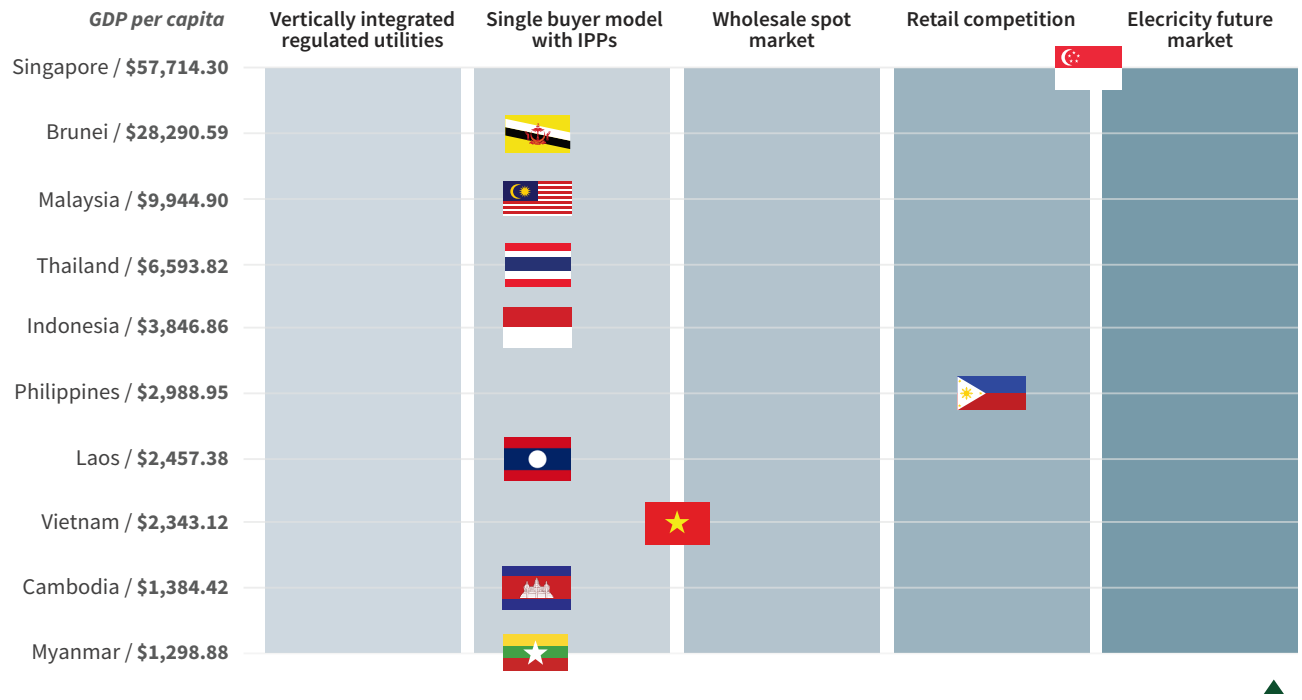

Figure 4 *Power markets in Southeast Asia*

Source: Adapted from International Renewable Energy Agency, *Renewable Energy Market Analysis: Southeast Asia* (Abu Dhabi: IRENA, 2018), https://irena.org/-/media/Files/IRENA/Agency/Publication/2018/Jan/IRENA_Market_Southeast_Asia_2018.pdf, and World Bank, "GDP per capita", World Bank Open Data (2017), https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?end=2017&locations=ID-MY-MM-TH-LA-KH-VN-SG-BN-PH&start=2017&view=bar.

In addition to driving down prices, auctions may also speed up development of projects by replacing the opaque and lengthy process of feed-in tariff development. In Vietnam, potential investors and developers waited for years while the government developed guidance for a utility-scale solar feed-in tariff.[36] Auctions can reasonably be expected to shorten lead times because the competitive bidding process sets the prices paid to developers for their electricity.

