REN21
RENEWABLES NOW

ASIA AND THE PACIFIC RENEWABLE ENERGY STATUS REPORT

2019

ADB

IN CO-OPERATION WITH
UN ESCAP

PARTNER ORGANISATIONS

The **Asian Development Bank** (ADB) is committed to achieving a prosperous, inclusive, resilient and sustainable Asia and the Pacific, while sustaining its efforts to eradicate extreme poverty. Established in 1966, it is owned by 68 members–49 from the region. Its main instruments for helping its developing member countries are policy dialogue, loans, equity investments, guarantees, grants and technical assistance.

The **Economic and Social Commission for Asia and the Pacific** (ESCAP) serves as the United Nations' regional hub promoting co-operation among countries to achieve inclusive and sustainable development. It is the largest regional intergovernmental platform with 53 Member States and 9 Associate Members. The Commission's strategic focus is to deliver on the 2030 Agenda for Sustainable Development, through reinforcing and deepening regional co-operation and integration to advance connectivity, financial co-operation and market integration. ESCAP, through its research and analysis, policy advisory services, capacity building and technical assistance, aims to support sustainable and inclusive development in member countries.

REN21 is an international policy network dedicated to building a sustainable energy future with renewables. This means having a clear vision about the future and what is needed to make the right decisions. We do this by telling compelling stories about why we need an energy transition and how renewables can contribute to this vision. We want to inspire and mobilise people across all sectors to make renewables a central part of any energy decision.

REN21's reports and activities are clustered under two main blocks: knowledge – what's happening now in the energy sector and what we think will happen; and debates – discussing a renewable energy future with players both within and outside the energy sector.

SUPPORTED BY

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Bundesministerium für Wirtschaft und Energie

DISCLAIMER

ASIA AND THE PACIFIC RENEWABLE ENERGY STATUS REPORT

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FOREWORD

REN21

As the world's fastest growing region, Asia requires increasing energy supplies to fuel its rapid pace of economic expansion. The sheer geographic size of Asia and the Pacific, its diversity and its varied institutional capacity offer a huge market potential for renewable energy. Renewable energy also presents an opportunity for the region to achieve a globally important position in the renewables market and to be a leader in the clean energy transition. But harnessing this momentum requires a key understanding of what is actually happening in each country.

The 2019 *Asia and the Pacific Renewable Energy Status Report* presents the current status of renewable energy uptake in the Asia Pacific region by examining the policy landscape, investment flows and how renewables are increasing energy access. Formal and informal data and information are used to reflect real-time developments in the region. The data and information collection process uses a collaborative approach that is the trademark of REN21.

Documenting the continual evolution and uptake of renewables in a timely manner is challenging. We acknowledge that data gaps exist in this report. Nevertheless, the report provides a starting point to better understand regional developments. It also highlights where data are missing and need to be collected. Given the importance of the region in the energy transition and the current speed of change, a continual data and information collection process is key. I hope that this report is just the beginning of this process.

On behalf of the REN21 Secretariat, I extend our thanks to the Asian Development Bank and the United Nations Economic and Social Commission for Asia and the Pacific for their collaboration in the development of this report. It is my hope that this publication inspires action, discussion and exchange. REN21 welcomes your feedback and support.

RANA ADIB
Executive Secretary
REN21

ADB

Renewable energy plays a significant role in sustainable and inclusive economic growth. In 2015, the United Nations declared energy as part of the 2030 Agenda for Sustainable Development, advocating access to affordable, reliable, sustainable and modern energy for all (SDG 7) and urgent action to combat climate change and its impacts (SDG 13). The Paris Agreement, through the Nationally Determined Contributions, contracted all nations to combat climate change and pursue a sustainable, low-carbon future.

Strategy 2030 of the Asian Development Bank (ADB) envisions a prosperous, inclusive, resilient and sustainable Asia and the Pacific. ADB has committed USD 80 billion for 2019-2030 to combat climate change, and at least 75% of ADB's operations will support climate change mitigation and adaption by 2030. The *Asia and the Pacific Renewable Energy Status Report* is in line with ADB's clean energy development and will inform investment decisions in order to achieve renewable energy targets in ADB's developing member countries.

The *Asia and the Pacific Renewable Energy Status Report* covers 18 countries from the five sub-regions, which together represent 88% of the region's population and occupy 71% of its land area. Efforts and milestones in adopting renewable energy technologies in power generation, heating and cooling, and transport are presented. This report serves as a valuable reference for researchers, policy makers and the private sector and offers wide-ranging discussions on the renewable energy industry and market, distributed renewables for energy access, policies, regulations, investment and financing.

YONGPING ZHAI
Chief of Energy
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The Asia Pacific region is progressing to a low-carbon energy future. Renewable energy development has gained momentum across the region and entered the mainstream, particularly in the power generation sector. Many policy makers in Asia and the Pacific and beyond have looked to renewable energy as a means of meeting multiple goals – diversification of energy resources, enhancing energy access, climate change mitigation and reducing air pollution, just to name a few. As the largest global region by population, GDP and energy use, the speed that the Asia Pacific region travels on its renewable energy journey will influence the rest of the world.

Capturing the diversity of a region such as Asia and the Pacific in one report is no easy task. Countries of the region have highly variable energy endowments and consumption patterns. By examining 18 countries in detail, drawn from across Asia and the Pacific's five sub-regions, the REN21 *Asia and the Pacific Renewable Energy Status Report* builds a comprehensive picture of the region's overall progress. Taken together, these countries cover 88% of the region's population and are embracing a wide range of renewable technology applications, from biofuels to wind power.

By examining the progress in areas beyond renewable energy technologies – such as energy efficiency, finance and policies – the report paints a detailed picture of the developments across the region and pinpoints some emerging trends. It presents a complex picture in a cohesive, engaging and accessible format, complementing other efforts such as the multi-agency Asia Pacific Sustainable Energy for All Global Tracking Framework report and the Asia Pacific Energy Data Portal operated by ESCAP.

This inaugural report will provide stakeholders with valuable and up-to-date information from across this diverse region and supports the further development of the renewable energy sector towards achieving the 2030 Agenda for Sustainable Development.

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EXECUTIVE SUMMARY

This inaugural *Asia and the Pacific Renewable Energy Status Report* provides a comprehensive overview of renewable energy developments in selected countries of the region. Asia and the Pacific plays a large role in the world, covering a vast territory and contributing a majority of world population and population growth. The region's economic transformation, accompanied by an energy transition, is fundamental to the success of global efforts to achieve sustainable development goals and decarbonisation objectives.

This report covers 18 selected countries representing five key sub-regions, as follows: Northeast Asia (China, Japan, Mongolia, the Republic of Korea); Central Asia (Georgia, Kazakhstan, Uzbekistan); South Asia (Bangladesh, India, Pakistan, Sri Lanka); Southeast Asia (Indonesia, Myanmar, the Philippines, Thailand, Viet Nam) and The Pacific (Fiji, Tonga). The countries are drawn from where networks and data sources were the strongest.

Although the Asia Pacific region is a renewable energy leader worldwide, the deployment of renewables continues to lag behind that of traditional energy sources in supplying the region's rapidly increasing energy needs. Continuing growth in energy demand in the power, heating and cooling, and transport sectors opens a multi-faceted renewable energy opportunity in the region. Some of the largest countries in size and renewable energy potential still have relatively low shares of renewables in their total final energy consumption (TFEC). For example, India had a less than 40% renewable energy share in its TFEC in 2016, while China's share was below 20% that same year.

Overall, the region's renewable energy share is still focused heavily on hydropower (especially large-scale hydropower) and bioenergy (biomass, biogas and liquid biofuels for heating, cooking and electricity). Modern renewable energy, such as solar photovoltaics (PV) and wind, has considerable room to grow. The region is innovating, and new technologies are being implemented in the market. Floating solar PV gained traction in 2018 and is attracting interest in a few countries, particularly those with limited available land.

Renewable energy for heating and cooling is still mostly underdeveloped in the region, except in China. Transport offers another possible avenue for renewable energy development. Electrification has started in the region's energy mix for transport, and although electromobility is not directly linked to renewables, it offers a step away from traditional fuels and an opportunity to develop renewable energy for transport uses.

