APEC REGIONAL STUDY: RENEWABLE ENERGY FINANCING AND INVESTMENT FOR GRID-CONNECTED WIND AND SOLAR

February 2019

This publication was produced by Nathan Associates Inc. for review by the United States Agency for International Development.

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Table of Contents

ACKNOWLEDGMENTS

This report was produced by USAID and the U.S. Department of State and funded by the US-APEC Technical Assistance to Advance Regional Integration (US-ATAARI) project. US-ATAARI is implemented by Nathan Associates Inc., and the APEC Regional Study on Renewable Energy Financing and Investment for Grid-Connected Wind and Solar was developed in a joint effort by Nathan Associates Inc and ICF.

The US-ATAARI project and the authors of this report — Dr Adam Borison (Nathan), Dr Andrew Kindle (ICF), and Mr Turner Shaw (Nathan) — extend their upmost gratitude to the many government agencies, authorities, developers, funders, and individual experts who provided support and expert input into its drafting. This includes the APEC Secretariat, the APEC Energy Working Group (EWG), the APEC Expert Group on New and Renewable Energy Technologies (EGNRET), USAID, the U.S. Department of State, the U.S. Department of Energy (DOE), the Millennium Challenge Corporation (MCC), the World Bank Group, the Asian Development Bank (ABD), the International Energy Agency (IEA), the International Renewable Energy Agency (IRENA), BMR Energy, Engie Energy, the Overseas Private Investment Corporation (OPIC), the Inter-American Development Bank (IDB), the Moroccan Agency for Sustainable Energy (MASEN), the European Bank for Reconstruction and Development (EBRD), the Japanese International Cooperation Agency (JICA), Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), the U.S. Trade and Development Agency (USTDA), the USAID Private Financing Advisory Network–Asia (PFAN) program, the USAID Clean Power Asia project, the Export-Import Bank of the United States (EXIM), and many more contributors.

ABBREVIATIONS

APEC	Asia-Pacific Economic Cooperation
CSP	concentrated solar power
FiT	feed in tariffs
IFC	International Finance Corporation
IRENA	International Renewable Energy Agency
MWh	megawatt hours
MW	megawatt
OPIC	Overseas Private Investment Corporation
PLN	Perusahaan Listrik Negara
PPA	power purchase agreement
RPS	renewable portfolio standard
TWh	terawatt hours
US-ATAARI	US-APEC Technical Assistance to Advance Regional Integration

EXECUTIVE SUMMARY

The Asia-Pacific region is growing rapidly, combining population and market expansion with consistent economic growth and greater purchasing power. This trend has resulted in increasing regional and domestic requirements for sustainable, affordable, and reliable energy access. APEC Ministers and Leaders agreed in 2014 to a goal of doubling the share of renewables in the APEC energy mix by 2030 as part of the approach to meeting this growing demand.

Wind and solar, two dominant renewable technologies, are undergoing a global revolution with rapidly increasing installations driven by a range of technical, economic, regulatory, and institutional factors. Most APEC economies have aggressive renewable energy generation targets, and renewable generation has seen widespread increases in nearly every APEC economy. Going forward, APEC economies are well positioned to achieve long-term, robust growth in wind and solar investments.

This report first highlights several success stories from both within APEC and outside of APEC and then provides recommendations categorized by type of barrier and enabler: technical, economic, regulatory, and institutional.

The first technical recommendation (T1) is to conduct an in-depth solar and wind resource assessment to establish specific locations that are suitable. The second technical recommendation (T2) is to conduct an in-depth grid assessment and to make the necessary investments to enable integration of grid-connected wind and solar generation. The first economic recommendation (E1) is to organize electric markets to allow for adequate renewable tariffs that can (a) provide the necessary support for renewables investments by reflecting market rates, social and environmental objectives and (b) include the energy services that new technologies require and can provide. The second recommendation (E2) is to use competitive auctions with bankable power purchase agreements to ensure sustainable developments for both investors and customers. Regulatory recommendations consist of (P1) instituting reforms allowing for Independent Power Producers and (P2) ensuring that government agencies of all types can work together and jointly support and facilitate renewable energy targets or programs. Finally, institutional recommendations include (I1) enlisting the formal participation of the local academic and business (including banking) sectors to build and use available financial technical expertise and experience. The second institutional recommendation (I2) is to enlist the formal participation of international institutions to kick-start, as necessary, domestic institutional development.

INTRODUCTION

According to the International Energy Agency, energy consumption in Asia-Pacific Economic Cooperation (APEC) member economies is expected to grow by over 35 percent over the next 20 years (APERC 2016). While APEC's use of conventional energy resources will continue into the foreseeable future, renewable energy is becoming increasingly attractive for both its smaller health and environmental footprint and its increasing cost competitiveness. For this reason, the APEC region can benefit from both more renewable energy and better ways to attract the necessary financing and investments for renewable energy projects.

To address the region's growing energy demand, APEC Minsters and Leaders agreed in 2014 to a goal of doubling the share of renewables in the APEC energy mix by 2030. In 2017, Leaders resolved to enhance energy security and sustain regional economic growth by encouraging "the facilitation of energy-related trade and investment, enhancement of access to affordable and reliable energy, and the promotion of sustainable, efficient, and clean energy sources." These key priorities fall under the responsibility of the APEC Energy Working Group. At the January 2018 World Economic Forum, the APEC 2018 Host, Papua New Guinea's Prime Minister Peter O'Neill, described an urgent need to confront the factors increasing climate change, which unevenly affect APEC developing economies, citing APEC economy cooperation as an avenue to best address this challenge. Specifically, Prime Minister O'Neill suggested a focus on boosting capital and investment for climate-resilient development and infrastructure projects, including renewable energy projects.

The growth in renewables in the APEC region has, so far, been dominated by the larger APEC economies such as Australia; Canada; the People's Republic of China: Japan; and the U.S. The smaller, faster-growing developing economies have achieved some success but have the potential for stronger growth. Designed to focus particularly on recommendations for more developing APEC economies, this report provides resources for the target economies to use and learn from by laying out how the four drivers of renewable energy have manifested in different target economies. This aim is achieved through the presentation of eight success stories on wind and solar investment.

This report details the four categories of factors — technical, economic, regulatory and institutional — that can (a) encourage or discourage financing and investment in solar and wind projects and (b) provide specific recommendations for overcoming barriers and exploiting enablers. It first provides an overview of the status of wind and solar technologies and of the drivers that result in increased adoption of wind and solar projects around the world. The report next details the status of solar and wind projects in APEC, explaining the trends in various economies. Lastly, it presents eight success stories, half from within the APEC region and half from outside the region, that illustrate how best to overcome barriers and exploit enablers.

STATUS AND DRIVERS OF SOLAR AND WIND TECHNOLOGIES AROUND THE WORLD

THE ELECTRICITY MARKET

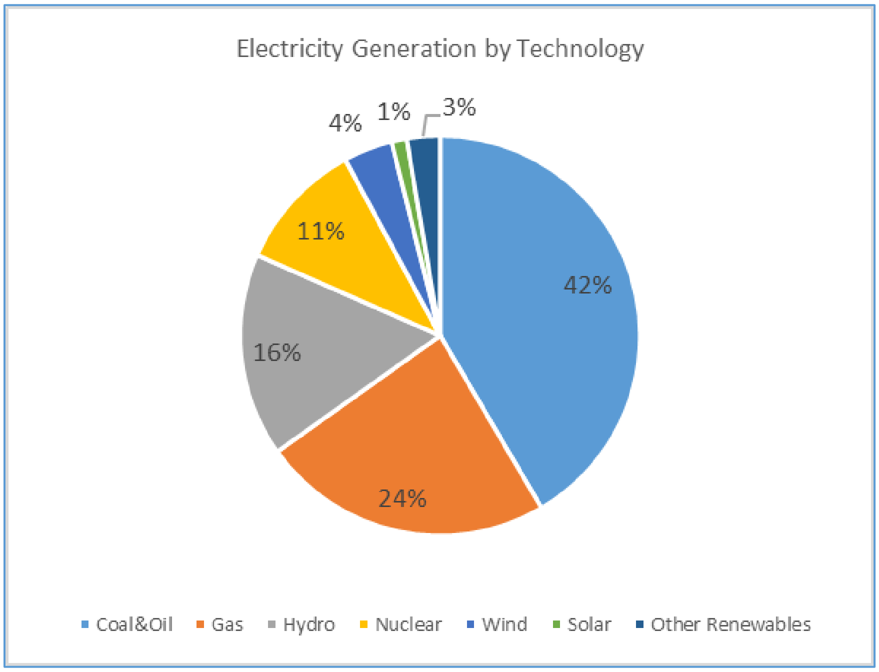
Centrally important to the world population's health and well-being, the energy sector represents roughly 8 percent of the global economy. Electricity alone represents as much as 5 percent of the economy and is widely regarded as the key engine of economic development and growth. Globally, trillions of dollars are spent each year on roughly 20,000 tera-watt hours (10^12 watt hours) of electricity. For calibration with daily experience, a typical US household spends roughly US$1,500 per year on roughly 10,000 kilowatt hours (10^3 watt hours).[1]

Across the globe, the electricity market can be quite diverse — different sources of supply, different types of demand, different business models, and different regulatory frameworks. Nevertheless, while new renewable technologies are showing remarkable growth, most electricity is still supplied by hydro, nuclear, and conventional fossil sources.

Figure 1 below shows the global generation mix from the International Energy Agency. As the figure indicates, generation is currently dominated by coal, oil, (large) hydro, gas, and nuclear. Wind, solar, and other renewables play a very modest part.

[1] All dollar amounts are in U.S. dollars unless indicated otherwise.

Figure 1. Electricity Generation by Technology, 2016



Source: International Energy Agency (IEA), 2018

While distributed generation is growing, most generation is still centralized; it is typically owned either by vertically-integrated utilities that also provide transmission and distribution services or by independent power producers. While the industry is changing, most electricity is still transmitted and delivered to customers by large government or regulated utilities.

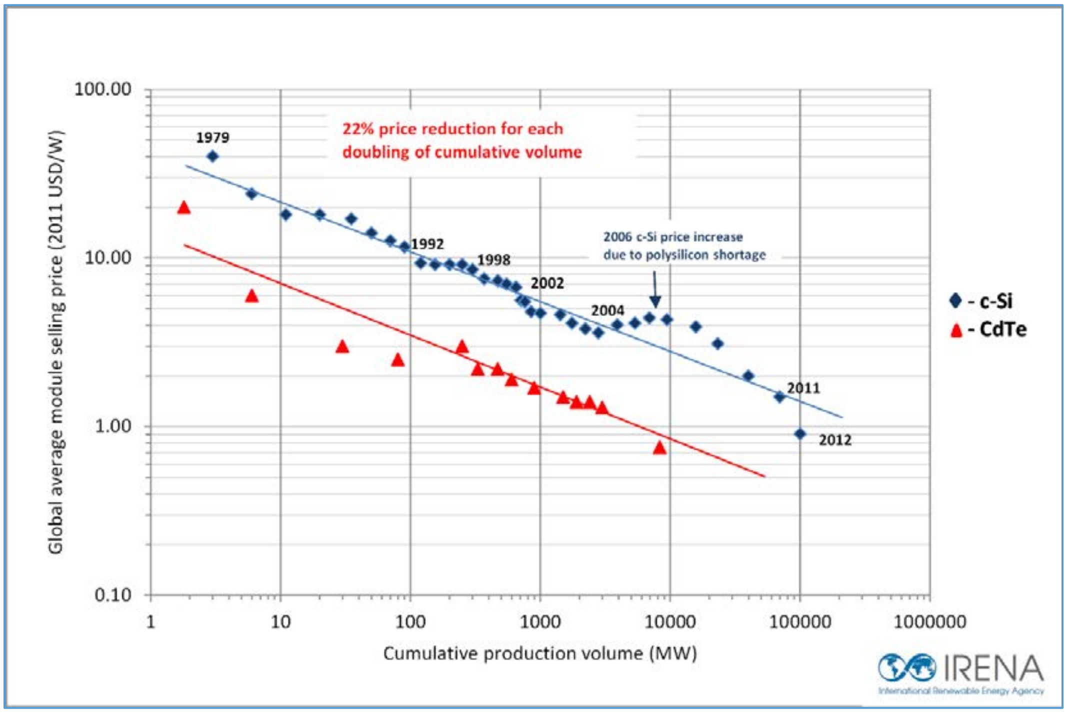
THE SOLAR AND WIND ENERGY MARKET

Over the past few decades, solar and wind energy technology has undergone a true revolution. The cost of the key technologies underlying grid-connected solar and wind, PV modules or panels in the case of solar, and wind turbines in the case of wind, have dropped to levels that would have been nearly inconceivable only a few years ago.

Figure 2 shows the learning or experience curve for solar from IRENA over the past few decades. This graph is on a logarithmic scale and shows that module prices in $/W have declined in cost literally by orders of magnitude. Cost reductions have continued past the last year on this graph — that is, 2012.

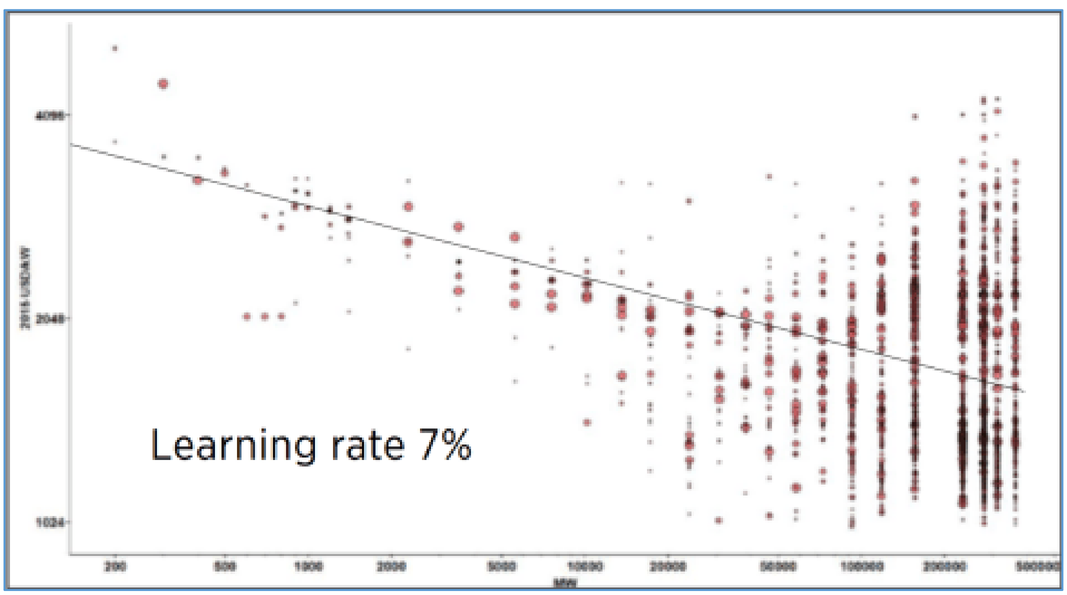
Figure 3 shows a similar curve for wind turbines, also from IRENA. Although the reductions are not quite as dramatic as with solar modules, they are nevertheless very substantial.