An important aspect of effective electrification planning is considering on-grid and off-grid solutions in a holistic fashion. Considering grid extension and off-grid solutions independently may lead to costly solutions that do not sufficiently meet the needs of populations currently without access to electricity. Multilateral development spending is paying increased attention to mini-grid and off-grid solutions. The World Bank, which invested $1.75 billion in the Southeast Asian energy sector from 2009 to 2016, provides an illustrative example.[37] From 2014 to 2017, the World Bank spent an average of $900 million per year on electricity access, with about $200 million (about 22 percent) going to mini-grid and off-grid programs and the remaining $700 million to grid extension.[38] In 2017–2018, lending to mini-grid and off-grid solutions jumped to $600 million, 43 percent of the $1.4 billion spent on electricity access.

read/irena-renewable-energy-competitive-fossil-fuels-2020.

36. Duy Anh, "Genco 3 to Build $422mn Solar Plants in Ninh Thuan," *Vietnam Economic Times*, May 4, 2017, http://vneconomictimes.com/article/business/genco-3-to-build-422mn-solar-plants-in-ninh-thuan.
37. International Renewable Energy Agency, *Renewable Energy Market Analysis: Southeast Asia.*
38. World Bank, "The Race for Universal Energy Access Speeds Up," July 10, 2018, http://www.worldbank.org/en/news/feature/2018/07/10/the-race-for-universal-energy-access-speeds-up.

COUNTRY FEATURE / MYANMAR

Myanmar is classified as a lower middle income country by the World Bank, with a GDP of about $63 billion in 2016.[39] In 2015, grid-connected generators produced 15,970 GWh of electricity, 58.9 percent of which was generated from hydropower. Thirty-nine percent came from natural gas, 1.8 percent came from coal, and a negligible amount came from oil (Figure 5).[40] However, grid-connected electricity reached only 26 percent of households in 2015.[41]

In the absence of grid extension, mini-grids have been installed to deliver electricity to many villages in Myanmar. In 2014, there were almost 17,000 mini-grids serving villages in Myanmar, of which about 13,000 ran on diesel, 2,400 on micro hydropower, 1,200 on biomass gasifiers; and 150 on solar PV (as shown in Figure 6).[42] These mini-grids do not necessarily cover all households in each village, however—only 25 percent of electrified villages with mini-grids had connected more than 70 percent of their households that year.[43] Many systems stand in disrepair because their generators are often old and inefficient and the villages they power lack the engineering expertise to ensure proper system operation.[44]

The World Bank is working with the government of Myanmar to implement the National Electrification Project, which seeks to supply 100 percent of households in Myanmar with electricity by 2030 through grid extension, mini-grids, or off-grid access.[45] In terms of the World Bank's multi-tier framework, solar home systems can supply tier 2 access, mini-grids can supply tier 3 access, and grid

39. World Bank, "Countries and Economies: Myanmar," *World Bank Open Data* (2016), https://data.worldbank.org/country/myanmar.
40. International Energy Agency, "Myanmar: Electricity and heat for 2015," https://www.iea.org/statistics/?country=MYANMAR&year=2015&category=Key%20indicators&indicator=TPESbySource&mode=chart&categoryBrowse=true&dataTable=ELECTRICITYANDHEAT&showDataTable=true.
41. ASEAN Centre for Energy, *The 5th ASEAN Energy Outlook* (Jakarta: ACE, 2017), http://www.aseanenergy.org/resources/the-5th-asean-energy-outlook/.
42. Mee Panyar, *Living in the Dark: Adaptive Learning for Rural Energy Development in Myanmar* (London: Mee Panyar, 2018), https://static1.squarespace.com/static/58f49f4c37c581427ce3f70a/t/5a68b265e2c4834ebbf6796e/1516811005738/MeePanyar_PositionPaper_FINAL.pdf.
43. Ibid.
44. World Bank, *Upscaling Mini-Grids for Low-Cost & Timely Access to Electricity Services* (Washington, DC: World Bank Group, 2017), https://www.climateinvestmentfunds.org/sites/cif_enc/files/esmap_mini-grids_action_plan_myanmar.pdf.
45. World Bank, "Electricity to Transform Rural Myanmar," September 16, 2015, http://www.worldbank.org/en/news/feature/2015/09/16/electricity-to-transform-rural-myanmar.