Renewable energy for power generation is growing the most aggressively, on the back of technology improvements in solar PV and wind power technologies. China, India, Japan and Bangladesh are at the forefront of renewable energy developments in the region's power sector.

Distributed energy offers another opportunity for renewable energy in the region providing both access to electricity as well as access to clean cooking. Distributed renewable energy is pushing the boundaries for the introduction of innovative solutions such as pay-as-you-go, combining expertise from mobile providers and energy companies.

Governments in the region are catching up with the latest market developments, and some are pro-actively looking to build an investment pipeline in renewable energy. Feed-in tariffs (FITs), the most common support mechanisms, are progressively giving way to auctions that will nurture renewable energy opportunities. Net metering is present, but it still needs to develop and to offer stable conditions and transparency that may lead to increases in investment flows compared to today.

Cities and local authorities are building their own mandates and are going green with renewable energy, offering an immediate opportunity for renewables in power, heating and cooling, and transport.

01 REGIONAL OVERVIEW

The 18 countries covered in this report are fundamental to the clean energy transition. They account for 52% of the world's population, represent 88% of the people living in the Asia Pacific region and account for 39% of the global primary energy supply. China and India dominate the landscape of this region: as the world's most populous countries, they account for 28% of global primary energy supply.

The region has developed considerable renewable energy capacity across a number of technologies including solar PV, wind power, hydropower, bioenergy and geothermal, as detailed in the Market and Industry chapter. Discussions about increasing the ambition of targets are ongoing, and the Policy Landscape chapter of the report provides information on both country targets and progress. Renewable energy also plays a role in addressing the issue of energy access – both for power and heating and for cooking purposes – in many countries in the region, as discussed in the Distributed Renewables chapter.

The world's megacities are disproportionately concentrated in Asia, and the countries covered in this report are home to 27 of the world's 50 largest cities. A top priority for the region is creating functioning megacities that can grapple with congestion and effective mobility, create effective electricity distribution networks and efficiently improve access to clean forms of heating and cooling. Few countries in the Asia Pacific region demonstrate self-sufficiency in energy, with the majority importing at least some of their primary energy supply.

As a complement to efforts and commitments to increase renewables, energy efficiency has become more common practice, and overall energy intensity in many of the countries covered is either flat or falling steadily. Widespread challenges remain in adopting renewable energy and energy-efficient practices, including in financing, the transition to more sophisticated government support for renewables, changing industry dynamics in response to rapidly growing demand, climate change constraints and growing urbanisation.

The development of renewables also addresses energy security, another key challenge for the region. As energy demand increases and as domestic resources dwindle, self-sufficiency is expected to decline in the coming decades. In many countries, the rapid growth in energy demand has fuelled the expanded use of both fossil fuels (especially coal and natural gas for electricity generation and oil for transport) and renewable energy (including large hydropower and geothermal for power generation). Still, most of the world's planned, under construction or operating coal-fired power plants are in Asia.

Various forms of regional co-operation in energy exist across the five sub-regions, and some of these efforts have been effective in improving clean energy practices and energy security through cross-border power trading, notably in Southeast Asia. Examples of organisations and initiatives that are promoting further development of renewable energy and energy efficiency in the region include the United Nations Economic and Social Commission for Asia and the Pacific (UN ESCAP), the Asia-Pacifc Economic Cooperation (APEC) Energy Working Group, the South Asian Association for Regional Cooperation (SAARC) Energy Centre, the Central Asia Regional Economic Cooperation (CAREC) programme, the Association of Southeast Asian Nations (ASEAN) Centre for Energy and the Pacific Centre for Renewable Energy and Energy Efficiency (PCREEE).

02 RENEWABLE ENERGY MARKET AND INDUSTRY OVERVIEW

The Asia Pacific region has a leading role in the continued push for renewable energy on the global stage, and the 18 countries covered in this report have demonstrated considerable progress as well as strong potential for future developments. The countries with the highest shares of renewables in total final energy consumption are Myanmar (68%), Sri Lanka (51.3%), the Philippines (47.5%) and Indonesia (47%), driven by hydropower and bioenergy.

The overall picture of renewables in the region requires contrasting renewable energy development against the background of energy supply dynamics. Although the deployment of renewable power is increasing, this is occurring at a slower rate than that of conventional fossil fuels such as natural gas and coal.

The sub-regions with the highest penetrations of renewables in the energy mix are Southeast Asia (45.7% on average) and South Asia (42% on average), in contrast to sub-regions where renewable energy comprises a smaller share of the total (Central Asia, at 16.2% on average, and Northeast Asia, at 11.7% on average). Across the region, traditional biomass, the most widely used renewable energy source, has been gradually replaced by cleaner fuels, although most of these fuels are non-renewable in origin. Overall, 5 of the 18 countries – China, India, Japan, the Republic of Korea and Thailand – use significant shares of renewables for heating and cooling, specifically solar thermal, with a combined capacity in 2017 of 362 gigawatts-thermal (GW_{th}), 97% of it located in China.

Many Asian countries have vast geothermal resources. Some, like Indonesia and the Philippines, use geothermal for power generation, while direct use of geothermal heat is more popular in other countries. The combined geothermal heating capacity of the 18 countries at the end of 2017 was 22.4 GW_{th}. Bioenergy, especially traditional biomass such as fuelwood, is used for heating in many remote regions, although data on this use remain limited.

Nine countries in the region produce biofuels for transport, with the largest contributions from China, Indonesia, Thailand and India, which are also among the world's top biofuels producers. Production in the region totalled 12 million tonnes in 2018, an increase of 2.5 million tonnes from the previous year. Fuel ethanol production accounts for around 45% of this production, and the remaining 55% is fatty acid methyl esters (FAME) biodiesel. Electrification of road transport is also gaining ground in the region. Although electromobility is not directly tied to the uptake of renewables, as its impact on emissions depends on how "green" the energy mix of a country is, it can represent a step away from fossil fuel consumption.

Renewable energy capacity in the power sector has grown steadily in the 18 countries. In 2000, hydropower (including large-scale hydropower) accounted for 95% of the renewable capacity, and geothermal, bioenergy and wind power were also in the mix. Over the ensuing years, the renewable capacity grew six-fold, reaching 988.9 gigawatts (GW) in 2018 as a result of the accelerated deployment of wind and solar PV technologies. Although hydropower still had the largest share, at 46%, the shares of solar PV and wind power reached 28% and 23%, respectively. Bioenergy was around 3%, and geothermal (in China, Indonesia, Japan and the Philippines) accounted for 0.45%. The Republic of Korea and China had ocean power capacities of 255 megawatts (MW) and 4.3 MW, respectively.

China is primarily responsible for the large scale of renewable energy additions in the region, due to strong progress on the country's 13th Five-Year Plan, which included capacity targets for renewables to 2020. Driven largely by additions of solar PV, China's renewable power generation capacity grew from 480 GW in 2015 to just under 700 GW in 2018.

03 DISTRIBUTED RENEWABLES FOR ENERGY ACCESS

Regionally, the vast majority of the renewable generation capacity in the 18 countries – 92% – is concentrated in just three countries: China, which accounts for 71% of the capacity, India (12%) and Japan (9%).

Renewable energy resources can play a pivotal role in achieving universal access to modern energy. Small-scale solar, wind and hydropower technologies, as well as internal combustion plants using biomass or biogas, can provide a reliable source of electricity in remote locations.

Across the Asia Pacific region, several countries report that the majority of their populations are now fully electrified, including in Central Asia (Georgia, Kazakhstan, Uzbekistan), most of Northeast Asia (China, Japan, the Republic of Korea) as well as in Sri Lanka, Thailand and Viet Nam. However, other countries have a long way to go. In Mongolia, Indonesia, the Philippines and the Pacific (Fiji and Tonga), the remaining few percent of the population still needs to be connected as last-mile customers. Power reliability continues to be a challenge in many places.

Although countries in Asia and the Pacific have made significant progress in connecting their populations – the region is home to three-quarters of the 570 million people worldwide who gained electricity access between 2011 and 2017 – an estimated 350 million people still lack access across developing Asia. The remaining work towards electrification is challenging, and is exacerbated by the fact that many of the households without access are located in very remote areas including mountains, islands or isolated hamlets and villages.