Figure 2. Solar Module Learning Curve



Source: Solar Photovoltaic Summary Charts, IRENA, (2018)

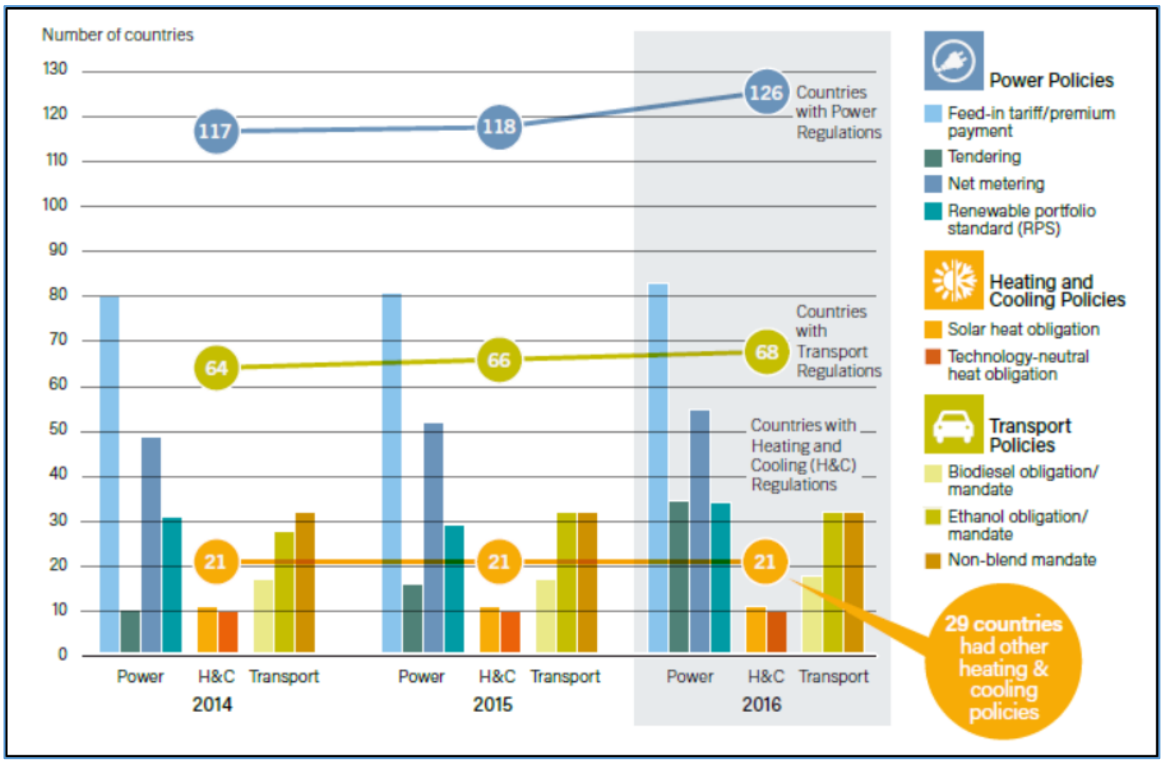
Figure 3. Wind Turbine Learning Curve



Source: "Onshore Wind Industry Learning Fast," IRENA, (2018) The drop in solar and wind technology costs has been accompanied by (and perhaps caused by) substantial growth across the globe in government policies that favor solar, wind, and other renewables. Supportive policies are in place in much of the developing and developed world. In fact, Figure 4 shows the extent and growth of mandates and subsidies favoring renewables, including feed-in tariffs, net metering, and renewable portfolio standards.

For example, more than 120 economies have policies favoring renewables in the power sector, including more than 80 economies applying net metering. The number of economies with such favorable policies is increasing from an already high level. The combination of technology improvements and favorable policies has led to massive reduction in the all-in price of wind and solar energy and an explosion in wind and solar deployments.

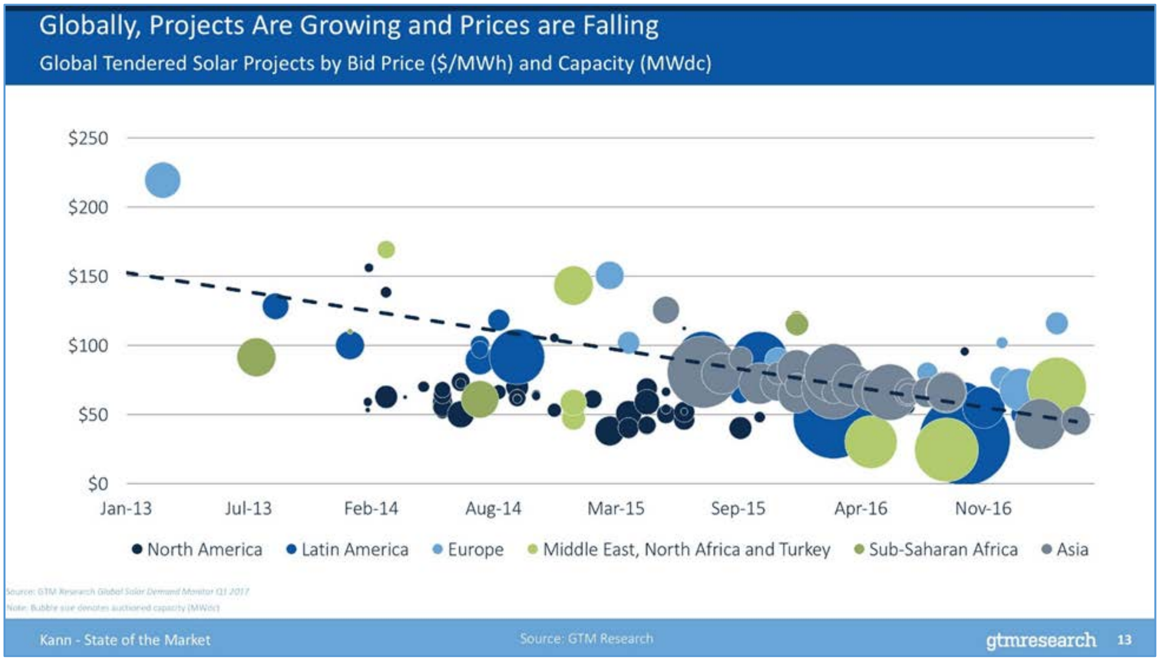
Figure 4. Renewable Energy Mandates and Subsidies, 2014–2016



Source: (Ilas et al. 2018)

Figure 5 above shows the decline in the winning price at auction for utility-scale solar power. Despite considerable variation, winning power purchase agreement (PPA) prices have declined from well over $100/MWh to well below $50/MWh in just the past few years. Recent PPA's have been as low as $30/MWh.

Figure 5. Solar PPA Price Decline, 2013–2016

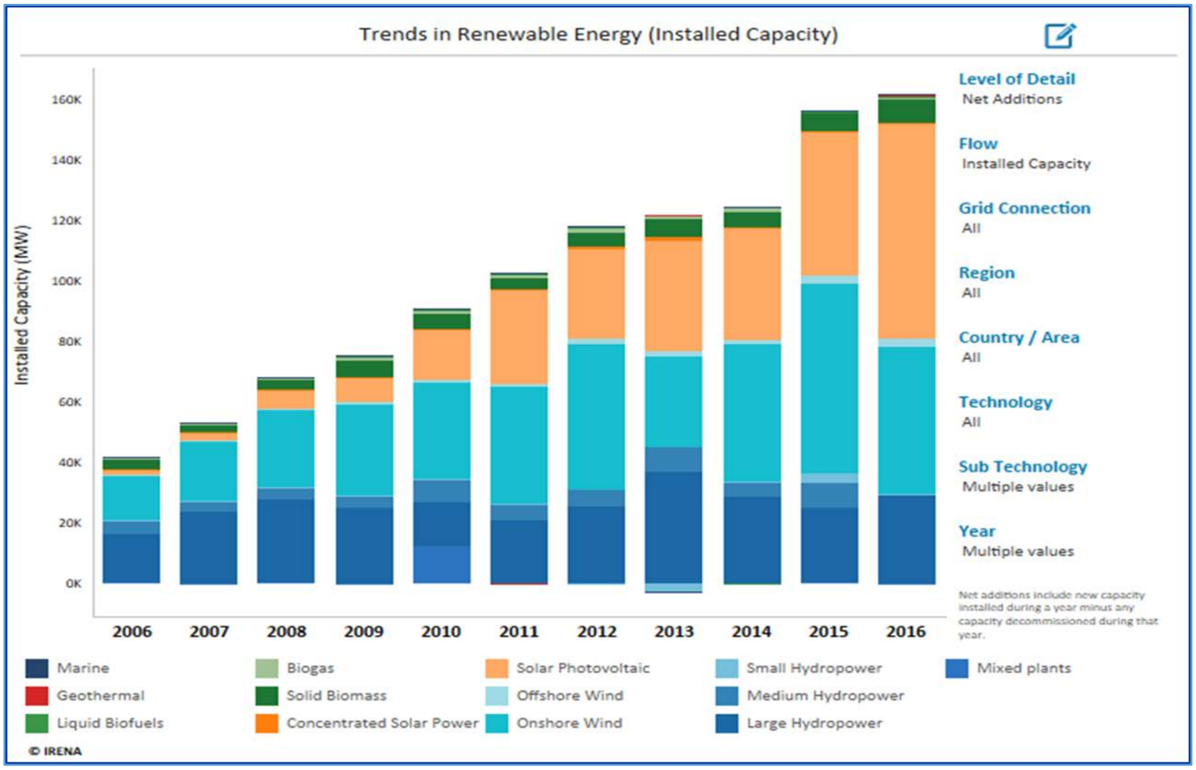


Source: University of California Berkeley, Lawrence Berkeley National Laboratory (LBNL), (2018)

Price reductions and favorable policies have led, in turn, to remarkable increases in wind and solar adoption around the world at all scales. Figure 6 shows the net installations of renewable energy by year. Between 2006 and 2016, annual installations of grid-connected solar and wind increased from perhaps 20GW to more than 120GW. This far exceeds the amount of fossil generation capacity added. Roughly 40 percent of the PV installations are distributed ("rooftop") — residential or commercial/industrial — rather than centralized ("utility scale").

Most experts project that certain trends will continue for a decade or more: these include the phenomena of improving technology, policies that are more favorable, declining prices, growing social interest and increasing deployments.

Figure 6. Installed Capacity for Renewables, 2006–2016



Source: (Ilas et al. 2018)

TYPES OF DRIVERS

There is a wide range of drivers — strongly influential market factors — associated with the adoption of grid-connected solar and wind energy. When positive, such as favorable regulation, these drivers are enablers. When negative, such as unfavorable regulation, these drivers are barriers.

The authoritative International Renewable Energy Agency (IRENA) describes four categories of drivers and identifies key barriers by category, as discussed below (Ferroukhi, Sawin, and Sverisson 2017).
Technical: Physical properties that affect solar and wind deployment. These typically include the underlying solar and wind resources, the geography, weather conditions, and grid design and conditions. According to IRENA, a key technical barrier is "integrating high shares of variable renewable energy (VRE) into existing grids" (Ferroukhi, Sawin, and Sverisson 2017).

Economic: Supply and demand conditions affect solar and wind deployment. These typically include capital and operating costs for solar and wind, capital and operating costs for competitive technologies, the level of economic development, and the level of energy use. According to IRENA, key economic barriers are "relatively high initial capital costs for some technologies; subsidies for fossil fuels and nuclear power; unfavorable power pricing rules" (Ferroukhi, Sawin, and Sverisson 2017).

Regulatory: Government policies and regulations affect solar and wind deployment. These can be specific to solar and wind or to energy. Alternatively, they can be more general. These typically include electricity market rules, import tariffs, and environmental or social mandates, or both. According to IRENA reports, key regulatory barriers are "non-existent or in-sufficient legal framework for independent producers; restrictions on siting, construction and transmission access; arduous permitting processes and utility interconnection requirements; inadequate market operation rules" (Ferroukhi, Sawin, and Sverisson 2017).

Institutional: Individual and organizational resources that affect solar and wind deployment. These typically include capital access, insurance availability, expertise, and suitable data. Key institutional barriers, also according to IRENA, are "lack of access to credit; higher cost of capital due to lack of experience; perceived technology performance uncertainty and risk; lack of technical or commercial skill and information" (Ferroukhi, Sawin, and Sverisson 2017).

EXAMPLES: GLOBAL DRIVERS IN NON-APEC ECONOMIES

Four examples are provided below of drivers — in particular, those for non-APEC economies.

A Case of Significant Benefits: Spain

Spain is a developed economy in which drivers have worked together positively to enable massive grid-connected solar and wind deployment. In 2017, renewables supplied more than one-third of the economy's electrical power; grid-connected solar and wind alone provided roughly 25 percent. It should be noted, however, that the renewable share appears to be reaching a technical, economic, and regulatory limit.

Spain is geographically blessed with considerable solar and wind resources that — because of Spain's compact nature — are fairly close to demand centers. Spain also has a strong electricity grid, and one that is interconnected — at least on a limited basis — with Portugal, France, and North Africa. Because of the size and diversity of the resources on this grid, Spain can absorb a great deal of intermittent solar and wind power without serious operational problems. Overall, Spain is very well-positioned technically for grid-connected wind and solar.

With an economy that is relatively strong on the global scale, Spain is highly developed despite recent issues of recession and unemployment. While not growing, electricity demand is high, and electricity is relatively affordable. Spain also has ready access to equipment and labor markets, and so, capital and operating costs are reasonable. Spain does have nuclear power but does not have ready access to inexpensive fossil fuels that compete with renewables. Overall, Spain is well-positioned economically for grid-connected wind and solar.

Spain made a strong commitment to wind and solar well before the recent dramatic changes in gas and renewable costs. In particular, from 2007 to 2013, Spain had a remarkably favorable feed-in tariff that guaranteed grid-connected solar and wind facilities of $0.25 per kWh or more. Not surprisingly, this led to an explosion of installations. Since 2013, Spain has provided support that is more modest. At the same time that renewables were being favored, Spain continued a mandate to move away from coal. Overall, Spain's policy has been very favorable for grid-connected wind and solar; it has become somewhat less so more recently. Policy is arguably the strongest single enabler for grid-connected wind and solar in Spain.

Spain has very well-developed institutions with the resources for wind and solar deployment. It has modern, global banking and insurance institutions. Since Spain has been heavily committed to renewables for many years, this economy also has local capabilities such as expertise, suitable business models, and the like. Overall, Spain is well-positioned institutionally for grid-connected wind and solar.

A Case of Moderate Benefits: South Africa

South Africa is a faster-growing developing economy that has historically been a leader in renewable energy in Africa, although less so recently owing to economic and political pressure. The renewable share of electricity production, including grid-connected wind and solar, is still very modest at a few percent.

South Africa has moderately good wind and solar resources, though being a large economy and having resources that are not always located close to demand centers. The economy has a sizable electricity grid, although apparently in desperate need of repair. Overall, South Africa is moderately well-positioned technically for grid-connected wind and solar.

South Africa is facing considerable economic challenges overall, particularly with a shrinking economy and declining income per capita. Energy access and affordability is an issue. South Africa continues to rely primarily on cheap coal for electricity. Most of these factors represent economic “headwinds” for grid-connected wind and solar.

South Africa has implemented a variety of policy measures over the years to support renewables — feed-in tariffs, tax incentives, and procurement mandates. However, there has not been a sufficiently strong, consistent approach to renewables development. Consequently, South Africa is only moderately well-positioned politically for grid-connected wind and solar. Policy is, perhaps, the most significant enabler in South Africa, but it is counterbalanced in part by other barriers, particularly the lack of institutional capabilities, as noted below.

Institutionally, South Africa has a dominant central utility but a modest independent power sector, which represents most of the activity and interest in renewables. There are positive signs, but institutional capabilities and resources for grid-connected wind and solar are still emerging. South Africa is positioned institutionally only modestly well.

A Case of Moderate Challenges: Poland

Poland is an example of a developed economy in which drivers represent barriers much more than enablers. Until very recently, Poland had little interest in renewable energy. Poland gets most of its power from coal and only 10 percent from renewables. Grid-connected wind represents about half of that; grid-connected solar is de minimis.

From a grid-connected wind and solar perspective, Poland is technically quite similar to Spain. It has good wind resources and modest solar resources; moreover, it is a compact economy in which supply and demand are in relatively close proximity. Poland has a strong, sizable grid that is interconnected with other economies on a limited basis. Overall, Poland is well-positioned technically for grid-connected wind and solar.

On the general economic front, Poland is much like most of Europe. It is moderately wealthy with sizable but stagnant electricity demand. However, a critical distinction is that Poland has lots of inexpensive coal, uses this coal for power, and consequently has lots of inexpensive coal-based power. Even with improved economics, grid-connected wind and solar cannot compete directly with coal if coal emissions are not monetized. For this reason, Poland has not been well positioned economically for grid-connected wind and solar. Combined with policy issues discussed below, economics has been a key barrier to grid-connected wind and solar in Poland.

On the policy front, Poland’s approach to energy has been highly variable, sometimes encouraging and sometimes discouraging renewables. The current government has recently made it very hard on renewables in favor of coal, gas, and perhaps, nuclear. For example, in 2016, Poland dramatically increased taxes, citing restrictions and inspection requirements on wind energy. There are indications that this on-again, off-again support for renewables will be switched back on in the near future. Generally, Poland has not been well-positioned politically for grid-connected wind and solar. As noted above, regulations and economics represent barriers for Poland.

Poland also has well-developed institutions with access to necessary resources for grid-connected wind and solar deployment. However, there is less local know-how than elsewhere given the emphasis on other fuels and the variable support for renewables. Overall, Poland is only modestly well-positioned institutionally for grid-connected wind and solar.

A Case of Significant Challenges: Nigeria

Nigeria is a developing economy in which unfavorable conditions have dramatically limited the deployment of grid-connected wind and solar. With a population of nearly 200 million, it is the largest economy on the African continent. Until recently, Nigeria has shown very little interest in renewable energy, and the current level of renewables is minimal.