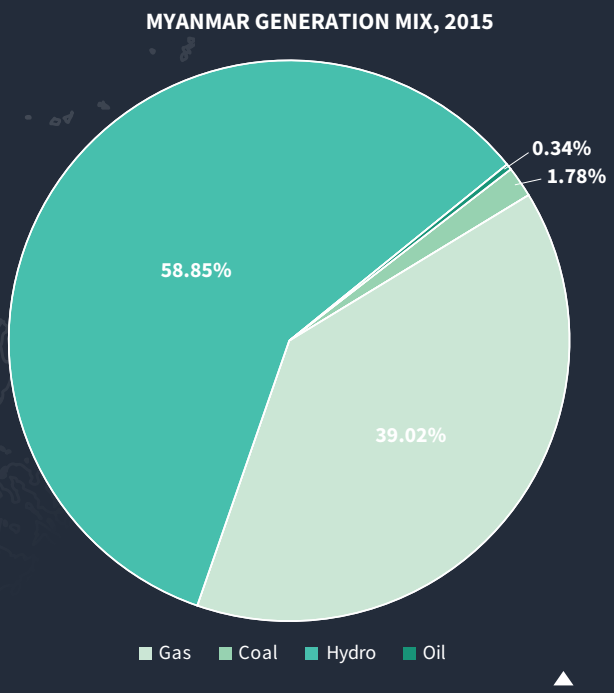

Figure 5 *Electricity generation in Myanmar in 2015, by technology.*
Source: International Energy Agency, "Myanmar: Electricity and heat for 2015," https://www.iea.org/statistics/?country=MYANMAR&year=2015&category=Key%20indicators&indicator=TPESbySource&mode=chart&categoryBrowse=true&dataTable=ELECTRICITYANDHEAT&showDataTable=true.

connection can supply tier 4 or 5 access.[46] The program is technology-neutral, as it seeks only to find least-cost, sustainable solutions. Given that renewable energy technologies have no fuel costs, however, 97.8 percent of the individuals connected through the program so far have been served entirely by renewables.[47]

As of June 2018, the project had connected 722,790 individuals—706,845 through mini-grids or off-grid connections powered by only renewable energy; 10,100 through grid extension; and 5,845 through fossil fuel or hybrid mini-grid or off-grid solutions. By the end of March 2021, the project aims to bring electricity to 5,672,500 individuals. The IEA expects that to achieve universal electrification in the early 2030s, grid extension will be the cheapest option for 40 percent of new connections, while mini-grid and off-grid solutions will be reasonable for the rest.[48] This would include 11.8 million individuals receiving power from off-grid solar PV. The IEA estimates a need for about $13 billion to achieve Myanmar's electricity access goal.