Half of the population in Asia and the Pacific – just under 2 billion people – relies on traditional biomass, coal and kerosene for cooking and heating. Reducing indoor air pollution and improving the health of rural residents are among the main objectives of clean cooking programmes in many countries. With the exception of several countries that have a strong institutional focus on access to clean cooking and fuels, difficulties persist in bringing these technologies – such as liquefied petroleum gas (LPG), biogas, electricity, advanced biomass cook stoves and solar cooking – to consumers in the region. Underinvestment in the sector will likely cause Asia and the Pacific to fall short of the target for universal access to clean cooking by 2030 set out in the United Nations' Sustainable Development Goal 7.

Rural electrification plans introduced by national governments are multi-dimensional and often include extension of the existing grid as well as the promotion of decentralised solutions, including mini-grids and stand-alone systems.

Energy access companies, working in partnership with development actors and local governments, provide a variety of technologies to power the needs of residential and commercial customers.

As the Asia Pacific region has experienced a boom in telecommunications infrastructure and the price of smartphones has dropped, integrating mobile and wireless network infrastructure into decentralised business models has become paramount in efforts to provide energy access. For example, pay-as-you-go (PAYG) solar enables lower-income customers to buy solar products through their mobile devices, either on credit or instalment plans or by paying a small fee for continuous use. Positive results are being seen from the ongoing focus on eliminating market barriers for private companies to increase access to modern energy services and to build the commercial viability of initiatives.

04 POLICY LANDSCAPE

The variation in policy support for renewables in the region reflects the diversity in countries' income levels, gross domestic product (GDP) growth and economic development levels. For example, high-income countries in Northeast Asia, such as Japan and the Republic of Korea, have adopted a range of targets to increase the share of renewables in the electricity generation mix and to improve energy efficiency.

Considerable policy attention has been given to renewable energy and energy efficiency in most countries of the region, recognising the need for improved energy security, environmental quality (particularly reducing air pollution), industry competitiveness, and the provision of cost-effective electrification solutions to populations that lack access to electricity in remote regions or islands. In countries with rapidly growing industries – such as China, India, the Philippines and Thailand – policies are aimed at reducing the carbon intensity of economic development. The need is urgent: although per capita greenhouse gas emissions in Asia and the Pacific remain below the global average, five countries in the region – China, Japan, the Republic of Korea, India and Indonesia – are among the world's largest emitters, together accounting for nearly 40% of the global total.

Renewable energy support policies and targets were present in all of the 18 countries in the Asia Pacific region as of mid-2019, at various levels of government. In most of the countries, they are combined with energy efficiency targets. FITs are the most common support mechanisms in these countries, followed by renewable energy auctions, or tenders. Quotas or mandated targets are less common. Net metering is present in all countries except three. With regard to fiscal incentives and public financing, countries have in place capital subsidies or grants, investment tax credits and customs duty exemptions, as well as public loans and grants. Energy production payments are the least common supports and are present in only three countries.

In some cases, countries have taken a regional approach to renewable energy policy. ASEAN has set a renewable energy target aimed at achieving an ambitious 23% renewables share in the energy mix of member countries by 2025 and reducing energy intensity 30% by 2025.

Most countries of the Asia Pacific region have given considerable attention to renewable power. Specific country approaches include integrating renewable power into the overall energy system (China) and into grid planning (Japan, Myanmar); the ongoing liberalisation and unbundling of electricity markets (the Philippines); and interfaces between renewables and energy efficiency (Japan). Despite the energy intensity of the heating and cooling sectors, only a few countries in the region – such as India and Thailand – have introduced targets and/or supportive frameworks for the use of renewables in these sectors.

Biofuel mandates are a popular policy instrument to incentivise domestic production of biofuels and diversify the fuel mix. Several countries in the Asia Pacific region have introduced targets for the share of biofuels in the transport sector, as well as national and/or provincial biofuel blending mandates for ethanol and biodiesel. These include China (E10), Indonesia (B20), the Philippines (E10, B2), the Republic of Korea (B2-B3), Thailand (B7) and Viet Nam (E5).

Northeast Asia leads in efforts to promote the domestic manufacturing and export of electric vehicles (EVs), both to neighbouring countries and farther afield. To reduce air pollution from the transport sector, several countries in Southeast Asia also have established policies and government initiatives across the EV value chain – from promoting consumer demand, to electrifying public infrastructure and passenger vehicles, to setting up safety guidelines for electric auto rikshaws (tuk tuks) to support electric mobility and incentivise the transition to an electric-power automotive industry.

Fiscal incentives for the renewables sector are becoming more common across the Asia Pacific region. In recent years, FITs – the instrument traditionally used to support renewable energy development in the region – have been either discontinued (the Philippines), revised (Indonesia), kept too low (Viet Nam) or replaced by auctions to reflect recent declines in solar PV costs and to prevent over-subsidisation in markets where renewables can compete with traditional power sources. The region has seen a few successful examples of reverse auctions for renewable energy projects, resulting in competitive costs for solar and wind generation at grid parity levels. Successful auctions have been held in Northeast Asia (China, the Republic of Korea), Central Asia (Kazakhstan), South Asia (India, Pakistan) and Southeast Asia (Indonesia, the Philippines, Thailand, Viet Nam).

Net metering is still a nascent support mechanism in the region, with fewer countries running successful net metering schemes than having in place FITs. India and Pakistan both operate net metering schemes at the national and state levels, and Indonesia recently launched a long-awaited net metering programme. Viet Nam, meanwhile, decided to cease its net metering scheme.

Several countries in the region are using carbon pricing or carbon tax measures to regulate their carbon emissions, including China, Japan and the Republic of Korea in Northeast Asia, and Kazakhstan in Central Asia. A few countries in Southeast Asia, such as Thailand and Viet Nam, also are considering carbon pricing initiatives.

Sub-national and municipal policies to promote sustainable energy through localised innovations are being developed in the region. For example, the regional Cities Development Initiative for Asia aims to promote sustainable and equitable urban development that would lead to improved environmental and living conditions for residents of medium-sized cities in Asia and the Pacific. Some cities have ambitious plans to "go green," including Ulaanbataar in Mongolia, Tokyo in Japan and East Kalimantan in Indonesia.

Overall, the policy landscape in Asia is dynamic and continues to develop at a variety of jurisdictional levels, reflecting growing support for renewable energy and energy efficiency as well as diverse efforts to directly address carbon footprints in the region.

05 INVESTMENT FLOWS

An estimated USD 288.9 billion was invested in renewable energy worldwide in 2018. China, the global renewable energy leader, saw renewables investment in 2017 of USD 145.9 billion – its highest level ever – accounting for 45% of the global total.

Renewable energy investment trends in the Asia Pacific region are mixed, reflecting the changing economic circumstances and fluctuating policy conditions in the countries under review. At the macro level, Asia accounted for 52% of new investment in the renewables sector worldwide in 2018, with China, Japan and India among the top 10 destinations of renewable energy investment globally, and Viet Nam and the Republic of Korea ranking among the top 20. Renewable energy investment is driven by a range of circumstances, including a country's economic strength, the existing energy infrastructure, the policy and regulatory environment, political support and the favourability of investment conditions.

China dominates the picture given its size. Renewables investment in China dropped to USD 91.5 billion in 2018 (32% of the global total), due in large part to a significant change in the country's FIT policy mid-year, to the rapidly declining capital costs of solar PV, as well as to timing differences in investment decisions. Investment in solar power in China fell by half, from USD 89 billion in 2017 to USD 40.2 billion in 2018, whereas investment in wind power declined 6% to USD 50.1 billion.

Climate finance funds have continued to provide opportunities for financing renewable energy and energy efficiency projects in the Asia Pacific region. The largest funds by overall investment volume are the Clean Technology Fund, the Green Climate Fund and the Global Environment Facility (GEF). The GEF administers by far the largest number of projects, with 168 projects active as of February 2019, while other funds aim for impact via larger infrastructure investments. Just three countries – India, Indonesia and China – received 53% of climate funds invested in the Asia Pacific region for the period 2003-2017, indicating the relative size and dominance of their economies and energy markets.

This report gives an updated view of where Asia and the Pacific stands in renewable energy development. Greater penetration of renewable energy sources presents an opportunity for the region to achieve a globally important position in the renewables market and to be a leader in the clean energy transition.