On the technical side, Nigeria has only limited wind resources. There are good solar resources, but these resources are often located far away from demand. Solar and wind also compete for land with other uses in a densely-populated, agriculture-based economy. Nigeria has a remarkably weak electricity grid. Electricity access is spotty at best, and quality and reliability are poor. Because the grid operates with difficulty under current conditions, adding generation that is more intermittent would only create further problems. As such, Nigeria is poorly positioned technically for grid-connected wind and solar. This is a significant barrier.

On the economic side, Nigeria has significant economic challenges. Energy access is limited, demand is modest, and affordability is an issue. At the same time, wind and solar face formidable competition from domestic oil and gas as well as hydro. Overall, Nigeria is not well positioned economically, both on the cost and revenue side, for grid-connected wind and solar. This is also a significant barrier.

At the regulatory level, Nigeria's focus is more on expanding energy access than in promoting renewable energy. However, Nigeria has recently incorporated renewables into this broader goal and has established ambitious targets. However, most of the new emphasis is on small-scale off-grid facilities and not grid-connected wind and solar. Most important, there is as yet no coordinated policy effort for achieving the renewable goals. This makes the regulatory situation for renewables neutral at best.

Nigeria's institutions are challenged in many domains including energy. Resources are scarce, and capabilities are weak. For this reason, Nigeria's institutions are too significant a barrier.

STATUS OF SOLAR AND WIND TECHNOLOGIES IN APEC ECONOMIES

Renewable energy project installations in APEC are growing rapidly. While historically the largest private investments into renewables projects have been concentrated in Europe, new economic drivers and regulatory incentives have made the Asia-Pacific region more attractive for investors for a number of reasons: Strong natural wind and solar resources, a growing population and energy demand, and increasing regional and domestic support for renewables have steered interested parties toward APEC economies in the past few years.

This section provides an overview and assessment of the status of renewable energy development, particularly wind and solar. Figure 7, below, depicts the APEC renewable energy generation targets.

Figure 7. Renewable Energy Generation Targets, by APEC Economy

Economy	Renewable Energy Generation Targets
Australia	23.5% by 2020
Brunei Darussalam	10% by 2035
Canada	n/a
Chile	60% by 2035; 70% by 2050
China	27% by 2020
Hong Kong, China	n/a
Indonesia	25% by 2025
Japan	22–24% by 2030
Republic of Korea	13.4% by 2035
Malaysia	11% by 2020
Mexico	35% by 2024; 50% by 2050
New Zealand	90% by 2025
Papua New Guinea	100% by 2050
Peru	60% by 2025
The Philippines	15,304 MW by 2030
Russia	18—27 TWh by 2035
Singapore	n/a
Chinese Taipei	20% by 2025
Thailand	33% by 2036 (at least 59,300 MW)
United States	n/a
Viet Nam	38% by 2020; 32% by 2030; 43% by 2050

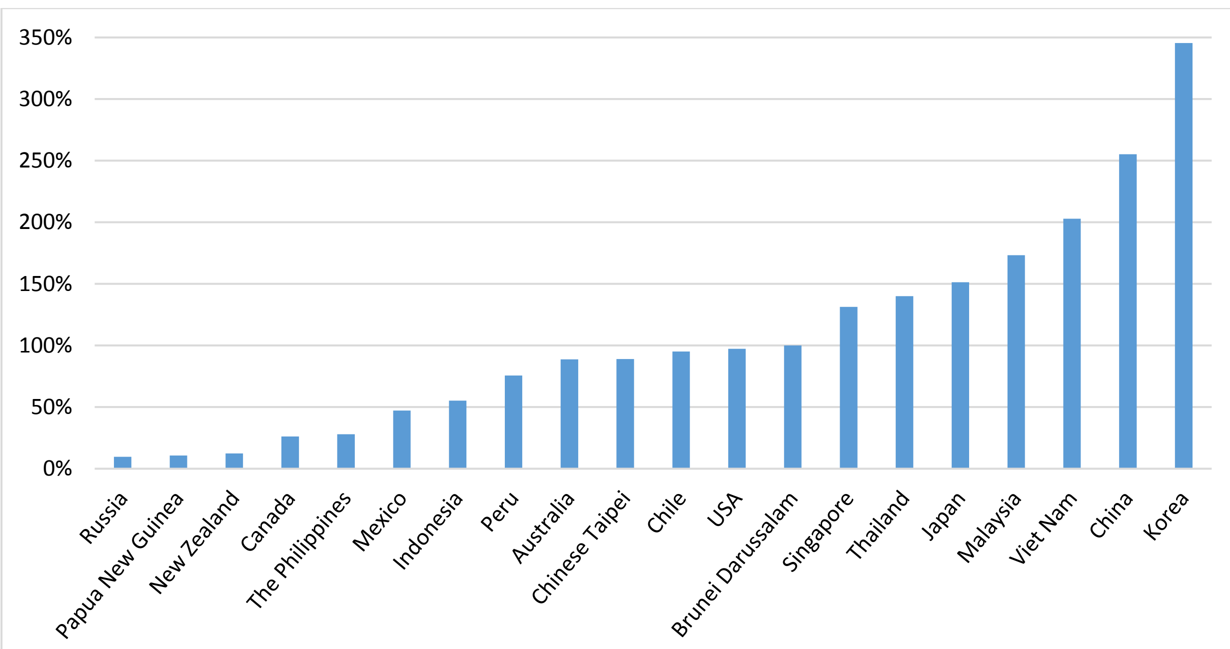
Source: APEC EWG 2017.

To meet the APEC Leaders' goal of doubling renewable energy by 2030, most APEC economies have set further domestic generation targets for the mid to long-term. These targets range in terms of ambition but demonstrate an overall trend of economies publicly stating their commitment to increasing their share of renewables in line with regional objectives. Certain economies where the public drive for increasing renewables is strongest have committed to enthusiastic targets, such as Papua New Guinea targeting 100 percent and Chile targeting 70 percent of renewable generation by 2050.

The APEC region has seen high potential for increased renewables. With an incredibly diverse group of member economies, APEC is a model of the globe with member economies of all sizes, climates, and levels of growth and development. Nonetheless, one characteristic that every APEC economy shares is the commitment to the establishment of more renewable energy projects. In the past several decades, APEC economies have seen a remarkable increase in their domestic power generation levels.

Figure 8 demonstrates the percentage growth in total generation from renewables between 2008 and 2017, making clear the universal increases in renewable energy that the region has seen. As discussed in more detail below, the great bulk of this increase comes from grid-connected wind and solar.

Figure 8. Trends in Renewable Generation across APEC Economies, 2008–2017

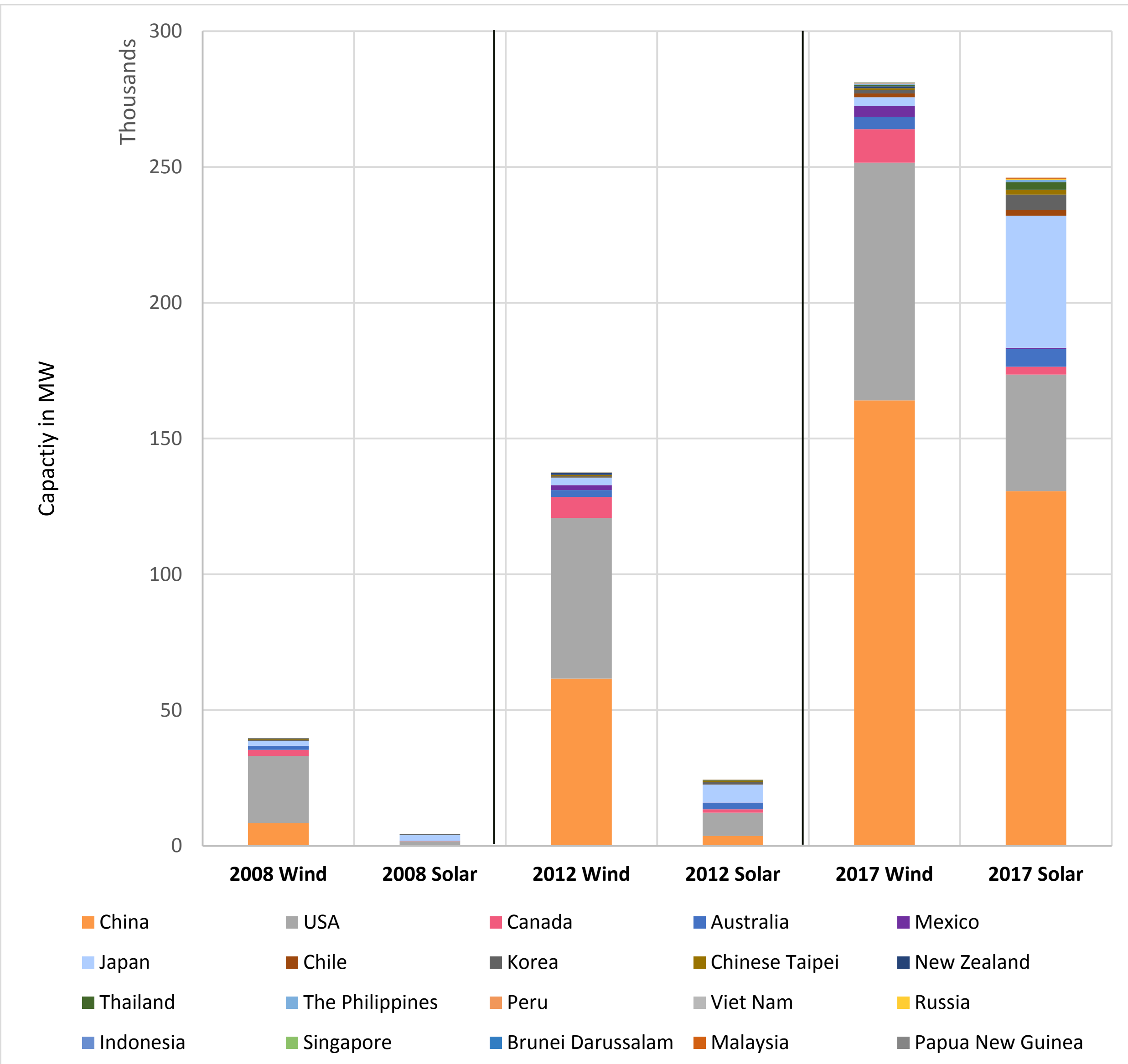


Source: (Ilas et al. 2018); Whiteman et al. (2018)

Grid-connected solar and wind projects, in particular, are well positioned for robust long-term growth across the APEC region, because of the vast natural resources in a majority of APEC economies and universal declining costs for related infrastructure development. While ever-growing electricity needs in APEC economies rise and most economies undergo population expansion and higher electrification goals, wind and solar offer a sustainable, efficient option for future energy supply.

Over the past decade especially, as APEC and other regions across the globe have undergone an exponential boom in renewable-energy infrastructure development, wind and solar generation have seen large upturns in nearly every APEC member economy. Of this generation, all wind projects are grid-connected as are the majority of solar. As evident from Figure 9, the largest economies (those in real terms but also GDP per capita) currently dominate the share of regional renewable generation through wind and solar attributable to higher levels of spending, far more investment opportunities and to more robust private sector engagement and public sector buy-in in certain cases. Australia; Canada; People's Republic of China; Japan; and the United States lead in terms of total capacity and have been the largest contributors to the overall growth of wind and solar in the region. While lessons can be learned from these highly developed market leaders, custom approaches will likely be needed given the vastly different levels of available funding, financing mechanisms, and respective barriers to entry.

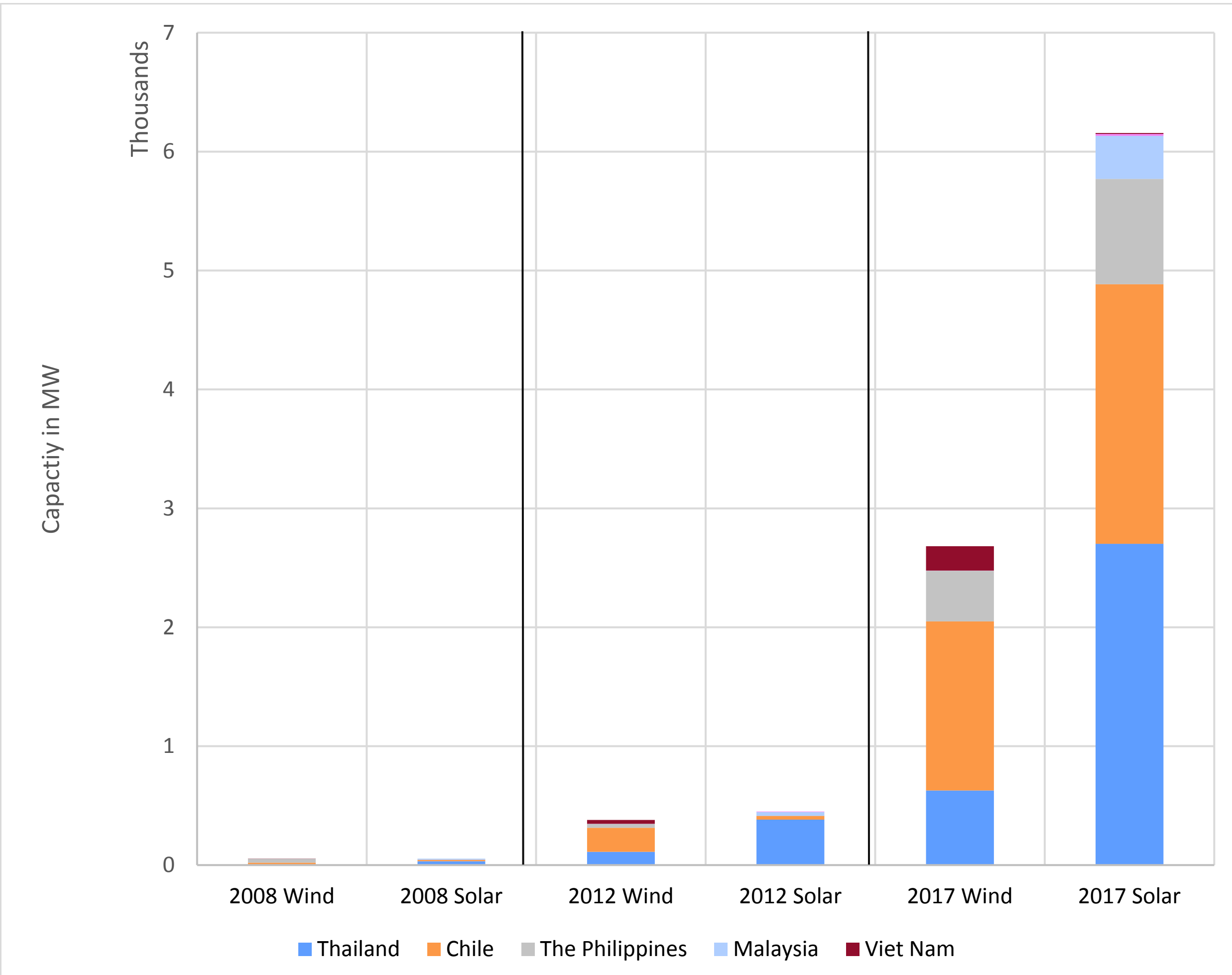
Figure 9. Growth of Wind and Solar Capacity in APEC, 2008, 2012, and 2017



Source: Nathan Associates calculations based on Whiteman et al. (2018)

Figure 10 below shows the same data on wind and solar growth but for only a smaller grouping of faster developing economies that have recently shown success in building out their wind and solar capacity — to demonstrate the extreme growth of solar and wind in APEC developing economies, in particular. Chile; Malaysia; The Philippines; Thailand; and Viet Nam are selected developing economies that have navigated rapid project development and scale-up for wind and solar especially.

Figure 10. Growth of Wind and Solar Capacity in Selected APEC Economies, 2008, 2012, and 2017



Source: Nathan Associates calculations based on Whiteman et al. (2018)

APEC ECONOMY MARKET DRIVERS

The four categories of drivers described earlier — technical, economic, regulatory, and institutional — are relevant to the APEC economies. This section provides specific examples of particular importance in these economies.

TECHNICAL DRIVERS

Technical drivers are identified as particularly important for a selection of APEC target economies and are summarized below.

Transmission and Grid

A common technical driver for each economy is the transmission system and grid capabilities. Economies that have not run into transmission and grid issues tend to already have robust, forward-looking policies toward transmission. The best example of this is Thailand, which makes extensive use of power system modeling to determine long-term transmission requirements to support renewable expansion. These economies apply an approach termed *renewable energy zoning* by which they use modeling to identify how different forms of renewable energy, including wind and solar, can complement each other across multiple regions and identify how transmission networks can support this. The result is a comprehensive path forward that can support the variability of wind and solar.