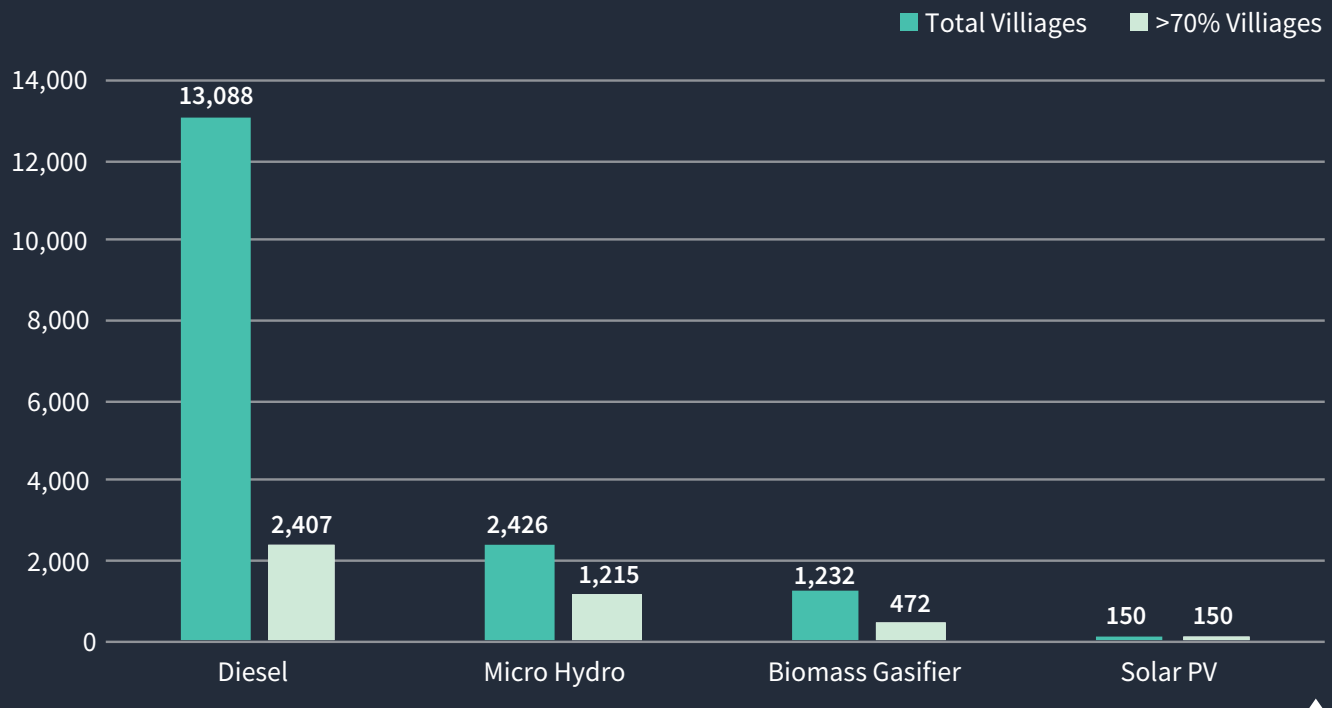

Figure 6 *Mini-grids in rural Myanmar, 2014*
Source: Mee Panyar, *Living in the Dark: Adaptive Learning for Rural Energy Development in Myanmar* (London: Mee Panyar, 2018), https://static1.squarespace.com/static/58f49f4c37c581427ce3f70a/t/5a68b265e2c4834ebbf6796e/1516811005738/MeePanyar_PositionPaper_FINAL.pdf.

46. World Bank, *Beyond Connections: Energy Access Redefined.*
47. World Bank, *National Electrification Project Implementation Status & Results Report* (2018), http://documents.worldbank.org/curated/en/917301531740317344/pdf/Disclosable-Version-of-the-ISR-National-Electrification-Project-P152936-Sequence-No-06.pdf.
48. International Energy Agency, *Southeast Asian Energy Outlook 2017.*

CONCLUSIONS & RECOMMENDATIONS

In areas where the electricity access challenge is due to the uneconomic nature of grid extension, renewable energy presents a highly valuable option for electrification because it imposes no fuel costs. Further, distributed renewable energy defers or eliminates the need for costly investments in transmission and distribution infrastructure. However, the contribution of renewable energy to electrification, both on the grid and in distributed applications, is also determined partially by market design, regulation, and policy certainty. Market design and regulation play a role in determining the extent to which renewables can participate in a country's electrification plan—particularly with on-grid connections, which can allow for more household energy services (lighting, appliances, etc.) than off-grid systems due to scale and flexibility.

Providing electricity to 100 percent of a country's residents requires careful planning that seeks to implement least-cost and sustainable solutions at the household level, which can include on-grid, mini-grid, and off-grid technologies. On- and off-grid solutions should not be seen as mutually exclusive investment options, and careful planning is necessary to minimize the risk of mini- and off-grid systems becoming stranded assets later—for example, when a grid solution arrives in a remote area.