CYBER BETA

01 REGIONAL OVERVIEW

Home to a majority of the world's population, the **Asia Pacific region** is fundamental to the success of the **global energy transformation**.

01 REGIONAL OVERVIEW

INTRODUCTION TO THE REGION AND SCOPE OF THIS REPORT

This inaugural *Asia and the Pacific Renewable Energy Status Report* provides a comprehensive overview of renewable energy and energy efficiency developments in the world's largest and fastest growing region. Asia and the Pacific covers a vast territory and contributes a majority of world population and population growth. The region's economic transformation, and the accompanying speed of transition towards cleaner energy sources, is fundamental to the success of global efforts to reduce greenhouse gas emissions.

Introduction to the Region

The Asia Pacific region is diverse, being home to some of the largest countries by both area and population as well as to some of the smallest and most remote nations on Earth. At the same time, the region is a global engine of economic growth, with rapidly increasing energy demand. Given this breadth and the presence of more than 60 countries in the region, this report takes a pragmatic approach to consider only 18 representative countries across five key sub-regions, as follows:

Northeast Asia	China, Japan, Mongolia, the Republic of Korea
Central Asia	Georgia, Kazakhstan, Uzbekistan
South Asia	Bangladesh, India, Pakistan, Sri Lanka
Southeast Asia	Indonesia, Myanmar, the Philippines, Thailand, Viet Nam
The Pacific	Fiji, Tonga

China and India together make up **36%** of world population and **16%** of world economic activity.

These 18 countries have differing energy circumstances and vary in their potential for, and progress on, renewable energy and energy efficiency, including developments in markets and industry as well as policy. The countries have been selected to provide a significant proportion of the Asia Pacific picture, and are drawn from where networks and data sources were the strongest.

Key parameters for the selected countries demonstrate the relevance of their choice for the report. The 18 countries account for nearly 90% of the population of Asia and the Pacific, for 80% of the region's population growth and for 70% of its land area (→ see Table 1).[1] In global terms, these countries represent more than half of the world's population and around one-third of its economic activity, including providing 31% of the total primary energy supply.[2] Information on these countries provides insight into wider regional trends, and, in some cases, neighbouring countries face similar geographic, resource endowment and cultural circumstances, particularly at the sub-regional level. The conclusions drawn in this report are thus valid for assessing the status and progress of renewable energy and energy efficiency developments in Asia and the Pacific as a whole.

Deserving special mention are the two Asian giants, China and India, which together make up 36% of world population and 16% of world economic activity and exercise a substantive influence over regional trends (→ see Figure 1).[3] However, a number of other countries covered by this report also have large populations and economies. In addition to China and India, 6 of the 18 countries have populations in excess of 100 million people and together provide another 1 billion in population, representing a further 13% of the world's people; meanwhile, Japan, the Republic of Korea and Indonesia are the world's third, twelfth and sixteenth largest economies, respectively.[4]

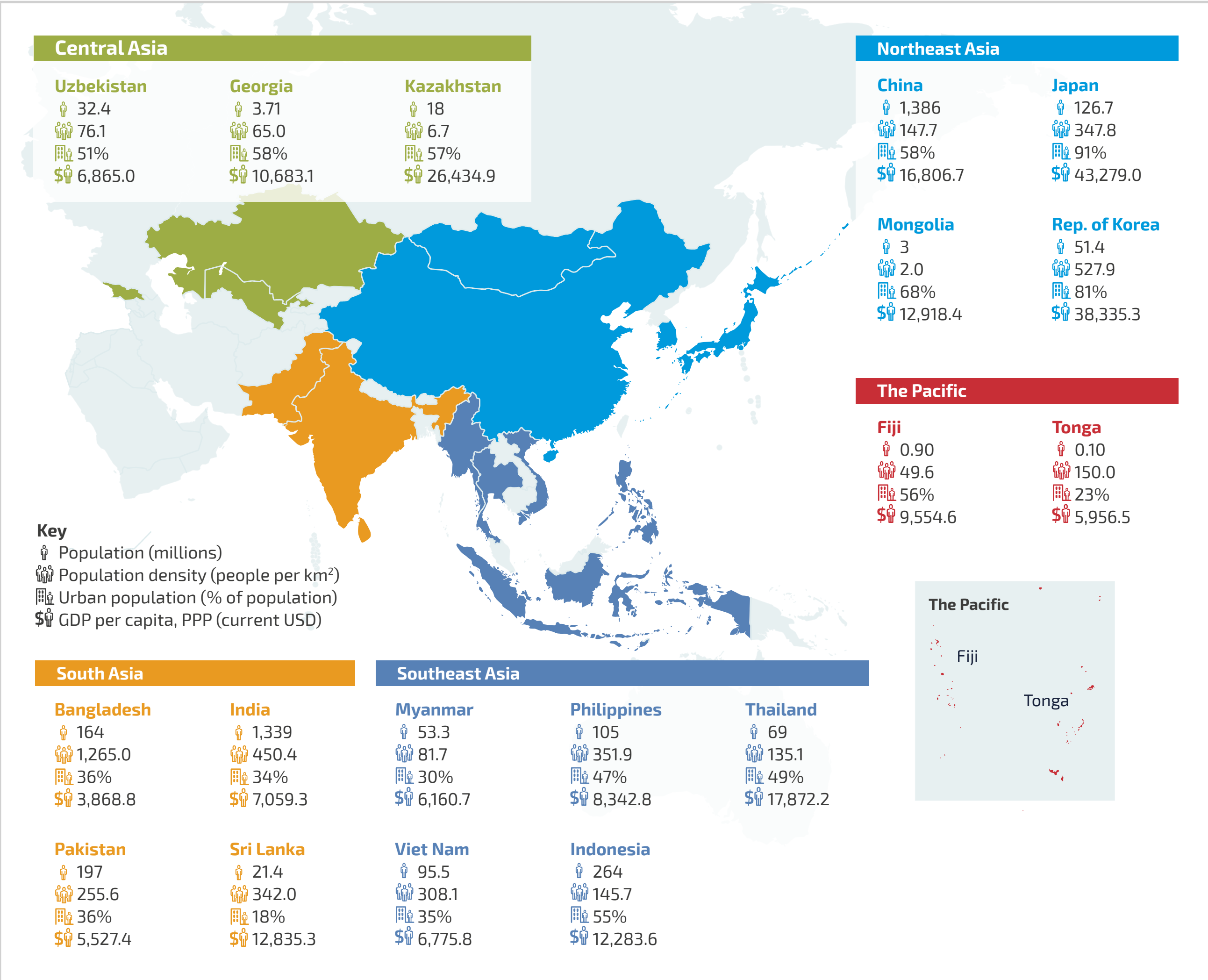
TABLE 1. Summary Overview of the Selected Asia Pacific Countries

	World	Asia and the Pacific	18 countries covered by this report	% of Asia and the Pacific covered by this report	% of world covered by this report
Population in 2019 (millions)	7,714.6	4,584.8	**4,018.9**	**88%**	**52%**
Land area (million km²)	148.9	31.0	**22.1**	**71%**	**15%**
Net increase in population (millions)	81.8	39.7	**31.7**	**80%**	**39%**
GDP (constant 2010 USD billions)	80,095.0	N/A	**23,163.7**		**29%**

Note: N/A = data not available

Source: See endnote 1 for this chapter.

FIGURE 1. Overview of the Selected Asia Pacific Countries, 2017



Source: See endnote 3 for this chapter.

At the other end of the population spectrum, the Pacific countries are among the smallest (by both area and population) and most remote nations on Earth and face a very different set of energy and development challenges. Their immediate energy sector priorities typically focus on improved access to services, including clean and affordable energy, for small remote communities, often in difficult geographic circumstances. Pacific Island countries also seek to secure adequate indigenous energy supplies at least cost to remove reliance on expensive fossil fuel imports.[5]

The countries covered in this report are home to **27 of the 50 largest cities** worldwide.