In addition, to qualify for the feed-in-tariff, developers of wind and solar projects must commit to providing semi-firm (can have 100 percent availability from 08:00-22:00 with 65 percent during the remaining period) or firm capacity (can provide power for a whole year). The result is developers hybridize their variable renewable energy with other sources to ensure they can meet these definitions.

With these policies, Thailand's Ministry of Energy has thus far had no issues with grid stability or curtailment (Chen et al. 2017b). Despite these enablers, some stakeholders suggest a barrier of significant uncertainty is created because Thai utilities do not publish their transmission expansion plans, making it difficult to assess potential wind and solar sites (Beerepoot et al. 2013).

Chile is in the process of turning what has been a *barrier* into an *enabler*. On account of a lack of transmission capacity, there have been delays in several solar projects because the government has not allowed utilities to proceed owing to incomplete transmission infrastructure (Critchley 2016). Chile is quickly transitioning this barrier into an enabler through policies that comprehensively consider transmission and the expansion of renewables. In 2016, Chile established The Transmission Law, which created a national transmission system and a national electricity coordinator to support grid expansion, interconnections, and the modification of the transmission toll to encourage renewables (IEA 2018a). This law was enacted because Chile was beginning to see curtailment of wind and solar energy in their northern regions because of the lack of transmission capacity.

Other target economies face barriers related to transmission infrastructure. Papua New Guinea already has an unreliable grid, making the addition of variable solar and wind generation a concern (APERC 2017). For another example, Viet Nam lacks administrative regulation and the necessary investments in transmission and distribution infrastructure to support large-scale renewables deployment (NDC Partnership 2017).

Both Indonesia and The Philippines face unique transmission-related barriers that stem from their geography. With many small islands, both economies have issues of limited transmission capacity and reliability issues on islands that are off the main grids. In The Philippines, the region of Northern Luzon suffers from increasing grid frequency violations because of large amounts of variable renewable energy, and some islands, even those with low solar and wind penetration, have curtailment issues (Chen et al. 2017).

Land

For some target economies, land plays a significant role as a driver. Indonesia is cited by the International Institute for Sustainable Development as having a lack of land available for wind or solar development near population centers. The low-cost land that is available is far from population centers or in areas with weak grid connections or poor wind and solar resources (IISD 2018).
Papua New Guinea's economy relies primarily on subsistence farming and smallholder cash crops, a scenario that results in highly fragmented land ownership. Solar and wind farms that require large areas of land must negotiate with a large number of landowners to acquire the land needed to develop.
Chinese Taipei, with a small land area, has limited land availability. The government is actively confronting this by releasing and making available as much land as possible with measures including opening up the possibility to put solar on landfills or ponds and exploring crops that can grow under solar panels like mushrooms (Hu and Mathews 2016).

The Philippines also has land availability concerns; the land that is available is high-cost, making it difficult for solar, in particular, to achieve the low-costs that other economies are able to realize.

Some economies are overcoming land barriers by considering alternatives to onshore wind and traditional solar PV. Chinese Taipei has completed an 8-MW offshore wind demonstration project with the goal of attracting further offshore wind projects to address land availability. For another example, Singapore has a pilot floating solar farm, which has been used elsewhere to overcome land barriers by placing solar panels above water.

ECONOMIC DRIVERS

Various types of economic drivers are being used in APEC economies to finance and invest in renewable energy projects, including established renewable energy targets, feed in tariffs (FiT), auctions, tax incentives, soft loans, capital subsidies, and tradeable renewable energy certificates (REC). The economic drivers identified and highlighted below are particularly important for selected APEC target economies.

Over the past decade, FiTs have served as one of the most popular drivers for promoting renewable energy worldwide. With FiTs, domestic governments are able to price fees for standard energy users for the renewable electricity they generate, and the market then determines the volume of energy capacity required dependent on the established infrastructure. There are two options for FiTs: either (a) a fixed tariff, wherein a purchase rate for electricity is set at a constant level independent from the fluctuating market price or (b) a premium "adder" tariff, which serves as an additional rate on top of the electricity market price. The Philippines; Thailand; and Viet Nam rely on feed-in-tariff schemes for both wind and solar PV and Malaysia and Indonesia use them for solar PV (Yaowapruek 2017).

Renewable energy auctions, on the other hand, also known as *demand auctions* or *procurement actions*, allow governments to set the volume of capacity and the market to then determine the price. With renewable energy auctions, the government allows tenders to procure a certain capacity or level of generation of renewables-based electricity. Project developers who engage in the auction typically submit bids for prices per unit of electricity, and the auctioneers evaluate offers based on price as well as on certain other criteria. A power purchase agreement (PPA) is ultimately signed with the most successful bidder.

Advantages to auctions include (a) the ability to set market prices, (b) the availability of competitive incentives for cost reduction, and (c) the flexibility to control volume to ensure grid capacity constraints are met. The downsides of auctions, however, are that a large number of bidders are required and that timely realization is not guaranteed. The scale of options is relatively small, though growing quickly. For instance, in 2015 Singapore had completed a pilot solar auction for a 76 MW capacity solar rooftop. In contrast, in 2017 Indonesia had managed 149 MW capacity for solar auctions, whereas Malaysia had reached 760 MW (Yaowapruek 2017).

Targets, FiTs, auctions, tax incentives, and soft loans all exist in Indonesia; Malaysia; and Thailand, whereas Singapore; Thailand; and Viet Nam all have targets, FiTs, and tax incentives (Yaowapruek 2017). Predictably, these several economies have shown significant recent progress in the establishment of more renewable-energy projects (Yaowapruek 2017). In Mexico and Peru, renewable energy auctions and other methods for promoting more renewable energy have also proved very successful. Mexico's enabling environment consisted of long-term PPAs with net-metering mechanisms to sell surplus energy produced by renewables to the grid. The imbalances of the contracted amount of energy versus the dispatched energy were then liquidated annually at a wholesale spot market. Between 2016 and 2017, Mexico held three energy auctions, which in total contracted 19.8 TWh, of which 60 percent was solar and 39 percent was wind. This resulted in 21 million 20-year clean energy certificates (60 percent solar, 37 percent wind), with the average contracted prices for these certificates falling by 58 percent during this period from $47.6/MWh to $19.8/MWh (Molina, Scharen-Guivel, and Hyman 2018).

The first two actions were open only to the state-owned electric utility, the Federal Electricity Commission, but the third auction was then opened up to the private sector. Mexico's auction process was very successful because it was transparent, with a publicly disclosed process. In addition, there were targets for contracting clean energy certificates, technology-neutral auctions, disclosed ceiling prices per technology type, preferential access to the transmission grid, relatively few qualification requirements, and bidders were able to select the project site — all of which contributed to the effectiveness of the auctions (Molina, Scharen-Guivel, and Hyman 2018).

Peru, a much smaller market than Mexico, had 13 GW of installed capacity in 2016. For their auctions, they engaged in a two-round process, where in the price ceiling were revealed in the second round. These were also 20-year PPAs with premium feed-in-tariffs, indexed to the U.S. dollar and inflation rate.

Bidders had the option to select project sites with few qualification requirements, and Peru included preferential dispatch with zero marginal costs and VAT reimbursements as well as accelerated depreciation (Molina, Scharen-Guivel, and Hyman 2018). Peru had four grid-connected renewable energy auctions from 2009 through 2015, as well as one off-grid solar auction. Between 2009 and 2015, prices fell from $221/MWh to $48/MWh for solar and from $80/MWh to $38/MWh for wind (Molina, Scharen-Guivel, and Hyman 2018).

In total, Peru and Mexico were able to attract experienced investors and developers to their auctions through the right incentives and processes. There are several steps that can be taken to raise investors' confidence and attract investment, and these examples prove that renewable energy enabling policies, transparent procurement of renewable energy resources, resource targets, PPAs with stable revenues indexed to foreign currency and inflation, fiscal incentives, timely information on capacity of transmission, and preferential dispatch all benefit the development of more renewables projects. Both Peru and Mexico have future renewable energy auctions scheduled in 2018 and beyond (Molina, Scharen-Guivel, and Hyman 2018).

Electricity Prices and Technology Costs

Electricity prices play an important role in attracting wind and solar investments. Higher electricity prices allow for the recovery of the large capital investments required for wind and solar.

Chile has the one of the lowest costs for wind and solar electricity in the world attributable to excellent wind and solar resources. As a result, Chile's rapid expansion of wind and solar has been driven heavily by economics and wind and solar installed capacity have been developed without any direct subsidy. In the northern part of Chile, this is especially the case: fossil energy is relatively expensive, and wind and solar resources are very strong. In that region, wind and solar have taken the majority of market to meet incremental electricity demand (IEA 2018a).

For other target economies, technology costs and electricity prices are a barrier despite high-quality wind and solar resources. Wind and solar costs are declining rapidly around the globe; however, they still have some difficulties competing with fossil fuel generation in many economies. When fossil fuel generation is subsidized, this is especially the case. Many economies also subsidize their electricity price, directly or indirectly. When this is the case, investors have difficulty with cost recovery for wind and solar generation. Examples of both of these occur in several target economies, including Indonesia where the coal industry is heavily subsidized by the government, effectively decreasing the cost of electricity (IISD 2018). In Viet Nam, industrial electricity prices are subsidized, for another example (Perera 2018). And in Chinese Taipei, the utility Taipei has a quasi-monopoly and subsidizes electricity prices. All of these factors makes it difficult for wind and solar to compete.

In Indonesia, a barrier related to cost is created owing to regulations capping power-purchase prices to 85 percent of the local average generation cost. This is designed to ensure that adding wind and solar will not raise electricity prices. However, it creates a significant barrier for wind and solar to compete with subsidized coal when it has to come in at 85 percent of cost by law. There are some areas of Indonesia where wind and solar can still be competitive with the 85-percent cap, but those are areas where populations are low or the grid is weak.

Energy Demand

A limited number of target economies had references that considered energy demand as a barrier. Most of the target economies have rapidly increasing energy demand providing sufficient room for wind and solar growth. Papua New Guinea, which has less than 15 percent of the population electrified and a similarly low percentage of the population living in urban areas, faces energy demand barriers (APERC 2017). One report on Chile found that recent slumps in the mining sector, which is a large driver of energy demand, lowered spot prices enough to make it difficult justifying additional capacity (Critchley 2016). This example illustrates how energy demand can be a driver for energy prices and the viability of wind and solar.

Wind and Solar Subsidies

An important driver of wind and solar investment is the availability of subsidies and other policies designed to help lower the cost of wind and solar energy. Feed-in-tariffs can help to increase returns for investors in wind and solar generation. Indonesia; Malaysia; The Philippines; Chinese Taipei; Thailand; and Viet Nam all have feed-in-tariffs at varying levels. Feed-in-tariffs at a high enough level can spur investments, while too low of feed-in-tariffs can have little effect. The feed-in-tariffs have the potential for flexibility by allowing them to vary by region depending on local conditions. For example, Indonesia has areas where electricity costs are high (Papua province), and electrification rates are low. In these areas, the feed-in-tariff is higher than in areas where it is less expensive to produce electricity like Java. The feed-in-tariff has this type of flexibility that can enable development goals (Cox and Esterly 2016).

Subsidies for wind and solar have been shown to play an important role in incentivizing wind and solar investments. In Thailand, the current feed-in-tariff replaced an older adder (feed-in-premium), which in turn, increased the price paid to wind and solar on top of the market price. The original 2007 adder started out too low, resulting in fewer investments than desired. The government raised the adder resulting in so many investors subscribing to it that they had to halt wind and solar projects in 2010 before lowering it again.

Some of the target economies have recently been using auctions to procure wind and solar capacity, considered one of the better ways to determine market prices for wind and solar investments. Indonesia has increasingly been using auctions for small solar projects, resulting in greater transparency of current solar market prices; moreover, Malaysia had a 2017 auction for solar capacity, resulting in 563 MW of procurement (Ferroukhi, Nagpal, and Hawila 2018).

Other supportive policies have been implemented in the target economies like net metering in Malaysia; The Philippines; and Viet Nam, and net billing in Chile. Renewable energy credits, designed to help organizations meet renewable goals, exist in Chinese Taipei and The Philippines. Chile, The Philippines, and Viet Nam have renewable portfolio standards (RPS). Chile's renewable generation has exceeded the renewable portfolio standards given the high level of competitiveness of the resources.

REGULATORY DRIVERS

The policy and regulatory drivers identified and summarized below are particularly important for selected APEC target economies.

Government Policies

A policy driver that differs for many of the target economies is how they treat imports and domestic capabilities. To spur wind and solar investments to the greatest degree possible, the lowest cost source should be provided. However, many economies want to build up or support their domestic industries and workforce. As a result, some barriers to wind and solar investments can be created. The Philippines and Viet Nam both offer duty-free imports to lower the cost of wind and solar investments. Thailand has duty-free imports of machinery and raw materials for wind and solar. However, their domestic manufacturing capabilities for wind and solar are not advanced, and they must import equipment and completed parts that face high import duties (e.g., solar panels and inverters face an import duty of 35 percent of their total value) (Beerepoot et al. 2013).

This results in significant cost escalation for solar projects. Indonesia has a local content requirement that 40 percent of cost must be sourced locally for wind and solar projects. Indonesia's relatively small solar manufacturing capabilities results in production that is costlier than the international market. This mandate then increases prices for developers, thus creating a cost barrier (IISD 2018).

The actual process of developing policies is identified as an enabler for Chile. Chile's Energy 2050 policy promotes renewables and was developed with an inclusive participatory process in which all stakeholders across Chile were involved, including politicians, an advisory committee, technical experts, industry sectors, and citizens; all through working groups, a citizen platform, workshops, public consultation, and meetings set in different regions of Chile to allow for everyone to easily participate (IEA 2018a). Chile's Energy Roadmap 2018-2022 has also been released, marking the latest participative process related to renewable energy development in the economy.

Government policies can also be too complex or disjointed, inconsistently enforced, or involve too many entities. In Thailand, some think that too many government departments are involved in the planning and permitting process for wind and solar developments, resulting in it being slower than necessary (Beerepoot et al. 2013). Similarly, in Indonesia, there are too frequent changes in policy, regulatory delays, and inconsistent implementation policies by Perusahaan Listrik Negara (PLN), the state-run utility (PwC 2017). Interviews in The Philippines indicate that the permitting process can take a long time (1-2 years for wind) and a required renewable energy service contract can take a year to acquire. Additionally, interpretations of regulations can differ between local and regional government organizations, and permitting guidelines can change drastically when office administrations or heads of departments change (Rosellon 2017).

Markets and Monopoly

An important contributor to the success of wind and solar in certain economies is the allowance for private participation in electricity markets. Chile was a pioneer in deregulating the power sector and opening it up for private participation in 1982. Thailand has encouraged private participation in their energy market since 1992. This is a key reason for both economies leading to the development wind and solar power among the target economies. Other target economies have begun to see the usefulness of private participation. Chinese Taipei, dominated by its quasi-monopoly power company Taipower, has recently created a renewable energy credit that allows all companies, including foreign companies, to procure from renewable energy projects (Porter and Labrador 2018). A local financial services group, Cathay Financial Holdings, was the first to use the program procuring T-RECs from recently constructed rooftop solar projects.

Several target economies face barriers created by monopoly utilities. Electricity Viet Nam has a monopoly on the market and the ability to cancel power purchasing agreements (PPA) at any time with no guarantee that they will purchase electricity for the length of contracts, resulting in significant risk for investors (Green 2018). In Indonesia PLN has a monopoly on transmission and distribution and on the majority of generation. Industry stakeholders see a conflict of interest between PLN and renewable energy since PLN supplies the majority of fuel-to-diesel generation and owns the majority of fossil generation. An increase in wind and solar could result in stranded assets for PLN, giving them an incentive to maintain current fossil generation (IISD 2018).

INSTITUTIONAL DRIVERS

The institutional drivers identified and summarized below are particularly important for selected APEC target economies.

The first stages of attracting private sector investment are for the host economy government to define the needs for a project as well as the strategy and the resource requirements. International institutions, such as or USAID or the World Bank Group, can assist with these processes. Following this is the identification of opportunities, wherein feasibility studies are conducted and programs are designed, sometimes with the help of expert bodies such as the U.S. Trade and Development Agency. The final step is then implementation, in which private sector investment and financing from development finance institutions can serve to mobilize investment. Certain such institutions have included renewable energy as components of their long-term sector strategy, with the understanding that renewable energy projects fit into many economies' domestic development goals and that successful first projects for certain technologies can act as catalysts to facilitate further private sector investment and lending.