One major conclusion was consistently emphasized at the roundtable discussion: the role of policy certainty in spurring investment in renewables, both on and off the grid, is significant. It is important for policymakers to be able to adjust policy mechanisms to address changing conditions, but a consistent direction sends a signal to potential investors that their investments will not be upended in the next few years. This is difficult when transparency in the regulatory process is low. A lack of communication and clear price signals, as in Vietnam's lengthy solar feed-in tariff development, makes investments riskier or even delays them. In addition, there are few protections to guarantee that the utilities will be able to pay for the power they generate. Therefore, governments seeking to invite more investment in renewable energy may wish to reexamine their policies and ensure regulatory processes are transparent and consistent and provide stable price signals.

OCTOBER 2018

RENEWABLE ENERGY IN SOUTHEAST ASIA

The State of the Clean Energy Transition in the Indo-Pacific

EVENT SUMMARY

THE STATE OF THE CLEAN ENERGY TRANSITION IN THE INDO-PACIFIC

On September 26, 2018, CSIS held a public forum titled, *The State of the Indo-Pacific Clean Energy Transition*, under the CSIS-Pertamina Southeast Asia Energy Initiative.[1] The event examined two critical elements related to the future of renewable energy in the Indo-Pacific: 1) the regional interconnectedness of the electric grid and 2) clean energy financing.

SESSION 1 Grid Interconnection in Southeast Asia: The ongoing effort to realize the ASEAN Power Grid (APG) illuminates how disparate the participating countries are with regards to the anticipated level of energy and economic savings/benefits from APG, as well as intuitional and technical capacity, let alone the levels of political interests. Moreover, as interconnection can affect many aspects of participating countries—including legal and regulatory systems, economic structures, and other political-economic features—balancing national sovereignty and system efficiency has been particularly challenging. However, regional governments are increasingly recognizing how a regionally interconnected electric grid in Southeast Asia can facilitate more efficient use of energy resources as well as enhanced integration of renewable energy in the regional energy supply mix. The APG stakeholders are closely examining lessons learned from grid interconnection efforts around the world in an effort to realize a regional grid and multilateral power trading.

Yanfei Li (Economic Research Institute for ASEAN and East Asia or ERIA) shared the key elements of the APG initiative that is currently underway in Southeast Asia. ERIA contributes by providing a cost-benefit analysis of the grid interconnections to industry, policymakers, and stakeholders, as well as feasibility studies of select cross-border transmission lines. Li noted that there has been an increasingly robust exchange of ideas and lessons learned from other grid regionalization experiences, including those from North America (e.g., PJM Interconnection). Yet, there remain technical, economic, political, and institutional barriers to turning a number of existing bilateral/bi-national grid systems in Southeast Asia into a regional, multilateral grid system that is accompanied by electricity trading among multiple participants (e.g., utilities) in the APG. Li emphasized the importance of setting up a suitable market design for multilateral electricity trading and corresponding institutions to support the trading.

The importance of market and institutional rules were also emphasized by **Jaquelin Cochran** (National Renewable Energy Laboratory or NREL), who used results from NREL studies in the United States and South Asia to discuss the engineering and economic benefits of integrating and interconnecting multiple power systems. Specifically, grid integration aggregates wind and solar resources that are spatially diverse and can reduce power supply variability and

1 Visit https://www.csis.org/events/state-indo-pacific-clean-energy-transition for more information.

Dr. Jayne Somers, Senior Energy Advisor, Asia Bureau, U.S. Agency for International Development (USAID)

thus need for reserves. Moreover, interconnecting grid systems provide lower net ramping needs and thus cost savings when compared to separate management of each area without the interconnection. In addition to institutional elements, such as market regulations and rate regulations, Cochran also noted how planning and procurement elements, such as project siting, proper evaluation of project competitiveness, and allocation of cost and risk, warrant serious attention for successful grid interconnection.

Craig Glazer (PJM Interconnection) discussed key lessons PJM has to offer towards the successful regionalization of grid systems in Southeast Asia. In discussing how grid interconnection models evolved in the eastern and western regions under the PJM, Glazer summarized advantages and disadvantages of a vertically integrated utility model and a power pool model and illustrated how balancing "sovereignty" (among U.S. states) and system efficiency is a challenging and delicate exercise. Moreover, he emphasized the importance of trust for multilateral power trading to work.