While Asia and the Pacific as a whole is less urbanised than the global average, the world's megacities – urban areas with populations exceeding 10 million people – are disproportionately concentrated in Asia.[6] The countries covered in this report are home to 27 of the 50 largest cities and to 13 of the 20 largest cities worldwide.[7] A top priority for the region is supporting functioning megacities that can improve air quality while grappling with congestion and effective mobility; can develop clean, effective and reliable electricity distribution networks; and can efficiently improve access to low-carbon heating and cooling.

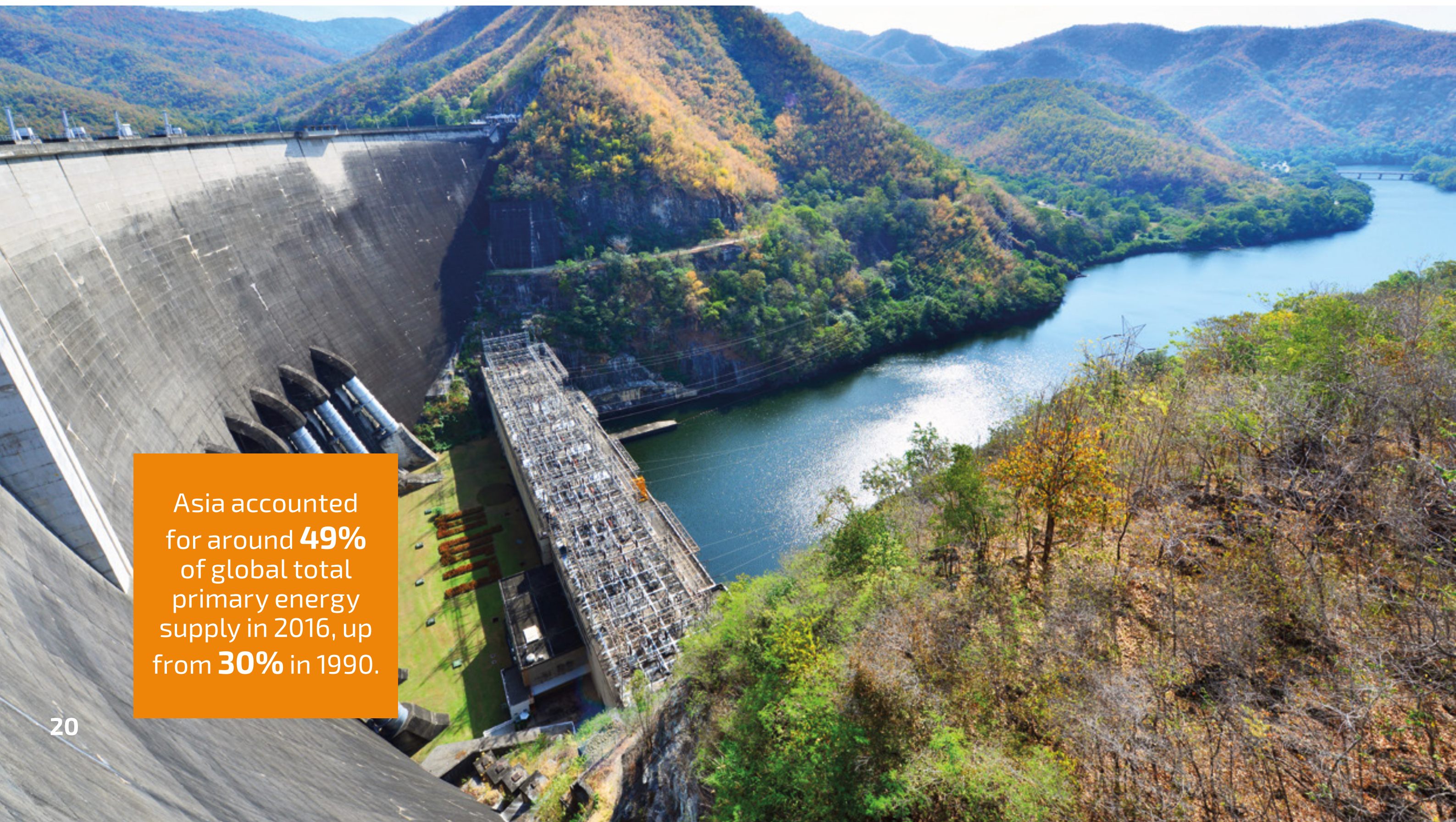
The economies of these countries are extremely varied in both size and complexity. China is the dominant economic force, and Northeast Asia is by far the dominant sub-region, with the three economies of China, Japan and the Republic of Korea accounting for around 76% of the combined GDP of the 18 countries.[8] In terms of GDP per capita and overall prosperity levels for Asia's citizens, the picture is more mixed: Japan and the Republic of Korea are the most developed nations of those studied, at a level comparable to or above many Western nations, while those countries with lower per capita incomes are classified as "lower-middle income" countries, alongside less-developed nations worldwide.[9]

Along with wide variations across Asia and the Pacific in the level of development, there is variation in income distribution and equality, with clear implications for access to energy and energy consumption. Compared globally, most Asian countries fall within a moderate band of income distribution; of the 18 selected countries, Kazakhstan has the greatest income equality, whereas the Philippines has the least.[10]

REGIONAL ENERGY OVERVIEW AND TRENDS

In line with its overall demography, the Asia Pacific region is a dominant player in energy markets, with substantial and rising energy demand (→ *see Table 2*).[11] The total primary energy supply (TPES)[i] of the 18 selected countries was 4,232,919 kilotonnes of oil equivalent (ktoe) in 2016 (→ see Table 3), or approximately 31% of the energy supplied globally.[12] Asia as a whole accounted for around 49% of world TPES that year, up from 30% in 1990.[13]

i Primary energy is an imperfect metric for measuring the share of renewable energy in the energy sector, as it requires consideration of conversion losses for thermal generation technologies (e.g., coal, nuclear, bioenergy) that overstate their contributions to final energy use. Adoption of non-thermal renewable energy sources can help reduce primary energy intensity. See Glossary for more information.



Asia accounted for around **49%** of global total primary energy supply in 2016, up from **30%** in 1990.

TABLE 2. Energy Overview of the Selected Asia Pacific Countries

Country	Net energy imports (% of energy use)	Energy use per capita (MJ/capita)	Electrification rate (% of population)	Energy subsidies as % of GDP
	2014	2014	2017	2017
Northeast Asia				
China	15%	2,237	100%	0.3%
Japan*	93%	3,429	100%	N/A
Mongolia	-168%	1,838	86%	N/A
Republic of Korea*	81%	5,413	100%	N/A
Central Asia				
Georgia	69%	1,178	100%	N/A
Kazakhstan	-117%	4,435	100%	3.0%
Uzbekistan	N/A	N/A	100%	10.9%
South Asia				
Bangladesh	17%	222	88%	0.6%
India	34%	637	93%	0.6%
Pakistan	24%	484	71%	0.7%
Sri Lanka	50%	516	98%	0.2%
Southeast Asia				
Indonesia	-103%	884	98%	1.7%
Myanmar	-33%	372	70%	N/A
Philippines	N/A	N/A	93%	N/A
Thailand	42%	1,970	100%	0.2%
Viet Nam	N/A	N/A	100%	0.1%
The Pacific				
Fiji	N/A	N/A	96%	N/A
Tonga	N/A	N/A	98%	N/A

*For Japan and the Republic of Korea, data on energy imports and energy use per capita are from 2015.

Note: Energy subsidies refer to any measures by governments to keep prices for consumers below market levels or for producers above market levels, or to reduce costs for consumers and producers. N/A = data not available.

Source: See endnote 11 for this chapter.