Development finance institutions, such as the Overseas Private Investment Corporation (OPIC), can play either a direct or indirect role in risk mitigation by acting as an honest broker. This has benefits from both the government's and the investor's perspective, ensuring interests are aligned and projects are in adherence with international standards. As such, OPIC is one of the multilateral institutions that has successfully been mobilizing private capital and investment, particularly for solar PV projects in APEC. Once a project is deemed commercially viable, OPIC offers "innovative financial solution to support private investors including debt financing, risk insurance, and support for private equity investment funds." Debt financing makes up the majority of the project support portfolio; this can include financing for the public or private sector, commercial projects; Moreover, there are also specific programs designed for providing finance to small and medium-size enterprises (SME). Risk insurance includes coverage against currency inconvertibility, expropriation, and political violence or terrorism; it can be for up to 20-year terms with a fixed premium. Lastly, private equity investment funds are selected through a competitive process, and through OPIC, they can provide up to $250 million with set repayment plans and a zero-coupon structure (OPIC 2017).

There are also many local banks that have realized the benefits of investment and have begun supporting renewable energy projects within their home economies. In Viet Nam for example, a large private commercial bank, Saigon-Hanoi Commercial Joint Stock Bank, has demonstrated committed interest in financing renewable energy projects in the domestic economy.

Domestic Capabilities and Education

Several of the target economies have strong domestic solar manufacturing capabilities. Chinese Taipei is the 2nd largest manufacturer of solar panels in the world, and Malaysia is the 3rd largest exporter of solar PV modules. Enhancing and creating the environment to utilize the capabilities can result in lower costs and domestic economic benefits. Where human resources and domestic industries to support wind and solar are lacking, this can be a barrier — as is the case in Indonesia; Papua New Guinea; The Philippines; Thailand; and Viet Nam. When economies with less capable domestic industries have requirements for the use of local industry, it can escalate project costs (e.g., Indonesia and Malaysia).

Several target economies place significant focus on enhancing domestic manufacturing and education in order to reduce cost barriers, generate enablers in terms of a local workforce, and enhance their economy. In Chile, the Energy 2050 policy embeds renewable energy culture into all formal education plans (IEA 2018a). In Malaysia, domestic manufacturing capabilities are enhanced by offering a premium tariff for projects meeting a minimum of local content. Malaysia has implemented advocacy programs to communicate and educate stakeholders and the general public on renewable energy. They have also developed training institutes and centers of excellence and offer financial support to individuals after completing renewable energy courses (Ferroukhi, Nagpal, and Hawila 2018). All of these serve to improve the environment for renewable energy and to make it more attractive and cheaper for investors who can use local labor and manufacturing as they are able to. These policies, which build up capabilities without local content requirements for wind and solar development, can reach the same end-goal without generating cost barriers.

Financing

Financing enablers and barriers tend to revolve around having low-interest-rate loan options, risk mitigation, and access to financing from development banks, international banks, or local banks. Local banking can be a strong enabler by providing easy access to financing and the experience to navigate local conditions.

One of the most successful examples of government support for financing is in Chile. To address financing barriers the Chilean Economic Development Agency implemented a concessional loan program to support commercial banks in providing low-interest loans for renewable energy. This has resulted in some Chilean banks engaging in the provision of affordable financing for renewable energy projects. Thailand also has strong domestic financing options. Local banks have experience and knowledge on project financing for renewable energy owing to a strong history of government support. The Energy Conservation Promotion Act 1992 (ENCON) transfers money from a petroleum fund to an ENCON fund, which uses it to promote renewable energy investments. The ENCON has a revolving fund, which gives out 0 percent interest loans to banks, for them to loan to renewable projects at a maximum interest rate of 4 percent for 7 years (Beerepoot et al. 2013).

A financing barrier in The Philippines was investors having difficulty financing preparatory work (site identification, design, planning, permitting, etc.) for wind and solar projects. This was overcome through targeted loan programs. The Development Bank of Philippines offers 0 percent loans for preparatory activities, and the Land Bank of Philippines also provides 0 percent loans for 50 percent of project preparatory costs (Chen et al. 2017).

Viet Nam has seen success from subsidized rates of interest for wind and solar financing through its Ministry of Finance and loan options from the Viet Nam Development Bank. However, Viet Nam still faces barriers from a lack of domestic banks having experience with financing wind and solar investments, despite the recent support from the Saigon-Hanoi Commercial Joint Stock Bank. In addition, the small size of commercial banks in Viet Nam makes funding entire projects difficult, and their interest rates are high (Tran et al. 2016).

The Philippines faces difficulty with local bank financing. Local institutions require proponents put up 25-30 percent of project cost as equity, so some companies are unable to raise this domestic equity, and foreign ownership is constitutionally capped at 40 percent, so they are unable to proceed.

EXAMPLES: SELECTED APEC ECONOMIES

While the largest economies in APEC such as Canada; China; Japan; and the United States dominate the relative share of grid-connected wind and solar projects and capacity generation, this report analyzes the status of wind and solar and provides a market assessment for financing grid-connected wind and solar energy projects in selected, smaller APEC economies with high potential for further development. Thus, the economy profiles below, discussing market status as well as renewable energy drivers, barriers, and enablers, are focused on four smaller APEC economies: Chinese Taipei; Malaysia; Thailand; and Viet Nam. These are shared to demonstrate that grid-connected wind and solar projects need not be clustered in the largest economies and to show that all APEC economies can successfully attract large-scale investment for grid-connected wind and solar projects with the proper policies, incentives, and communications in place. These profiles highlight the energy situations and relevant renewable energy policies and promotion strategies in Chinese Taipei; Malaysia; Thailand; and Viet Nam.

Chinese Taipei

Chinese Taipei has proved very adept at sourcing financing for recent wind and solar projects, rapidly expanding its renewable energy capacity in the past decade. Overall, Chinese Taipei is heavily reliant on energy imports as 98 percent of the total energy supply came from imported energy in 2015 and its domestic demand continues to increase. This is one of the main reasons Chinese Taipei is strongly promoting the use of renewable energy domestically. In 2015, the 3.2 percent of electricity was generated from renewables, including hydropower, but that percentage has been increasing for the past several years (APERC 2018).

One of the two major objectives of Chinese Taipei's 2016 "New Energy Policy" under the Ministry of Economic Affair's Bureau of Energy is to enlarge the clean energy share of the energy mix, increasing the renewable energy share to 20 percent of total power by 2025 and reducing coal use to 30 percent in the same period. Strategies to achieve the New Energy Policy include furthering diversifying the energy mix with modern clean energy technologies, accelerating energy-saving systems and strengthening the stability of the power grid, and integrating domestic resources and a greater system to promote clean energy. Of the four guiding principles contained in the revised 2017 "Guideline on Energy Development" for Chinese Taipei, one is focused on Green Energy, including a goal to, "establish an environmental costs pricing mechanism through policy tools or market a market mechanism… to foster green production and green energy investment." A second principle also highlights Environmental Sustainability to improve air quality by "taking the cap of total emissions from air pollutants as the basis for the planning of new power plants" and continuing the control of greenhouse gas emissions (APERC 2018).

In order to become a nuclear-free economy and achieve the goals as stated in the Greenhouse Gas Reduction and Management Act, reducing greenhouse gas emissions to 50 percent below 2005 levels by 2050, the Ministry of Economic Affair has been focusing on generating enterprise. One of the renewable energy-generating corporations can sell electricity through wholesale, wheeling, or direct supply, while the traditional energy-generating corporation is not allowed to sell electricity to the end user and can only sell to a retailing utility corporation. Additionally, renewable energy retailing corporations can only purchase electricity generated by renewable energy generation equipment for wheeling to users (APERC 2018).

The two major renewable energy resources in Chinese Taipei are solar PV and wind power. For Photovoltaic systems, the government has established both short and long-term plans for the promotion of PV. In the short-term, the strategy is to establish a foundation, and therefore, the Bureau of Energy proposed a Two-Year Solar PV Promotion Project in 2016 with a target of 910 MW for rooftop and 610 MW for ground installations, totaling up to 1,520 MW of solar capacity. In the long-term, Chinese Taipei plans to expand the installation across the economy, targeting 6.5 GW in 2020 and 20 GW (3 GW rooftop and 17-GW ground system) in 2025 (APERC 2018).

In July 2009, Chinese Taipei passed the Renewable Energy Development Act, focusing on a Feed-in-Tariff (FiT) system, which has resulted in lower costs per kWh for energy generated through PV technologies. In 2016, Solar PV accounted for 1,210 MW of power capacity and 1.1 TWh of electricity generation. By 2025, Chinese Taipei aims to increase these figures to 20,000 MW and 25.0 TWh respectively. Meanwhile, wind power accounted for 682 MW of power capacity and 1.4 TWh of electricity generation in 2016 but plans to be increased to 4,200 MW and 14.0 TWh by 2025 (APERC 2018).

For wind power systems, Chinse Taipei has divided their promotion strategies into two parts, namely, dividing targets and drivers for onshore wind power and offshore wind power. For onshore wind, by 2016, Chinese Taipei had installed 682 MW of onshore wind turbines and is on track to reach their set target of 1,200 MW by 2025. For offshore wind power, the government had installed 8 MW of demonstration offshore wind turbines, and it is expected to install up to 520 MW wind farms in shallow sea area and to develop wind farms in deep sea to reach the target of 3,000 MW by 2025 (APERC 2018). As of May 2018, Chinese Taipei was awarded 3.8 GW of offshore wind capacity, with a further 2 GW of capacity to be awarded in later 2018 and to be built before 2025. Chinese Taipei has invoked a number of economic drivers to promote domestic wind productions, and lawmakers are also expecting to auction another 3–4 GW for deployment after 2025 (Deign 2018).

These economic and regulatory drivers have made Chinese Taipei the second largest offshore market for wind in Asia, following the People's Republic of China. China has one of the largest offshore wind markets in the world and is expected to install up to 28 GW of capacity by 2027.

Malaysia

Malaysia has established various regulatory drivers to push forward renewable energy development, though experts in Malaysia note that due to relatively less abundant natural resources for solar and wind, Malaysia has been more focused on other renewable energy sources such as biomass.

Under the Eleventh Malaysia Plan, the government of Malaysia set a renewable energy target of 2,080 MW of capacity (APERC 2018). As of February 2018, the total installed capacity for renewable energy in commercial operation was 532.2 MW, with solar PV leading the technologies at 357.9 MW. Challenges to renewable project developments in the economy currently include a lack of experts in the sector, including renewable energy project developers, financial personnel, and service providers.

Malaysia is also experiencing difficulties in securing financing to develop renewable energy installations. The economy has established a feed-in-tariff and other drivers to better promote external financing for meeting renewable goals (APERC 2018). "To complement Malaysia's existing Feed-in-Tariff mechanisms that encourage renewable energy promotion, a new instrument termed *net energy metering* is planned for the Eleventh Malaysia Plan. The objective of net energy metering is to promote and encourage more solar PV generation by prioritizing internal consumption before any excess electricity generated is fed to the grid (APERC 2018).

Under the FiT, Solar PV no longer has new quote release after 2017, and the government is implementing a large-scale solar program based on a bidding process. The total quota allocated for the large-scale solar from 2017 to 2020 is 1,250 MW, of which 250 MW was granted direct award under the fast-track program, going into commercial operation as of 2017. The remaining 1,000 MW will come under the bidding mechanism. In August 2017, the bid open price was announced for large-scale solar PV plants for 2019 and 2020. The bid was divided into three categories based on capacity, and the results show that the lowest bid received was in the 10–30 MW category with a tariff of MYR 0.3398/kWh (USD 0.079 kWh). Currently, as mentioned above, wind does not have any significant contributions to energy production, but studies are being conducted to further assess its potential (APERC 2018).

Thailand

Thailand, which was previously leading the development of solar growth in Southeast Asia, is the last APEC economy example that this report uses to demonstrate the drivers utilized in APEC economies.

Thailand is dependent on energy imports, particularly oil. In 2015, Thailand's total electricity generation was primarily supplied by natural gas and coal, accounting for 92 percent of total electricity generation. Renewables accounted for 10 percent of electricity generation, but most of that was biomass-related with wind and solar making up only 1 percent and 5 percent of renewables, respectively (APERC 2018).

Nevertheless, to ensure greater energy security, Thailand has stated a goal of encouraging electricity production from potential renewable energy sources, particularly from small-scale generating projects (APERC 2018). Although the 2015–2016 National Power Development Plan targeted a 33 percent contribution of renewables (59,300 MW) by 2036, in March of 2017, Thailand's Prime Minister Prayut Chan-o-cha proposed raising the target for renewables generation to a more ambitious 40 percent (Oxford Business Group. 2017).

Thailand's stated goals for solar development, in particular, are to reach an installed 19.635 MW of solar energy by 2036 (Thailand Government 2015). Historically, Thailand had served as a leader for solar support and infrastructure deployment, though in the past couple of years, the economy has taken a step back in providing public support for solar projects.

Following the securement of funding for the largest wind power project in Southeast Asia, Thailand is being touted as a frontrunner for wind energy as well. In December 2017, the Thai renewables developer Wind Energy Holding Co. Ltd. successfully raised US$1.1 billion to finance five new onshore wind famers in the northeastern provinces of Nakhon Ratchasima and Chaiyaphum. In total, the farms will produce 450 MW of energy for the domestic grid. The project procured financing by Siam Commercial Bank. Wind Energy Holding assessed both the project's social and environmental impacts, reporting that local residents had strongly supported the project. Nop Narongdej, chairman on the Wind Energy Holding executive committee, stated that "while achieving financial close for all five of our projects represents a major milestone for Wind Energy Holding, it also represents a significant milestone for the [economy], which has shown itself to be a regional leader in the renewables space" (Boo 2017).

Thailand was the first ASEAN economy to introduce a feed-in-tariff, starting in 2007. Following the premium tariffs, there were enormous applications of solar PV, and in 2010, the adder was decreased from 8 Thai baht/kWh to 6.5 baht/kWh, and at the same time, the solar PV targets were increased from 500 MW to 2,000 MW. These targets were steadily increased over the next five years, so that by 2014, the target was 3,800 MW and there were tariffs for solar farms and rooftop solar. The success of projects encouraged more development and related innovations. In 2015, solar for government agencies and agricultural cooperatives were developed, followed by a pilot project for solar PV rooftop for self-consumption. The growth of solar in Thailand was enabled by both financial and fiscal incentives, including attractive FiT rates, competitive packages for tax incentives, high-quality PPAs with long durations (20 years), funding supported by the Energy Conservation Fund, and interest from local commercial banks in solar projects (Yaowapruek 2017).

Viet Nam

Viet Nam has employed a diversity of drivers to promote renewable energy development in its economy as of late. As a developing economy, Viet Nam has, nonetheless, proved very successful in recent years in fostering a positive environment for investment in renewable energy project development.

Viet Nam's electricity demand continues to increase as its population grows, and the economy has a wealth of diverse domestic energy resources including oil, gas, coal, and renewables. APERC conducted several surveys and assessments for the potential of renewable energy technologies in Viet Nam, particularly for large hydropower but also for solar and wind, and the government is devising deployment of new wind, solar, biomass, and solid waste projects over the next 15 years. As such, APERC hypothesizes that Viet Nam will play a significant role in APEC's goal for doubling renewable energy by 2030 if potentials are met and utilized effectively. Modern renewables accounted for 15.2 percent (8,027 Ktoe) of the economy's total energy consumption in 2015 (APERC 2018).

Viet Nam's goals include that the total share of renewable energy, including large hydropower, reach 31 percent of total supply by 2020, 32 percent by 2030, and 44 percent by 2050. With these, the government expects that renewable energy growth will contribute to greenhouse gas mitigation of roughly 5 percent by 2020 and 25 percent by 2030 compared to business as usual projections (APERC 2018).

Support mechanisms and policies for renewable energy development in Viet Nam include various fiscal incentives within import tax, corporate income tax, and land taxes and fees, as well as credit incentives; approved electricity prices (avoided-cost tariffs, feed-in tariff) for on-grid renewable energy; standardized power purchase and sale contracts (20 years) within an obligation for Electricity Viet Nam and its regional electricity utilities to prioritize renewable energy in grid connection and to dispatch and purchase electricity at approved tariffs; a renewable portfolio standard (RPS) obligation for major electricity generators and traders; net-metering for electricity consumers with simplified connection arrangements and environmental fees for organizations using fossil fuels for energy production (APERC 2018).