Nawal Kamel (ASEAN Studies Center) described both the origin and the progress of the grid regionalization initiative since the idea first arose in 1997, and the strong energy security, accessibility, affordability, and environmental sustainability rationales behind it. In addition to providing additional information on the stream of work underway to realize the APG, Kamel identified the key barriers to regionalization (from bilateral grids to multilateral) to be the heterogeneity of energy management, legal and regulatory frameworks, and technical standards and codes; and the lack of institutional and contractual arrangements

The second panel on clean energy financing in the Indo-Pacific.

for cross-border trade. On the issues of sovereignty, her center proposes that a regional electricity trading platform be set up for trading of excess power supply or marginal power demand among participating countries/utilities to allow each national power system a fair degree of autonomy.

SESSION 2 **Financing the Clean Energy Transition in the Indo-Pacific Region:** The region will need trillions, not billions (in USD) of investments to meet its rising energy needs from low-carbon emitting sources of energy. Meanwhile, compared to many other developing regions, the Indo-Pacific does not suffer from a lack of financing; the challenge is how to unlock and incentivize financing to flow into the renewables energy sector in addition to the fossil fuel sector, which is projected to continue attracting investments. Renewable energy projects tend to carry lower risk than large infrastructure and hydro projects. As such, the biggest barrier to investments is regulatory risk and policy uncertainty.

Jayne Somers (U.S. Agency for International Development or USAID) described a host of U.S. government undertakings in the area of clean energy deployment, including the Asia EDGE (Enhancing Development and Growth through Energy) initiative, launched by the Trump administration, in July 2018, to promote Indo-Pacific countries' energy security and access by boosting U.S. exports and encouraging market-based policies. Somers discussed the key risks associated with clean energy projects in the region and how USAID works to help address regulatory risk—considered to be most important—to create the foundation for investors. Additionally, she noted the strength of renewable energy projects from the financing perspective in that they tend to be smaller in both scale and capital.

While coal remains to be the dominant source of energy in Indo-Pacific today and for the foreseeable future, **Benjamin Attia** (Wood Mackenzie) noted that solar and wind are projected to account for 13 percent of the total generation in the Indo-Pacific by 2035. Wood Mackenzie expects up to $457 billion in capital expenditure (CAPEX) investment in new wind and solar projects in the region within the next five years. Attia warned that policy uncertainty presents a major barrier to solar/PV projects in the region and across the world and emphasized the importance of eliminating policy uncertainty. He also outlined ways in which different groups of stakeholders (including regulators and policymakers, investors and banks, and developers) can learn from past experiences in financing clean and renewable energy projects and increase their commerciality going forward. In particular, he stressed the strength of renewables projects being low risk although low return and noted the emerging interest by some large, international oil and gas companies—which generally have experience with operating in developing regions as well as strong balance sheets—in investing in renewable generation projects.

ABOUT THE AUTHORS

Stephen Naimoli is a research associate in the Energy and National Security Program at CSIS, focusing on the electricity sector and climate change. Prior to joining CSIS, he worked as a research and communications fellow at the International Council on Clean Transportation. He holds a BA from the University of Texas at Austin and a master's degree in public policy from Oregon State University.

Jane Nakano is a senior fellow in the Energy and National Security Program at CSIS. Her areas of expertise include U.S. energy policy; global market and policy developments concerning natural gas, nuclear energy, and coal; and energy security issues in the Asia-Pacific region. She frequently writes and speaks on these issues at domestic and international conferences and to media around the world. She has also testified before Congress on U.S. liquefied natural gas exports and before the U.S.–China Economic and Security Review Commission on U.S.–China nuclear energy cooperation. Prior to joining CSIS in 2010, Nakano worked in the Office of Policy and International Affairs in the U.S. Department of Energy, where she covered a host of energy, economic, and political issues in Asia. From 2001 to 2002, she served at the U.S. embassy in Tokyo as special assistant to the energy attaché. Nakano graduated from Georgetown University's School of Foreign Service and holds a master's degree from Columbia University's School of International and Public Affairs.

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