TABLE 3. Energy Mix in the Selected Asia Pacific Countries, 2016

Country	Total TPES	Non-renewable TPES	Renewable TPES	Renewable share of total TPES
	thousand tonnes of oil equivalent			percent
Northeast Asia				
China	2,959,101	2,687,521	271,580	9%
Japan*	425,616	397,533	28,082	7%
Mongolia	4,961	4,677	162	3%
Republic of Korea*	282,411	274,785	7,574	3%
Central Asia				
Georgia	4,793	3,590	1,209	25%
Kazakhstan	81,643	80,613	1,137	1%
Uzbekistan	37,586	36,692	1,021	3%
South Asia				
Bangladesh	39,555	30,057	9,498	24%
India	862,483	653,265	209,218	24%
Pakistan	95,701	58,685	36,975	39%
Sri Lanka	11,702	6,619	5,083	43%
Southeast Asia				
Indonesia	230,151	152,633	77,518	34%
Myanmar	19,306	8,310	10,995	57%
Philippines	53,189	33,502	19,687	37%
Thailand	138,525	107,801	29,138	21%
Viet Nam	80,995	59,609	21,215	26%
The Pacific				
Fiji	N/A	N/A	N/A	N/A
Tonga	N/A	N/A	N/A	N/A
Total	**4,232,919**	**4,595,892**	**730,092**	**17%**

Note: Viewing renewable energy generation as a percentage of total primary energy supply (TPES) tends to underrate the impact of renewables in a country's energy mix; renewable energy supply as a percentage of total final energy consumption is a metric more reflective of the extent to which renewables are actually being used; however, consistent and comparable data for total final energy consumption were not available. N/A = data not available.

Source: See endnote 12 for this chapter.

China dominates energy requirements in the region, accounting for 70% of the TPES of the 18 selected countries.[14] For perspective, India, with nearly the same population, has less than a third of China's TPES, and the large developed economies of Japan and the Republic of Korea have TPES shares of around 14% and 10%, respectively.[15] Action in China is critical to the clean energy transition both regionally and globally. During the period from 1973 to 2015, China alone accounted for 34% of the growth in the world's energy supply.[16]

Asia and the Pacific has seen a tremendous increase in its energy demand, alongside rapid economic growth. Although some decoupling of economic growth and energy demand has occurred, with resultant reductions in energy intensity, in general the pace and scale of growth in energy demand has outstripped the speed at which countries have been able to transition quickly to decarbonised energy generation.[17] This has implications for the needed uptake of clean energy solutions, as well as for energy security. Fossil fuel subsidies still exist in most countries in the region, notably in Indonesia and in Central Asia, while Asia remains the largest region globally for planned, under construction or operating coal-fired power plants.[18]

Few of the 18 selected countries demonstrate a clear self-sufficiency in energy, with the majority importing at least some of their primary energy supply. Notable exceptions include Indonesia, which is the world's largest coal exporter; Kazakhstan, the world's tenth biggest net oil exporter; and Mongolia, the world's ninth largest coal exporter.[19] Japan, the Republic of Korea, Georgia, Sri Lanka and the Pacific island countries all rely on imported energy for more than half of their energy demand requirements.[20] (→ See Market and Industry chapter for more on specific countries.)

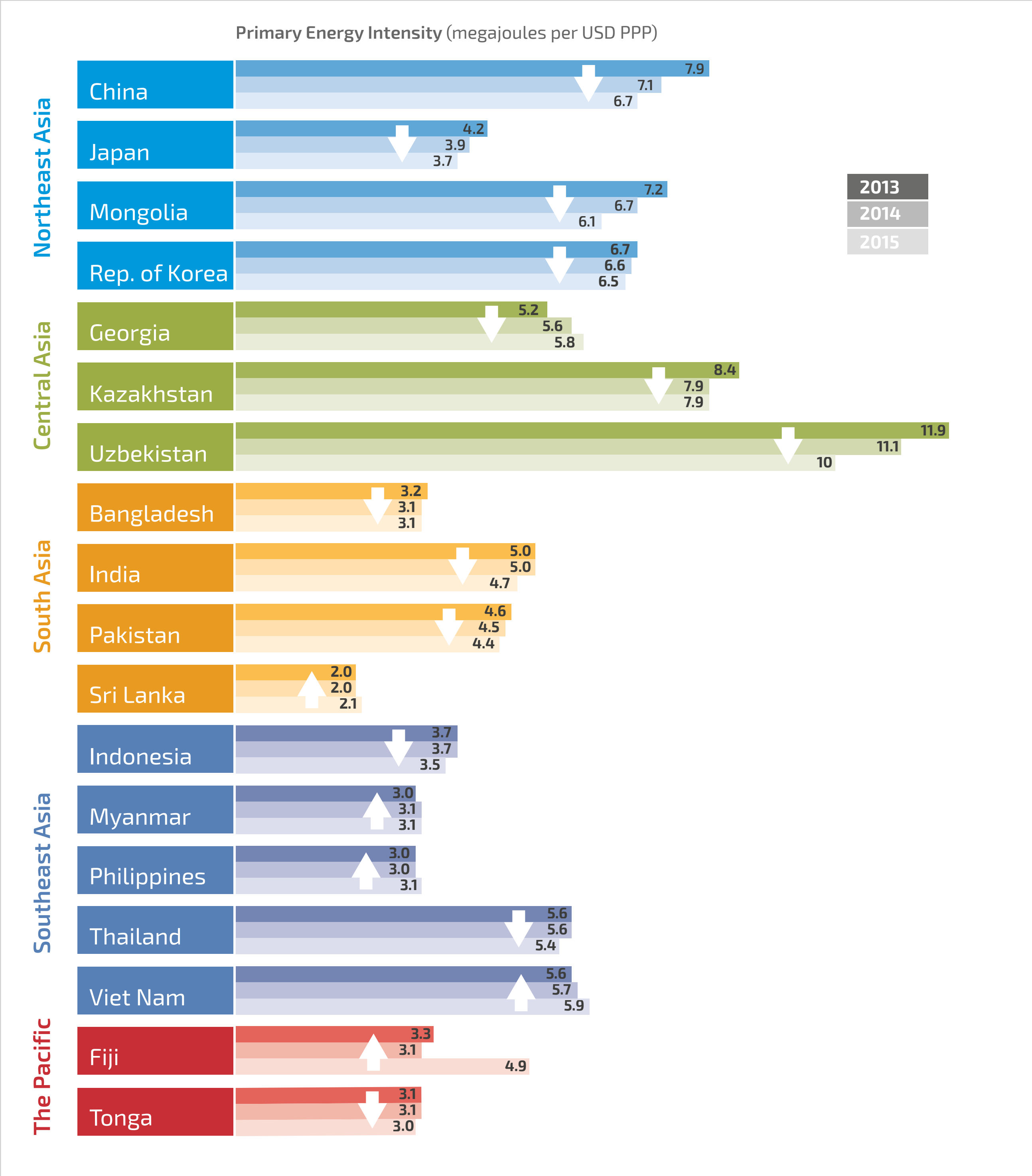
Even before the landmark Paris Agreement and its Nationally Determined Contributions (NDCs) towards mitigating greenhouse gas emissions were agreed, countries in the Asia Pacific region showed a rising commitment to developing both renewable energy and energy efficiency, including through important innovations in tariffs, increased use of independent power producers (IPPs) to meet growing electricity demand, and new legislation to incentivise mini-grids and distributed energy generally. But improvement has not been uniform: several countries have encountered technical, financial and political barriers to the continued expansion of renewables, and the development of non-renewable energy sources such as coal continues as countries struggle to meet rapidly rising electricity demand.

The region has developed considerable renewable energy capacity across a variety of technologies, including solar, wind, hydropower, bioenergy and geothermal (→ see Market and Industry chapter). China and India, the world's most populous countries, have led and appear poised to continue to lead the recent renewables push. India plans to achieve 175 GW of renewable electricity generation by 2022, and China has overarching goals for a 20% share of non-fossil fuels in its primary energy consumption by 2030, and a more than 50% share by 2050.[21] Discussions about increasing the ambition of targets are ongoing. (→ See Policy Landscape chapter for more on country targets and progress.)

As a complement to efforts and commitments to increase renewable energy, energy efficiency has become more common practice, with overall energy intensity[i] in many of the selected countries either flat or falling steadily (→ see Figure 2).[22]

i In macro-level analyses, energy intensity typically is used as a proxy for energy efficiency.

FIGURE 2. Primary Energy Intensity in the Selected Asia Pacific Countries, 2013-2015



Note: Data for 2015 are the latest available for the region.

Source: See endnote 22 for this chapter.

Changes in energy intensity across the region result from many varied factors. In some cases, they reflect ongoing structural shifts in the composition of economies, and in others, fluctuating levels of economic growth among sectors of different energy intensity. Adopting technologies that improve final energy efficiency in the end-use sectors – such as EVs and heat pumps – may both improve overall energy intensity and aid in the effective integration of variable renewable energy sources such as wind and solar.[23]

Many effective energy efficiency policies and programmes have emerged both from governments in the region and from private institutions that view energy efficiency as a cost-effective means to combat rising business costs while meeting environmental commitments. Regional programmes for energy efficiency also have been highly effective in some cases.