In 2017, Viet Nam further encouraged the development of solar power through (a) a circular approved by the prime minister and issued by the Ministry of Industry and Trade on model PPAs and (b) project development applied to solar power projects, making the list of feed-in-tariffs more exhaustive (Viet Nam Government 2017).

The potential capacity for wind power development has been determined to be 6 GW, while solar has been estimated at 12 GW.[2] The National Power Development Master Plan VII anticipates an electricity demand growth of 9.9 percent between 2016 and 2020, and in the long term, foresees growth rates of 8.1 percent for 2021 through 2025 and 7.2 percent for 2026 through 2030. The government of Viet Nam has designed a roadmap for wind power development through 2020 with an outlook through 2030 and has set goals of 1,000 MW by 2020 and 6,200 MW by 2030 (Tran 2017).

In the summer of 2017, Viet Nam created a FiT of 9.35 cents/kWh for 20 years to support utility scale PV projects. Now, the economy is cooperating with the World Bank Group to implement a pilot auction program for solar projects in particular. Capacities are to be announced at the auction, and developers will have the opportunity to bid respectively. Both moves are designed to reach the goal of 3 GW of solar PV capacity installed (from 850 MW) by the end of the decade (Otin 2018).

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[2] Government of Viet Nam, *Approving the Revised Viet Nam Power Development Plan for the Period 2011-2020 and with a Vision to 2030,* Decisions No. 428/QD-TTG, (March 2016).

SUCCESS STORIES AND RECOMMENDATIONS

As first noted in the section on global status and drivers of solar and wind technologies, four drivers underlie the development of grid-connected wind and solar: technical, economic, regulatory, and institutional. If unfavorable, these factors can be the barriers that restrain development. If favorable, they can be the enablers that facilitate it. In this section, the report presents eight successful grid-connected wind and solar developments. [3] Each development is distinct, and each success story emphasizes the role that one of these four drivers has played in enabling its particular success.

To cover a wide range in economy, geography, and type of barrier and renewable energy source, this report includes four projects in and four outside of APEC economics, four wind projects and four solar projects, and two of each type of main barrier and the associated method of overcoming these barriers. Of course, these projects in no way represent a definitive list of successful projects either inside or outside of APEC. And certainly, other successes in APEC exist that are not included.

These success stories can provide valuable lessons for other economies, particularly those showing how each economy built on “inherent” enablers to attract investment for these domestic projects.

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[3] For the purposes of this section and the report as a whole, a *successful development* is one that is financed, constructed, and operating.

TECHNICAL STORIES

Mongolia – Tsetsii Wind Farm

Tsetsii Wind Farm in the Gobi Desert of Mongolia

Source: European Bank for Reconstruction and Development

Background

Located in Northern Asia, Mongolia has a sizable area of over 1.56 million-square kilometers with a small population of just over 3 million distributed sparsely throughout. In 2017 the GDP was quite low at about US$11.1 billion, less than that of Papua New Guinea; the GDP per capita (on a PPP basis) was $11,000, comparable to Peru; and the real GDP growth rate was 5.1 percent (CIA 2018).

Mongolia has limited domestic conventional energy resources, including a modest amount of coal and oil but very little gas or hydro. On the other hand, Mongolia has sizable renewable resource potential, particularly wind and geothermal. Currently, Mongolia's electricity generation is dominated by coal with small shares from imports, hydro and diesel. Electricity demand has been consistently increasing since 2007, which has put a strain on the power system. Although there is a total of 1,158 MW in installed capacity, only 969 MW are available given aging power facilities (ADB 2018). Mongolia has provided access to electricity to almost all of its population, with a domestic grid consisting of four subsystems (ADB 2018).

As noted above, Mongolia has considerable wind resources, although bringing these resources to market is an issue in such a large, sparsely-populated economy. Domestic demand is limited, and electricity tariffs are among the lowest in the region, so there is talk of power exports. The government has a goal of 12-percent capacity for generation by renewables by 2020 and 30 percent by 2030, which should be met with a mix of wind and solar installations. The government of Mongolia has undertaken several initiatives to increase renewable energy deployment, including substantial incentives and mandates for renewable development, including feed-in-tariffs. In recent years, Mongolia has also been rapidly modernizing its business sector, particularly banking. It has also become much more connected with global institutions, particularly donors and funders.

Project

The Tsetsii wind farm is a 50 MW facility built in 2017 (for a total cost of just over $100 million) in the Gobi Desert in Umnugobi province, 500 kilometers south of the capital of Ulaanbaatar. It is Mongolia's second-largest wind farm, consisting of 25 2.0 MW, V90 Vestas turbines. Based on similar facilities, Tsetsii is projected to generate about 150 GWh of electricity each year. Tsetsii was developed both to increase clean, affordable renewable energy in Mongolia and to fit into the so-called Asia Super Grid, or ASG, announced in 2011 to supply clean energy to other Asian economies as well. Tsetsii has served as a model for the successful development of wind resources in a developing economy, and the project won the Environmental Upgrade of the Year at the Asia Power Awards of 2018.

Tsetsii was developed by Clean Energy Asia LLC, a renewable energy company based in Mongolia (established as a joint venture between the 49 percent owning Japanese developer SB Energy of Japan's Softbank and 51 percent owning Newcom, a Mongolian infrastructure investor).[4] In addition, Tsetsii was financed by the European Bank for Reconstruction and Development (ERBD) and Japan International Cooperation Agency (JICA).

Enablers

In Mongolia, some but not all of the factors underlying successful development are aligned. Tsetsii was successful in part because it took advantage of the positive conditions on a technical level.

First, Mongolia was one of the first developing economies to develop a detailed atlas of its wind resources. As noted above, Mongolia has limited conventional energy resources but considerable renewable energy potential. Before 2001 the wind resource was not well characterized and, thus, could not be easily exploited. This changed when the National Renewable Energy Laboratory developed the first-ever Mongolian wind atlas (Elliott et. al.2001). Based on this characterization, specific attractive locations could be selected, including Umnugobi in particular. The specific resources identified in this wind atlas are the resources that have been and are being developed.

Second, Mongolia is capitalizing on its geographic position and sparse population by pairing wind with transmission for export. Potential customers include neighbors such as not only Russia but also Japan and Korea. Mongolia was able to secure financing by fitting into the larger goals of multilateral financers and developers, creating a win-win situation for the economies involved (TMO Reporter 2017).

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[4] For a project report, see "Tsetsii Windfarm," European Bank for Reconstruction and Development, https://www.ebrd.com/work-with-us/projects/psd/tsetsii-windfarm.html.

Without a grid capable of getting the wind resource to market, good wind resources are essentially useless, and wind development cannot be financed.

> ***The commercial launch of the Tsetsii wind farm marks the first step for the SoftBank Group to establish a renewable energy business in Mongolia under the Asia Super Grid project.***
>
> ***— Masayoshi Son, SoftBank Group chairman and chief executive***

Current Status

The Tsetsii wind farm has operated according to plan since commissioning. Given the success of Tsetsii and other large wind farms, Mongolia aims to continue to build renewable energy projects with the assistance of international financers and partners. A new 55 MW wind project has been developed by Engie and was made operational by the end of 2018, making it Mongolia's third operational wind farm. As part of its strategy to reduce its dependence on other energy sources, the government of Mongolia is ambitious in its goals, hoping to commission two or more wind power projects every year for the next decade.[5] Confident in the continuation and long-term potential of the market for wind generation in Mongolia, Vestas established their subsidiary Vestas Mongolia in 2017 to continue to serve the economy (TMO Reporter 2017).

[5] Wind Power Monthly, *2017 Edition,* (2017).

Morocco – Noor Ouarzazate I Concentrated Solar Power Plant

Noor Ouarzazate Solar Complex in Morocco

Source: Power Technology, https://www.power-technology.com/projects/noor-ouarzazate-solar-complex/

Background

At the northwest tip of Africa, Morocco landmass is 446,000 square kilometers, mostly arid land. With over 1,835 kilometers of coastline along the Atlantic Ocean and the Mediterranean Sea, the economy shares the Strait of Gibraltar with the southern tip of Spain.[6] With a population of roughly 34 million and a total GDP of over $109 billion in 2017, Morocco has seen a range of real GDP growth rates — between 1 and 4 percent over the past several years. GDP per capita (on a PPP basis) in 2017 was US$8,600, roughly the same as The Philippines and significantly lower than Indonesia and Peru (CIA 2018).

With no domestic fossil fuels, Morocco is a significant net importer of both crude oil and petroleum products, making alternative forms of energy generation to decrease its dependence an important goal. For electricity, Morocco relies primarily on imported coal with moderate shares from both hydro and renewables. The economy is almost fully electrified with only 1 percent of the population lacking

6 These figures are for Morocco proper; they do not include Western Sahara.

electricity (CIA 2018). Electricity prices are moderate, and electricity demand has been growing very rapidly.

While Morocco has no fossil resources, it does have considerable renewable resources — solar in particular. Morocco gets more than 3,000 hours of sunshine each year. Domestic electricity demand is growing, and Morocco is the only economy in Africa to have a transmission link to allow for renewable energy exports to Europe. The Kingdom of Morocco has previously announced a decision to pursue low-carbon growth and employ new energy strategies in a commitment to sustainable economic development. The economy's National Energy Strategy calls for an increase in nearly every type of renewable energy, including solar, wind, small hydro, and biomass. By 2020, Morocco aims to get 42 percent of its energy from renewables, increasing to 52 percent in 2030. The Moroccan Agency for Sustainable Energy (MASEN), established in 2010 as the Moroccan Agency for Solar Energy, is the lead agency in this effort; it will be developing at least an additional 3,000 MW of capacity by 2020 and 6,000 MW by 2030 to meet these goals (MASEN 2018). Morocco has a successful, improving academic and business environment, including a particularly well-developed banking sector.

Project

The crown jewel of Morocco's renewable strategy is the Noor Ouarzazate complex, a 580 MW multi-technology solar facility spanning more than 7,500 acres. The size of the complex provides economies of scale (the entire complex is scheduled to be fully operational in 2018). The first plant of the complex is the Noor Ouarzazate I (Noor I) 160 MW concentrated solar power (CSP) plant, covering over 1,000 acres located about 10 kilometers outside of the Moroccan town of Ouarzazate and 200 miles south of the city of Marrakech. The area outside of Ouarzazate was chosen for its superb solar resources, access to water for cooling, and proximity to the established power grid. The plant commenced production in December 2015 (and was inaugurated by the King of Morocco in February 2016) (GIH 2018). As a CSP project, the plant can both produce and store energy, generating about 400 GWh each year.

Noor Ouarzazate I is the first CSP project developed in the Middle East and North Africa, and represented an investment of 7,100 million Moroccan Dirham or $850 million at 2014 exchange rates – roughly $670 million in debt and $180 million in equity. The project benefited from the participation of several international financial institutions including the European Investment Bank (EIB), African Development Bank (AfDB), Agence Française de Développement (AFD), KfW (a German government-owned development bank, on behalf of the BMZ, the German Federal Ministry for Economic Cooperation and Development and the BMUB, the Federal Ministry of the Environment, Nature Conservation and Nuclear Safety), the Clean Technology Fund (via the AfDB and the IBRD), the World Bank Group, and the European Union (Neighborhood Investment Facility) (GIH 2018).

ACWA Power consortium was selected through an international bidding process and is responsible for the project's implementation, including design, construction, and operation and maintenance. The original construction period was 30 months, with an expected 25 years of operation. The project was structured as a public-private partnership on a Build, Own, Operate, and Transfer (BOOT) basis. The PPP was supported by a 25-year fixed term, fixed tariff PPA at 1.62 Dhs/kWh or about $0.18/kWh and a power sales agreement with the ONEE, as well as significant concessional finance projected by the Clean Technology Fund and other international finance institutions (GIH 2018).

Enablers

Morocco has considerable technical advantages with respect to grid-connected solar development. Because of its geography, it has one of the best solar resources in the world with over 3,000 hours of sunshine per year. To accompany this natural advantage, the economy has developed an electricity infrastructure capable of delivering power both for domestic consumption and, because of its proximity to Spain, for export to Europe via the Sustainable Electricity Trade initiative. Morocco has also taken steps to play a direct role in solar technology development, with MASEN supporting domestic research and development efforts for technological innovation.

Current Status

The Noor Ouarzazate I project is now operational after its successful commissioning, and it is just the first of several large Noor Ouarzazate plants planned in Morocco. Noor Ouarzazate II (a 200 MW CSP plant) became operational earlier in 2018. Noor Ouarzazate III (a 150 MW CSP tower plant) and Noor IV (a 70 MW PV plant) are expected to be operational very shortly. The entire 580 MW Noor Ouarzazate complex will generate more than 1,300 GWh a year and reduce carbon emissions by more than 800,000 tons a year. Noor Ouarzazate is only one of several similar complexes planned totaling 2GW of grid-connected solar by 2020.

TECHNICAL RECOMMENDATIONS

Technical factors can be a considerable challenge for grid-connected wind and solar. Resources may be intermittent and far from load, or the available land may be unsuitable for development. Many of these technical factors — such as wind speed or solar insolation, cannot be easily changed if at all. Nevertheless, it is still possible for governments to put measures in place to make the best use of what is available.

- *Recommendation T1*. Conduct an in-depth solar and wind resource assessment in order to establish the specific locations that are suitable. Understanding the quality of wind or solar resources and their geographic distribution are key initial steps to ensuring that available resources can be most effectively developed and reduce up-front preparatory costs for developers.
- *Recommendation T2*. Conduct an in-depth grid assessment, and then make necessary hardware and software improvements to enable the integration, use, and (potentially) export of grid-connected solar and wind resources. Dealing with the unique grid impacts of intermittent resources is crucial for moving forward with their development without compromising grid stability and power quality/reliability.

ECONOMIC STORIES

Indonesia – Eastern Indonesia Renewable Energy Project

Jeneponto Tolo I PLTB in Indonesia

Source: Pantau.com, https://www.pantau.com/berita/mengintip-pltb-tolo-i-jeneponto-yang-tak-kalah-ciamik-dari-pltb-sidrap

Background

Indonesia is a large and populous archipelago, with a land area of 1.8 million square kilometers, a coastline of over 54,000 kilometers, and population of about 260 million (4th in the world). The economy is the largest in Southeast Asia with a GDP of over $1 trillion in 2017 (16th in the world), and it is growing at more than 5 percent per year. The GDP per capita of $12,400 (on a PPP basis) is slightly above both The Philippines and Viet Nam (CIA 2018).

Indonesia is a large producer and consumer of fossil fuels and is a net exporter of both coal and natural gas. In 2017, Indonesia was the world's 5th largest producer of coal and the largest exporter of coal (IEA 2018b). Electricity generation in Indonesia is predominantly from coal with 55.85 percent of generation in 2017 (Indonesia, E&MR 2018). The remaining sources of generation are natural gas at 25.8 percent, diesel at 9.1 percent, hydro at 6.9 percent, and geothermal at 2.26 percent. The majority is generated by the state-owned utility, Perusahaan Listrik Negara (PLN), which also has a monopoly on transmission and distribution. But electricity prices are comparable to other economies in the region.

As of 2017, there was essentially no wind or solar generation in Indonesia. Electricity demand is growing strongly at 7 percent per year as the economy expands and electrification increases. Over 80 percent of households are currently electrified.

Indonesia consists of over 15,000 individual islands, and there is considerable diversity in the solar and wind potential across these islands. Overall, Indonesia has good, but not great, insolation. Given the high population density, varied terrain and small islands, there are relatively few locations suitable for a large solar farm. Indonesia also has good wind resources in some locations, particularly in the Java-Bali, Sulawesi, and Nusa Tenggara regions (Gielen, Saygin, and Rigter 2017).

Indonesia has strong economic and electricity demand growth, which so far have been met with the available non-renewable resources. With relatively low electricity prices and abundant conventional resources, it has been difficult for developers to recover investments in wind or solar generation (IISD 2018).

There have been some limited efforts to encourage renewables, although energy sector policies and regulations have changed frequently. For example, a solar auction program was declared unconstitutional only one year after being introduced in 2013 (BNEF Climatescope 2018a). Recent regulations removed previous feed-in-tariffs and replaced them with a cap that limits the price renewables can receive. Indonesia has well-developed energy and financial sectors, but relatively little expertise in renewables.