REGIONAL RENEWABLE ENERGY CHALLENGES

Financing

The financing of renewable energy infrastructure in Asia has faced difficulties in keeping pace with the rate of transition that is needed to meet international and national targets for both emissions reductions and energy sector decarbonisation, set by governments through the United Nations Framework Convention on Climate Change (UNFCCC) process and numerous national policy commitments. While the deployment of renewables is relatively rapid in many countries and a number of innovative financing schemes are in operation, the volume of activity remains below that required by these targets. Financing has been driven by the private sector, including numerous large financial institutions, energy companies and utilities that have been willing to underwrite utility-scale renewable energy.

Accelerating financing for small to medium-sized renewable energy projects (between 0.5 MW and 30 MW), which have proliferated in the region in recent years, has been particularly challenging (→ see Market and Industry chapter). The renewables market remains served by a small number of specialised investors who have developed the requisite investment knowledge and know-how but who tend to focus on larger renewable energy projects, given the transaction costs. Achieving greater deployment of renewables will require "upskilling" the large tier of potential small to medium project investors that exists.

Investment decisions require considerable data, documentation and analysis that need to be supported to spur better investment uptake and increase project confidence. A lack of reliable, comparable datasets on resource availability, capital and operating expenditures, and energy prices at the local level prevents access to renewable and energy efficiency finance[i]. For emerging markets, sovereign risk and the absence of local currency financing can present issues as well.

Funding from public climate investments and from global and regional support programmes has had a significant and growing effect on the adoption of renewable energy and energy efficiency technologies in the Asia Pacific region. Reinforcing this trend is a concerted phase-out of international donor support for oil and coal-based power generation. Countries are progressively making commitments to greater decarbonisation of their energy sectors, and companies are looking to reduce their exposure to climate-related risks.

India has increased its renewable power generation capacity by **40 GW** since **2015**.

Member countries of ASEAN, for example, have set a target for a 23% renewables share in the region's primary energy mix by 2025.[24] In India, meanwhile, supportive policy conditions have contributed in large part to the 40 GW increase in the country's renewable power generation capacity since 2015, to reach 117.8 GW at the end of 2018.[25] (→ See Investment Flows chapter for more on programmes and financing for renewable energy and energy efficiency projects.)

System Reliability and the Changing Role of Utilities

Rapid changes have occurred in the cost competitiveness and performance of renewable energy technologies that can be deployed in smaller and decentralised applications. This is changing the shape of renewables investment, driving a shift in private and public investor behaviour away from large, centralised fossil fuel generation infrastructure and towards smaller, distributed solar and wind assets (between 0.5 MW and 30 MW). This is redefining the role of utilities, the value and role of their transmission and distribution assets, and their need to engage with new grid conditions and control systems.

In China alone, a record 19 GW of small and medium-sized renewable energy projects was installed in 2017, representing an investment of USD 19 billion and nearly 35% of all solar investments made in the country.[26] The most common types of projects associated with distributed generation are commercial and industrial rooftop solar projects, community solar projects and floating PV, as well as local energy storage, micro and mini-grids, small wind power, biomass and small-scale hydropower (→ see Market and Industry chapter). New digital technologies – in the form of advanced metering, control and dispatch systems – are further enabling this shift.[27]

Smart grid technology is especially important for island nations in Southeast Asia and The Pacific, using decentralised electricity systems to improve the grid network's reliability and resilience to natural disasters (→ see Sidebar 1).[28] State utilities and energy departments are working to integrate smart grid technologies into energy planning. India and the countries in Northeast Asia have recently invested in the development of smart grids, with the main drivers being to improve system efficiency and reliability (China and India) as well as to reduce greenhouse gas emissions, improve efficiency and increase the renewable energy share (Japan and the Republic of Korea).

i For example, this report encountered challenges in gathering reliable cross-country data on financing.

SIDEBAR 1. The Role of Smart Grids in Decentralised Energy Access

A smart grid is an electricity network that uses digital technology to monitor and manage the movement of electricity from generation to various demand loads in the service area. Smart grids with remote monitoring can be a potential game-changer for rural and remote regions and hard-to-access islands in Asia and the Pacific. The technology can incorporate energy storage technologies (batteries) to store variable power generated by solar or wind for night- or peak-time use, and the operational data from these smart meters guide electricity supply planning and load management. In rural areas with grid access, elements of a smart grid can be programmed to improve the grid's reliability, integrate and balance volatile renewables with baseload generation through fossil fuel, and monitor/reduce energy consumption.

State Grid Corporation of China initiated a smart grid roadmap with a focus on building a smart ultra-high-voltage transmission system alongside urban and rural distribution grids co-ordinated at various levels, as part of the power development expansion programme, with public sector funding. Pilot projects include integration of clean energy, energy storage and microgrid technologies; superconducting transmission; smart sub-stations; distribution automation; electricity quality monitoring; customised power service; power consumption information systems; smart communities/buildings; EV charging and battery-switching facilities; smart streetlamp monitoring systems; interactive service centres; smart demand management and fault management systems.

The Philippines Department of Energy has drafted a policy and roadmap to support the adoption of smart grid technologies on the country's numerous islands, titled Providing a National Smart Grid Policy Framework for the Philippine Electric Power Industry and Roadmap for Distribution Utilities, which opened for public comment in July 2019. The country's largest distribution utility, Meralco, with more than 5 million customers, also plans to integrate an advanced smart grid platform for consumers to better manage their electricity consumption, with prepaid smart metering as one of its first services.

In Indonesia, the state-owned utility company PLN partnered with a French non-profit organisation, Think Smart Grid, to develop smart microgrids in West Nusa Tenggara province and on Sulawesi Island as well as a plan for renewable energy grid integration for Sulawesi in the coming years.

Source: See endnote 28 for this chapter.

Greenhouse Gas Emissions and Climate Change

The Asia Pacific region is a major contributor to global greenhouse gas emissions, and a large gap remains between the ambition of climate change mitigation and the pace of actions to reduce emissions. In addition, more countries are factoring in local concerns related to climate change and the environmental impacts of energy systems, leading them on a path towards increasing the share of renewables in the energy mix and improving energy efficiency.

Sustainable Cities and Mobility

Much of the burgeoning growth in Asia is centred in cities, and the region is home to a majority of the world's large urban agglomerations. As such, the region faces significant challenges in addressing pollution and poor air quality: based on concentrations of particulate matter 2.5 measured between 2009 and 2017, Asia housed 93 of the top 100 most polluted cities in the world.[29] Fifty-six of these cities were in China and 17 were in India, including 9 of the top 10 most polluted cities.[30]

Asia is home to **93** of the **top 100 most polluted cities** in the world.

Cities are an important engine for economic growth and socio-economic development. Over half of the global population currently lives in cities, and the urban share is projected to reach around 60% (nearly 5 billion people) by 2030, resulting in rising energy requirements to power growth and expand basic infrastructure.[31] Increasingly, cities are being recognised as an influential tier of decision making in the global clean energy transition that is now under way.[32]

With the largest share of world population, Asia also faces an enormous challenge in moving both people and goods. The region by far has the world's largest number and volume of public transport and metro systems globally, but pressure remains on long-term sustainable urban development.[33]

Energy Access

As in many developing regions worldwide, an ongoing challenge for governments in Asia and the Pacific is ensuring access to sustainable and modern forms of energy. In recent years, many governments in the 18 selected countries have made progress in improving energy access. Some countries – including Kazakhstan, Thailand and Viet Nam – achieved full electrification between 2014 and 2017, and many others are following close behind.[34]

However, an estimated 205 million people in the selected countries still lack access to electricity.[35] Around 94% of the population without electricity access is in just four countries: India (48%), Pakistan (28%), Bangladesh (10%) and Myanmar (8%).[36] Myanmar and Pakistan face the greatest challenges in terms of overall percentages, with electrification rates of only 70% and 71%, respectively; aside from these countries, only Bangladesh (88%) and Mongolia (86%) have electrification rates below 90%.[37] (→ See Distributed Renewables chapter for a discussion of efforts to improve electricity access.)