Project

Vena Energy, a Singapore-based Independent Power Producer (IPP), is leading the development of a two-phase wind and solar project. The first phase, begun in December 2017, is a 72 MW wind power plant, called Tolo I, in Jeneponto, South Sulawesi. Construction is in the final phases, and the plant is expected to begin operation shortly (*Jakarta Post* 2018). The second phase consists of 4 solar plants totaling 42 MW — a 21 MW solar farm in Likupang, North Sulawesi, and 7 MW solar farms in Pringgabaya, Selong, and Sengkol in Lombok, West Nusa Tenggara. Overall, the total facility is projected to generate roughly 250 GWh each year. Vena Energy has received $161 million in combined loans from the Asian Development Bank, the Leading Asia's Private Infrastructure Fund (LEAP), and the Canadian Climate Fund for the Private Sector in Asia II (CFPS II).[7] All the projects — that is, both wind and solar sourced — will sell electricity directly to PLN at a reported price of roughly $0.10 per kWh.

Enablers

Indonesia is a large, rapidly growing economy with abundant solar and wind resources. Energy consumption increased by 65 percent between 2000 and 2014 — and is projected to increase another 80 percent by 2030 (Gielen, Saygin, and Rigter 2017).However, equally abundant fossil resources, relatively low tariffs, and regulatory instability have limited renewable energy penetration to nearly zero. With an ambitious target that 23 percent of Indonesia's energy mix will be renewable by 2025, the government has been trying to balance attracting financing from private developers and reducing risk for the national utility PLN. When the feed-in-tariff was more attractive for developers, there was clear success at attracting investments. The Vena Eastern Indonesia project was one of the first sizable

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[7] See the Asian Development Bank's Project Documents Database, https://www.adb.org/projects/documents/ino-51209-001-rrp.

renewable energy development to profit from the ambitious target and flexible feed-in-tariff rates. The project negotiated a feed-in-tariff of 11.85 cents/kWh that was high enough to support the project.

Current Status

The Tolo I wind plant is nearing completion with a PPA in place, and the four solar plants continue to move ahead in planning stages. Since the Tolo I PPA was signed, a new regulation capping the purchase price to 85 percent of local generation costs has generated concern that renewable projects will not be able to attract financing. A potential sign that this could be the case is that Tolo I's PPA of 11.85 cents/kWh would not be possible under the new regulation for most regions of Indonesia.[8] Another 75 MW wind plant, Sidrap, will be completed shortly but also has a PPA from prior to the new regulation. It remains to be seen if the new regulation, designed to reduce risk of overpaying by PLN for renewables, will be a barrier to continued investments.

[8] See figure 4 of (IISD 2018).

Viet Nam – Bac Lieu Near-Shore Wind Farm

Wind Turbines at Bac Lieu Wind Farm

Source: Nhan Dan (People), http://en.nhandan.org.vn/scitech/item/4015102-from-wind-power-to-solar-power.html

Background

Viet Nam is a densely populated economy with a land area of 310,000 square kilometers, a coastline of over 3,000 kilometers, and population of about 96 million (15th in the world). The economy is growing quickly at roughly 6 percent per year. The GDP is over $220 billion (36th in the world), but with a GDP per capita (on a PPP basis) of $6,900, it is one of the lowest in the APEC region (CIA 2018).

Viet Nam has modest fossil fuel resources, including coal, oil, and gas.[9] Because Viet Nam lacks refining capability, it is a net exporter of crude oil with production declining since 2004.[10] Viet Nam also has good hydro potential. Electricity is produced primarily from hydro, coal, and gas with a small amount

9 "Energy Resources: Vietnam," World Energy Council, accessed December 30, 2018, https://www.worldenergy.org/data/resources/country/vietnam/.

10 "Vietnam Crude Oil Production," *Trading Economics,* accessed December 30, 2018, https://tradingeconomics.com/vietnam/crude-oil-production.

coming from petroleum, imports, and a tiny fraction from wind and solar (0.4 percent). Electricity prices are regulated and fairly low, and 99 percent of households are electrified.

Viet Nam has large areas with good solar potential, and the best wind resources in South East Asia.[11] However, these resources have not been fully characterized and mapped. Wind projects in particular spend up to a year collecting wind data in order to meet international standards (Tran et al. 2016). The electricity grid is fairly strong, and an improvement program is underway.

As noted above, the economy and electricity demand are growing rapidly, particularly with the fairly low, subsidized prices. This is a challenge for renewable investment (GIZ 2016).The government owned utility, Viet Nam Electricity, offers a moderate FiT for wind (7.8 cents/kWh) that has been in place since 2011. Since 2017, Viet Nam Electricity has also offered a solar feed-in-tariff (9.35 cents/kWh) (Massmann 2018). There has been some concern with Vietnam Electricity not honoring past PPAs (Nguyen 2018). Viet Nam has been setting stronger wind and solar targets, most recently targeting (a) 800 MW of wind by 2020 and 6 GW by 2030 and (b) 850 MW of solar by 2020 and 12 GW by 2030.[12] Viet Nam is a large, rapidly developing economy, and the academic and business infrastructure is making considerable progress. However, commercial banks in Viet Nam have not yet offered financing for renewable projects on their own.

Project

Despite rapid economic growth and attractive resources, wind and solar development in Viet Nam has been quite modest. One of the few successful developments is the Bac Lieu near-shore wind farm that that began development in September 2010. The farm had an original Phase 1 capacity of 16 MW, and Phase 2 capacity was added in 2015 and 2016 to bring the total to 99.2 MW with about 300 GWh generated annually (GIZ 2016). In a planned Phase 3, the capacity will be expanded by another 142 MW. Wind turbines are supplied by General Electric, and 18 kilometers of 110 kV transmission lines were built to connect it to the grid.

The project was developed by Cong Ly Construction-Trade-Tourism. The total investment for Phases 1 and 2 was $260 million (for 99.2 MW), including $39 million in equity from Cong Ly (Vietnam Plus. 2014). The Viet Nam Development Bank funded the project.

Enablers

Several factors came together to enable the development of the Bac Lieu wind farm. One of the most important factors was economic. Viet Nam has a large economy, growing at more than 6 percent a year, and a large population with electricity demand growing at 13 percent a year. This growth requires

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[11] "Support for Scaling Up Wind Power," Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), accessed December 30, 2018, https://www.giz.de/en/worldwide/28291.html.

[12] "Vietnam," *BNEF Climate Scope*, accessed December 30, 2018, http://global-climatescope.org/en/country/vietnam/#/enabling-framework.

energy, and the Viet Nam government recognized that limited domestic supplies of gas, coal, and hydro would be inadequate (Chi 2016). They also recognized that renewable energy investors would not help fuel this economic growth without adequate financial incentives. At the same time, they understood that renewable energy projects can be expensive and that increasing electricity prices too much, too quickly may not be sustainable with a still-developing economy. The key economic enabler then was a higher, but not too high, FiT. Cong Ly pushed for a higher tariff, and the government ultimately agreed to increase the FiT from the usual 7.8 cents/kWh to 9.8 cents/KWh. This helped to provide the necessary electricity price support for the economics. A quote from Cong Ly perhaps indicates the balancing act in this rate: "the … price is lower than we hoped, but it is acceptable" (Vy 2016).

Current Status

The Bac Lieu wind farm has been generating power according to plan since becoming operational. It has also served as a tourist attraction owing to its location close to shore, where people can walk on docks between the turbines. As noted above, Cong Ly is expanding this project with an additional 142 MW of additional capacity. Cong Ly has also begun two new wind power projects; Khai Long-Ca Mau tourism zone near-shore wind farm (100 MW) and the Soc Trang onshore wind power project (30 MW in Phase I) (*Vietnam Investment Review* 2018). The government has been increasing electricity rates with the explicit goal of attracting foreign investment. Specifically, in support of wind power, the prime minister recently published Decision No. 39 to set a new FiT for onshore projects of 8.5 cents/kWh and 9.8 cents/kWh for all offshore projects (VIETNAMNET Bridge 2018).

ECONOMIC RECOMMENDATIONS

Economic conditions are of course important for many reasons beyond renewable energy development. Although economic conditions are driven by broad global forces, governments have a variety of ways to influence and improve these conditions, and hence, the following are advised:

- *Recommendation E1*. Organize electric markets to allow for renewable tariffs that reflect both market prices and social/environmental objectives. In addition, expand markets to price in innovative energy technologies, services, and products that that support renewable energy.
- *Recommendation E2*. Use competitive auctions or similar methods to ensure that resources connected to the grid are transparently the most economic and that developments are sustainable not just for investors/operators but also for customers. Use prequalification and similar procedures to ensure that the competitive process results in truly bankable PPAs.

REGULATORY STORIES

Jamaica – BMR Wind Project

Wind Turbines in Jamaica

Copyright BMR Energy LLC

Background

Jamaica is a small Caribbean economy. It has a land area of 10,000 square kilometers (twice the size of Brunei Darussalam) and a population of 3 million (slightly less than New Zealand) (CIA 2018). The economy's total GDP is $14.4 billion, and its GDP (on a purchase power parity, or PPP, basis) is modest at $9,200 (slightly higher than The Philippines), growing between 1–2 percent per year. The Jamaican economy, heavily dependent on tourism, has had difficulty in strengthening its economic stability over the past decade.[13]

Other than a small amount of hydro, Jamaica has no conventional energy resources. Until perhaps ten years ago, Jamaica was actually 100 percent-dependent on imported petroleum for virtually all residential, commercial, industrial, and transport energy. Per capita energy use is fairly low at about 1000 kg of oil equivalent per capita (~100th in the world, comparable to Indonesia).[14] Most of the economy has electricity access, and — like much of the Caribbean — electricity prices are very high.

Historically, grid-connected wind and solar energy operated in a mixed environment in Jamaica. Although Jamaica has good solar and wind resources, these were not well studied until recently. As in much of the Caribbean, its electricity grid can be weak outside of key urban areas. Jamaica's high

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[13] The World Bank Group Indicators, (2018).

[14] The World Bank Group Indicators, (2018).

electricity prices provide a strong incentive for new sources of energy, but the economic conditions are challenging albeit improving very slowly. While there is a strong public commitment to renewable energy and political pressure to lower electricity prices, there is also a complex regulatory framework for energy in general and electricity in particular. Finally, not surprisingly for a relatively small, still developing economy, there is limited institutional capability for financing, constructing, or operating grid-connected wind and solar.

Project

Despite the evident challenges in Jamaica, BMR Energy LLC succeeded in planning (2014), financing (2015), constructing (2015–2016), and operating (2016 on) a 36-megawatt wind farm in Jamaica, the economy's largest private-sector renewable energy project. The wind farm was financed through a $26.9 million equity investment from BMR, a $42.7-million senior loan from the Overseas Private Investment Corporation (OPIC), a $10-million senior loan from the International Finance Corporation (IFC), and a $10-million loan from the IFC-Canada Climate Change Program. The farm consists of 11 Vestas turbines about 90 kilometers west of the capital city of Kingston, close to a major East-West 69kV transmission line. The wind farm generates 120 GWh annually for the local utility — Jamaica Public Service Company — under a 20-year PPA. The farm is now helping to diversify the economy's energy matrix, ease its dependence on imported fossil fuels, reduce its greenhouse gas emissions, and accelerate its shift from fossil to renewable energy.

Enablers

BMR made this project possible through its extensive research and persistent execution. But several other factors contributed to this success as well. Importantly, a variety of governmental entities played key roles.

First, Jamaican domestic officials "walked the talk" on renewables. The government not only set renewable energy targets, it took sometimes complicated, controversial steps to achieve those targets. For example, it designed and conducted a renewable energy auction process, only approving the BMR project after it was selected as one of the winners. At the inauguration of the BMR project, the Jamaican energy minister made this government support evident. Dr Andrew Wheatley concluded his remarks: "What you will witness today and in the days and years to come is a testimony of commitment of the government of Jamaica to ensure that this economy has a modern, efficient, diversified and environmentally sustainable energy sector" (Wheatley 2016).

Second, government entities outside of Jamaica were active supporters, providing financing as well as technical and organizational assistance. This includes the governments of both the United States and Canada as well as member states of the World Bank Group — IFC's parent organization.

While U.S. vice president, Joe Biden at the time said, "It's profoundly in the self-interest of the United States to see the Caribbean economies succeed as prosperous, secure, energy-independent neighbors

… [BMR Wind in Jamaica is] a tangible example of what can be achieved when the public and private sectors work together."[15]

Catherine McKenna, Canada's Minister of Environment and Climate Change, emphasized the role of her government, saying "[t]he Government of Canada is proud to support Jamaica through this ambitious and effective initiative that will help them to secure a clean, reliable and affordable energy future" (OPIC 2018). Lastly, Luc Grillet, IFC Regional Manager, noted "[t]he BMR wind farm supports Jamaica's goals for ramping up renewable energy and transitioning to a clearer, more efficient energy matrix. This helps the economy's competitiveness, while having a positive impact on climate change" (*Jamaica Observer* 2016). The combination of BMR's initiative, and the sustained and active support of these government entities, enabled this effort to succeed.

Current Status

The BMR wind farm was not only a development success, it has been operating as planned for the two years since its inauguration. BMR anticipates that the wind farm will have a long, productive life. The government of Jamaica remains committed to a diverse generation mix — particularly given the need for security and resilience — but the new administration may have more moderated enthusiasm for a rapid transition to renewables. Of course, the U.S. perspective on global renewable energy has changed significantly with the new administration.

[15] "Delivering Wind Energy to Jamaica," BMR Energy, accessed December 30, 2018, https://bmrenergy.com/projects/jamaica-wind.

Mexico – Solem Solar PV Complex

168 MWp Solar Power Photovoltaic Plant

Source: Grupo Ortiz, http://www.grupoortiz.com/en/business-units/energy/renewable-energies/proyecto-id-1529/

Background

As the 11th largest economy in the world and still developing, Mexico is a unique APEC economy. It has a large population of over 125 million. With an area of just under 2 million-square kilometers and over 9,000 kilometers of coastline along both the Pacific and the Atlantic, Mexico has a large diversity of environments and climates. The total GDP is over $1.1 trillion, with a steady GDP per capita at nearly US$20,000 on a PPP basis, close to that of Thailand; Chile; and the People's Republic of China (CIA 2018). The economy is currently growing relatively slowly, generally no more than 2 percent a year.

In many respects, Mexico is an APEC regional leader in energy. It has large coal and oil reserves, considerable hydro and geothermal potential, and vast solar and wind resources. Mexico is a large oil producer and exporter but a net natural gas importer. It is a net exporter of electricity, producing over 292,000 GWh a year and consuming 245,000 GWh. Electricity production is dominated by oil, gas, and large hydro, with smaller contributions from coal, nuclear, geothermal, solar, and wind. In recent years, the Mexican government has made a concentrated, public effort to diversity their energy production with more natural gas and more renewable energy (CIA 2018). Electricity in Mexico reaches nearly all of the population, and electricity prices are relatively low by international standards.

Mexico is blessed with a mix of both conventional and renewable resources. As a large, relatively-developed economy, it has a reasonably strong, well-managed electrical grid capable of delivering power from these resources either for internal use or export. While Mexico has a large economy, economic growth has been weak. Over the past 25 years, GDP growth averaged less than 1 percent. Given its size and location, Mexico has strong institutional and individual capabilities with a skilled labor force, leading academic and business institutions, and the like.

On the regulatory front, the energy sector in Mexico was historically government-owned and -managed and heavily devoted to petroleum. In 2013 and 2014, Mexico embarked a major restructuring of its energy industry, particularly electricity and natural gas. This new structure greatly increased the role of independent power producers and of natural gas and renewable energy sources.

Project

Mexico has historically been well-positioned for growth in renewable energy. The one "missing piece" until recently was a suitable policy and regulatory framework; this all changed in 2014 with the complete and rapid restructuring of electricity and gas markets. This shift resulted in a dramatic increase in grid-connected wind and solar.

Mexico's Solem Solar PV Complex is perhaps the best example. The Solem Complex consists of two large-scale solar PV plants (Solem I and Solem II), each at roughly 150 MW. Solem I was commissioned in September 2018, and Solem II is scheduled to start operations in the summer of 2019 (Mesbahi 2018). The Solem I project was awarded the Latin America Solar Deal of the Year; it was the largest solar plant of its type in Latin America and the first that began operation in Mexico after the energy reform. The Solem Complex is located in a rural part of central Mexico, not far from Guadalajara. It consists of more than 1 million PV panels and will supply about 800GWh of energy per year to the domestic grid on a 230kV line via a 15-year PPA. There are separate PPAs for capacity and clean energy certificates. The Solem PV Complex is located in a rural part of central Mexico, close to Guadalajara. It will generate clean energy equivalent to the electricity needs of more than 400,000 inhabitants and avoid 362,000 tonnes of carbon emissions each year.[16] The Solem Complex will play an important role in the diversification of the economy's energy sources.

The Solem Complex was sponsored by a joint venture of two global developers — Cubico Sustainable Investments Limited and Alten R.E. Developments America — in the State of Aguascalientes, Mexico. The Inter-American Investment Corporation (IIC, now renamed IDB Invest), provided a $75 million loan package to finance the Solem Complex including 36 percent directly from IDB, 24 percent from IIC, 27 percent from the Canadian Climate Fund for the Private Sector in the Americas (C2F), and 13 percent from the China Co-Financing Fund for Latin America and the Caribbean. (IABD 2017).

Enablers

Most experts agree that the government sector — policy and regulation — plays a critical role in successful development of renewable energy. This is clearly evident in Mexico where government reform has been the key driver behind an explosion of renewable energy. For renewable energy, the most important element is that the reforms allowed for the establishment of a viable, strong IPP sector. There were a wide range of IPP-related reforms that benefit a spectrum of project developers, investors, and ultimate customers. An auction process helped ensure fairness, transparency, and low cost. Along with Chile and Peru, Mexico became a worldwide leader in renewable energy auctions in the past decade.[17] Market restructuring also ensured that projects were bankable.[18]

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[16] "Mexico," Alten Energías Renovables, accessed December 30, 2018, http://alten-energy.com/developing/espanol-mexico/.

[17] Tonci Bakovic (Chief Energy Specialist, Infrastructure and Natural Resources Department, International Finance Corporation), phone conversation with author, Dr Adam Borison, September 2018.

[18] Fernando Cubillos (Head of Energy, Infrastructure, and Energy Division, IDB Invest, Inter-American Investment Corporation), phone conversation with author, Dr Adam Borison, September 2018.

The projects demonstrate the power of political buy-in and support for domestic energy reform. Mexico's energy sphere saw a rapid restructuring and freeing of electricity and gas markets, which allowed for the lowering of prices and the necessary conditions for attracting new financing sources to other projects like Solem. Overall, a bankable PPA is the major key barrier for economies like Mexico that are not yet seeing intensive growth in grid-connected solar and wind. As evident in other economies, there are a variety of precedents required for this growth, including the natural resource itself, a working grid, a deregulated market, and credit guarantees. Mexico was able to overcome the original barriers to investment by already having the resources and established grid and then by taking policy steps in altering its market for energy and allowing for an influx of financing.

Current Status

Mexico's Solem Solar I is operational, and Solem II is nearly so. Several other large solar projects are in the planning or construction phases. The same is true of wind power with numerous large projects operating, in construction, or planned. The energy reforms have helped establish a viable, market-based Mexico renewables industry that is past the stage of mandated feed-in tariffs and subsidies. The next step may be to extend competitive markets to new technologies, such as storage; new products, such as clean energy certificates; and new services, such as frequency control. This would enable a shift from low-penetration projects operating at 20 percent to 40 percent capacity factor to high-penetration projects that can operate at 60 percent to 80 percent capacity factor.

REGULATORY RECOMMENDATIONS

The regulatory environment is perhaps the most obvious tool that APEC economies can use to encourage solar and wind development.

- *Recommendation P1:* Institute reforms that allow for appropriate independent power production because grid-connected wind and solar largely depends on a vibrant IPP sector.
- *Recommendation P2:* Ensure that government agencies of all types, including non-energy agencies, are active supporters and facilitators of any renewable energy target or program. Project development can be stalled temporarily or even permanently through non-energy government actions, such as environmental or social regulation, import-export or transport regulation, and the like.

INSTITUTIONAL STORIES

The Philippines – Nabas 1 Wind Power Project

Turbines in the Nabas Wind Farm

Source: Nabas Wind Farm Facebook Page, https://www.facebook.com/pg/NabasWindFarm

Background

The Philippines is a densely populated economy of 7,641 islands, with a land area of 298,000 square kilometers (74th in the world), coastline of over 36,000 kilometers, and population of about 104 million (13th in the world). The GDP was over $313 billion in 2017, and the economy is growing quickly at about 6–7 percent per year. The GDP per capita of $8,300 (on a PPP basis) places the economy slightly above Viet Nam by that measure (CIA 2018).

The Philippines has limited domestic reserves of fossil fuels. Domestic coal production in 2016 amounted to about 12 million tonnes, while coal imports amounted to another 20 million tonnes (Philippines, Energy Department 2016).

Some crude oil is produced and refined locally, and some crude oil and petroleum products are imported. The Philippines also produces some natural gas for domestic use (CIA 2018). Reserves are declining, and plans are well underway for LNG imports. Electricity generation in The Philippines is primarily fossil- based (50 percent coal, 22 percent natural gas, 4 percent oil) with smaller shares from geothermal at 10.8 percent, hydro at 10.2 percent, and renewables (biomass, solar, and wind) at 3.6

percent. More than 90 percent of the economy has electricity access,[19] and electricity demand is growing rapidly. Electricity prices are fairly high for the region.

The National Renewable Energy Laboratory has been mapping wind and solar resources in The Philippines since 1999 (Jain, Fichaux, and Gianvenuti 2014). There are good solar resources, and suitable sites are available across the 7,000 Philippine islands. The geography is highly varied, and there are good wind resources in many areas. The national grid is overall quite strong, although there are locations — such as the Luzon grid — where quality and reliability are increasingly becoming an issue because of the large amounts of variable energy (Chen et al. 2017). As noted above, both the economy and electricity demand are robust and growing, and projections are that added generation will be needed soon. The government has supported renewables for a decade or more, although implementation has been slow. Currently, there is an attractive FiT available of 20 cents per kWh for solar and 22 cents per kWh for wind, and new rules for a renewable portfolio standard (RPS) (Chen et al. 2017). The Philippines has a strong banking and business sector, and renewable energy projects are financed by a mix of corporations, Philippine banks, and international institutions (Chen et al. 2017). Local technical capability for renewables development is modest but growing. The government has also imposed a 40 percent cap on foreign investment in renewable energy projects, which is widely seen as a disincentive to foreign participation.

Project

The Nabas 1 Wind Power Project is a 36 MW onshore wind farm consisting of 18 Gamesa turbines in Nabas, Aklan. Construction was completed in 2015, and the project produces roughly 100 GWh per year of power for the Western Visayas grid at a capacity factor of over 30 percent. Nabas 1 has a guaranteed FiT of P7.40 ($0.16 originally, $0.14 currently) per kilowatt-hour for twenty years. Nabas was developed by PetroWind Energy Inc. (PWEC), a joint-venture of CapAsia, EEI Power, and PetroGreen Energy Inc. (PGEC), a wholly owned subsidiary of the publicly-listed, Philippine Resources Corp. (PERC). The total project cost was P4.6 billion or roughly $90 million (PetroEnergy 2015). Nabas 1 was financed by the Development Bank of The Philippines with a ₱2.8 billion or $50 million loan (Development Bank of The Philippines 2018). In 2017, the BCPG Public Company Ltd. of Thailand acquired CapAsia's stake resulting in PGEC owning 40 percent, BPCG owning 40 percent, and EEI owning 20 percent.

Enablers

Nabas was successful of course due to the favorable technical, economic and regulatory conditions for renewables in The Philippines — good resources and a strong grid, a growing economy and market electricity prices, and government support through FiT and RPS (Rivera 2018). However, these elements are not always sufficient. The Philippines also had a key strength missing elsewhere — institutional capability in both the business and banking sectors.

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[19] The World Bank Group Indicators (2018).

One major contributor to success was the cooperation, support and participation of local Philippine industrial companies. Given the 40 percent cap on foreign ownership, substantial direct local involvement was absolutely critical (Chen et al. 2017). The publicly traded Philippine energy company PERC has been shifting its focus from fossil to renewables since 2014. As part of this trend, its subsidiary PGEC, along with CapAsia and EEI Power, formed a joint venture, PWEC to invest in Nabas. PERC's participation — with its considerable energy experience — provided a local, credit-worthy, knowledgeable developer. PGEC's direct experience investing in renewable energy, including developing joint ventures for geothermal and solar projects, was also critically important (PetroEnergy. 2015).

A second related contributor to success was the cooperation, support and participation of the local banking sector. Given the emphasis on local participation, financing from the usual international institutions can be difficult. Fortunately, The Philippines has a unique institution — the Development Bank of The Philippines — that was prepared to provide financial backing.

Current Status

In January 2018, PERC announced that Nabas 1 had reached a lifetime generation mark of 250 GWh after being in operation for 2 years and 7 months. PGEC Energy Trading Head Dave Gadiano proclaimed the success of Nabas 1: "PWEI has been consistently achieving its target generation over the past two years. Despite seasonal variations, the consistently good wind trends over our facility have enabled us to record above average capacity factors" (Gatpolintan 2018). The sale of a portion of the project in 2017 is a clear sign of its financial success. The Nabas Wind Power Project is also serving as a tourist destination, benefiting the local economy beyond the direct jobs provided by its construction and operation (GNP 2017). In another sign of success, PWEC has received approval to begin planning for a 14 MW "Nabas 2" expansion (Flores 2018). Other wind developments, and even more solar developments, are in the works as well.

Senegal – Kahone and Touba Solar PV Projects

PV Panels in Senegalese Solar PV Project

Source: World Bank Group, Scaling Solar, https://www.scalingsolar.org/active-engagements/senegal/

Background

Senegal, with a long stretch of coastline along the North Atlantic Ocean, is a relatively small economy and the most western economy on the African continent. It has an area of 200,000 square kilometers and roughly 500 kilometers of coastline. It has a rapidly increasing population of 15 million. It has a GDP of roughly $16.4 billion, and a GDP per capita (on a PPP basis) of $2,700, 196th in the world. In this context, the economy is growing at a rapid 7.2 percent, the 14th fastest in the world (CIA 2018).

Senegal's energy sector is quite small and is based primarily on imported fossil fuel and traditional biomass. Electricity generation is 80 percent fossil-based with a small amount from hydro and renewables (CIA 2018). At 50 percent – 60 percent, electricity access is low but actually better than for many of its neighbors. Electricity penetration in rural areas is particularly low.[20] Given the reliance on imported fuel, electricity tariffs are quite high. Overall, demand is growing but supply is limited.

Senegal's first solar farm was developed in 2016, and a large wind farm is under development. As such, in 2017, the United Nations and the World Bank praised Senegal as being one of the least developed nations making enormous strides in expanding its energy access.[21]

Senegal has good solar and wind resources, particularly in the north. Not surprisingly for an economy with very modest energy use, it has a limited transmission and distribution grid. Starting from a low base, the economy and electricity demand are both growing rapidly. On the regulatory side, the

[20] World Bank Group Scaling Solar, (2018), https://www.scalingsolar.org/active-engagements/senegal/.

[21] The World Bank Group Indicators, (2018).

government has put a strong focus both on energy access and environmental sustainability. This has translated into interest and activity in solar, wind, and gas project development.

Senegal currently has only modest institutional capabilities in academic, banking, and business, particularly regarding renewable energy. Thus, Senegal has been actively partnering with the U.S. and multilateral agencies.

Project

In 2017 two European firms, Engie and Meridiam, were awarded solar PV projects in Senegal via a competitive auction process. The first 30 MW project, located in Kahone in western Senegal, will sell power under a long-term PPA to Société Nationale d'Electricité du Sénégal (SENELEC), a Senegalese power utility, for $0.044 per kWh. The second 30 MW project, located in Touba in the central region of Senegal, will sell power under a long-term PPA at $0.046 per kWh (Bellini 2018). The low prices have set a new benchmark for the price of electricity. Once completed, these projects should be Senegal's low-cost electricity source, and one of the lowest cost sources of electricity in all of Sub-Saharan Africa (IFC 2018).

The competitive auction process is part of Scaling Solar, a cooperative effort between Senegal's Electricity Sector Regulatory Commission and the World Bank. The Commission received 14 bids from 8 of the 13 qualified bidders for both locations.

Enablers

By any measure, Senegal has shown a great of success in recent years in renewable energy development. A big part of that success of course is the growing economy, good renewable resources, and a supportive government eager to diversify its energy sources. However, other economies have similar features and have not been as successful. One key difference is the institutional cooperation between the Senegal government and international agencies — and specifically, the accelerated, integrated Scaling Solar process enabled by CSRE and the World Bank.

Scaling Solar is a World Bank Group/IFC design that allows governments to easily procure and develop large-scale solar projects through private financing. This includes a one-stop-shop package, offering technical assistance, preapproved financing, insurance products, guarantees, and templates for documents all in one mechanism (IFC 2018). The program has financing support from USAID's Power Africa program, the Private Infrastructure Development Group, DevCo, and the governments of Denmark, the Netherlands, and the United Kingdom, as well as support from The Rockefeller Foundation. Scaling Solar allows attractive projects to be developed and commissioned in a relatively short time. For example, Senegal was able to choose among several prequalified bidders from a range of economies. And the resulting low prices allowed the government to move ahead quickly with substantial support.

IFC CEO Philippe Le Houérou pronounced Scaling Solar "the poster child for creating markets for clean and affordable energy in Africa," explaining that the program's "innovative approach brings together the IFC and the World Bank, investors, and governments in a transparent, streamlined, and competitive process. The result is great deals for consumers." The Scaling Solar program in Senegal follows another success in Zambia. Overall, the program is developing over 1 GW of solar (IFC 2018).

Current Status

Senegal's government has made a commitment to integrating more renewable energy resources into its energy mix and achieving this by collaborating with the World Bank and other institutions. Senegal currently anticipates, through its Plan for Emerging Senegal, adding 150 MW in wind power and 200 MW in solar power over the next few years.

INSTITUTIONAL RECOMMENDATIONS

Economies with few domestic institutions that support renewables — with the human, intellectual, and financial capital they require — may appear risky to developers and investors despite otherwise favorable conditions. Institutions have considerable inertia and can only be changed slowly by government actions. Nevertheless, government actions to increase the participation of academic, business, financial, and development institutions in renewable development can improve the bankability of potential projects.

- *Recommendation 11*: Enlist formal participation of the local academic and business sector (including banking) to build and apply financial and technical expertise. It is particularly important to develop contractual templates that both meet international standards and are suited to local conditions.
- *Recommendation 12:* Enlist formal participation of international development institutions to leverage their considerable technical and financial resources, including the use of "best practice" procedures such as competitive auctions and prequalifying bidders.

CONCLUSION

As noted above, wind and solar development is affected by a range of technical, economic, regulatory, and institutional barriers and enablers. The success stories demonstrate that there are a variety of ways that barriers can be overcome and enablers exploited. The target APEC developing economies (for this report) face widely varying conditions and are at widely varying development stages. The lessons from this report vary as well.

Technical drivers include (a) the understanding of wind and solar resources and (b) the capability of the grid and transmission system to integrate wind and solar generation. For some economies, technical considerations have been a problem with reliability issues or resources far from current transmission lines. Some economies, like Thailand or Chile, have already adopted approaches to ensure that resources are well characterized and the grid is fully-capable, turning this driver into a strong enabler. Case studies on the Tsetsii wind farm in Mongolia and the Noor Ouarzazate I CSP Plant show how economies can successfully overcome technical barriers.

Many developing APEC economies are rapidly growing, with resulting increases in electricity demand. At the same time, many APEC economies are still developing with only modest per-capita wealth and income. Regarding renewable energy development, threading the needle between investability and affordability can be a considerable challenge. Some faster developing economies, such as Peru and Mexico, are using market tools like FiTs, renewable energy targets, auctions, and bankable PPAs to enable renewable energy investments. Case studies on the Eastern Indonesia Renewable Energy Project and the Bac Lieu Near-Shore Wind Farm in Viet Nam show how economies can successfully overcome economic barriers.

As noted above, regulations are the most obvious government tool for encouraging or discouraging renewables development. For many APEC economies, wind and solar investments have been greatly facilitated through strong, consistent government support via favorable energy policies, active engagement of non-energy government agencies, and well as well-designed, open electricity markets. Case studies of the BMR Wind Project in Jamaica and the Solem Solar PV Complex in Mexico show how economies can effectively use government policy and regulation.

Institutional drivers refer to the human, intellectual, and financial capital provided by organizations to promote wind and solar development. This is important for APEC economies that have had, so far, limited renewable energy development — and consequently modest institutional capabilities. Some APEC economies have taken significant steps in this area, such as enlisting domestic banks to be involved in financing, recruiting local investors and technical expertise, and involving international development agencies. Case studies on the Nabas I Wind Power Project in The Philippines and the Kahone and the Touba Solar PV projects in Senegal show how economies can use institutions successfully.

If lessons from the success stories are considered and the resulting recommendations are customized appropriately, economy governments and stakeholders will certainly be able to point to increasing success at attracting investment and financing for more grid-connected wind and solar projects in the region.

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