Expanding access to clean cooking also is a stated priority of governments in the Asia Pacific region, but this has proven harder to address than electrification. On average, less than 60% of the region's population had access to clean fuels and technologies for cooking in 2016, although this share falls as low as 19% in specific countries, such as Bangladesh and Myanmar.[38] (→ See Distributed Renewables chapter for examples of replacing traditional cooking techniques with clean technologies.)

Energy Security

Many countries in the region are experiencing strong economic growth, giving rise to potential security of supply issues if countries are unable to meet their energy needs using available resources and infrastructure. Ensuring secure energy supplies to meet rising energy demand is a primary concern among policy makers, given the importance of access to clean and reliable energy in maintaining competitiveness, supporting economic growth and improving the livelihoods of citizens.

As energy demand increases and as domestic resources diminish, energy self-sufficiency is expected to decline in the coming decades. In many countries, the rapid growth in energy demand has fuelled the expanded use of fossil fuels (especially coal and natural gas for electricity generation and oil for transport) as well as renewable energy (including large hydropower and geothermal for power generation). At the same time, rapid improvements in the cost effectiveness of both utility-scale and smaller, decentralised renewable energy systems have improved the economic utility of renewables as an option for addressing energy security in many countries, in terms of both cost and overall system resilience.

With recent changes in the cost profiles for renewable energy technologies, as well as new enabling technologies for load control and grid management, significant new opportunities exist to address security of supply issues through renewable sources.

Further system efficiency improvements and renewables penetration may be achieved by interconnecting national electricity systems, taking advantage of the resource diversity and rising deployment of renewable energy in some regions. In Central Asia and Southeast Asia, significant regional co-operation is under way to try to achieve this. Enabling supra-national power exchange and planning can reduce system-wide costs by tapping into the rich renewable energy resources of some countries, and can help manage shortages that may occur as a result of the rising penetration of variable renewables, the variations in hydropower production during dry seasons, and the interruptions and price fluctuations in coal and natural gas imports.

PLATFORMS FOR REGIONAL ENERGY CO-OPERATION

Because of the region's economic, climatic and geographic diversity, Pan-Asian co-operation on energy has proven challenging. Some exceptions exist: the United Nations Economic and Social Commission for Asia and the Pacific (UN ESCAP) promotes regional co-operation by providing a platform for dialogue and by hosting workshops and expert group meetings designed to delineate and address the principal barriers to energy connectivity from national, sub-regional and regional perspectives.[39] Additionally, the Asia-Pacific Economic Cooperation (APEC) Energy Working Group offers a platform for collaboration among APEC member states in East and Southeast Asia, supporting the growth of renewables and reductions in energy intensity across those economies.[40] APEC also has initiatives on promoting female participation in renewable energy in the region (→ see Sidebar 2).[41]

Aside from this, most energy co-operation in Asia and the Pacific has occurred at the sub-regional level, where a number of long-standing platforms have worked to share knowledge and to improve efficiency in an effort to speed the renewable energy transition.

Northeast Asia

Regional platforms for energy co-operation are not prevalent in Northeast Asia, given the large economies of this sub-region and their complex and intertwined socio-political histories. Notable engagements and involvements have occurred in other areas of shared interest, however. For example, the Trilateral Cooperation Secretariat, established in 2011, aims to promote peace and common prosperity among China, Japan and the Republic of Korea. The Secretariat convenes a number of collaborative programmes and research initiatives on economic, trade and environment issues, all of which intersect with issues of energy security and decarbonisation.[42] The Council on East Asian Community (CEAC) also has made sporadic attempts to promote energy co-operation in Northeast Asia.[43]

SIDEBAR 2. Women in Renewable Energy

Promoting women's participation in renewable energy development is critical, as greater gender diversity in the industry can result in substantial co-benefits. For example, the International Renewable Energy Agency (IRENA) suggests that women bring new perspectives to the workplace, while increasing the number of qualified females in an organisation's leadership. Further, promoting women's engagement as active agents for the deployment of off-grid renewable energy solutions increases sustainability and gender outcomes. Currently, the global share of women in full-time employment in the renewable energy workforce is 32%, and women's participation is considerably lower in STEM jobs than in administrative jobs. In the Asia Pacific Accreditation Cooperation's (APAC) energy sector, only 9% of senior management are women.

In the Asia Pacific region, several initiatives have been introduced to promote female participation in the renewable energy sector, including the APEC initiative on Empowering Women as Managers of the Renewable Energy Sector. The initiative has worked with women across the region in renewable energy careers, offering six months of online training, mentoring and a workshop. From this, 14 finalists (including participants from Indonesia, the Philippines, Thailand and Viet Nam) were selected to further their business plan development for a renewable energy project and to pitch their business ideas before an evaluation committee with senior experts and key stakeholders at the workshop.

In Indonesia, Kopernik's Wonder Women programme aims to economically empower women by encouraging them to use solar-powered lighting and environmentally friendly stoves as well as training them on how to sell these clean and efficient technologies through micro-social enterprises, helping to boost household incomes. Also in the region, the women-led Women Entrepreneurs Finance Initiative (We-fi) aims to promote female entrepreneurship by ensuring that more women-led businesses have access to finance, training and mentorship opportunities. The initiative provided USD 20.2 million for an Asian Development Bank (ADB) project in Viet Nam and the Pacific in 2019 and also funded a USD 12.6 million ADB project in Sri Lanka in 2018.

Women-led institutions and organisations are actively working in the Asia Pacific region. For example, Yisha He is a co-founder and the chairwoman of Women in Renewables Asia (WiRA), the first women's non-governmental organisation (NGO) in the region's renewable energy industry; she also is the chairwoman of Unisun Energy Group, a world-leading renewable energy provider in China. In India, the NGO Swayam Shikshan Prayog (SSP), based in Maharashtra, helps women in the villages of Marashtra and Bihar run successful businesses by selling solar appliances to rural households. SSP has developed a network of rural women entrepreneurs who are marketing renewable and solar energy products in their communities. These women have placed the issue of clean energy at the centre of community development by motivating and converting all households across six districts in Maharashtra and four districts in Bihar into clean energy users.

Women in energy in Asia and the Pacific play an active role that can be leveraged in the future to deliver a more balanced approach to managing the region's valuable resources.

Source: See endnote 41 for this chapter.

Central Asia

A number of energy co-operation platforms exist across Central Asia, emanating in part from European Union (EU) support for initiatives for the region. Key platforms are described as follows.

- The International Energy Charter is a declaration of political intention aimed at strengthening energy co-operation among the signatory states, which include EU member states and most of the countries in Central Asia. The Charter promotes mutually beneficial energy co-operation among countries for the sake of energy security and sustainability.[44]

- EU4Energy is a regionally focused programme concentrated on the 11 countries in the Caucasus, Eastern Europe and Central Asia. Implemented by the International Energy Agency (IEA) and the EU, along with the Energy Community and the Energy Charter, the programme is designed to support the goals of the focus countries to implement renewable energy and energy efficiency policies and foster co-operative energy sector development at the regional level.[45]

- The United Nations Economic Commission for Europe's (UNECE) Sustainable Energy Division promotes sub-programme works to encourage member states across Central Asia to create a regional sustainable energy development strategy. It supports sustained access to high-quality energy services; security of energy supplies; the introduction of renewable energy sources to reduce health and environmental impacts resulting from the production, transport and use of energy; regional co-operation to create well-balanced energy network systems; and sustained improvements in energy efficiency. In the context of post-EU enlargement, the Division supports integrating energy restructuring; legal, regulatory and energy pricing reforms; and the social dimension into energy policy making.[46]

- The Central Asia Regional Economic Cooperation (CAREC) programme is a partnership of 11 countries (Afghanistan, Azerbaijan, China, Georgia, Kazakhstan, the Kyrgyz Republic, Mongolia, Pakistan, Tajikistan, Turkmenistan and Uzbekistan), supported by six multilateral institutions, working together to promote development through co-operation, leading to accelerated economic growth and poverty reduction. CAREC emphasises regional energy co-operation through the integration of energy markets to overcome the impact of uneven distribution of energy resources, optimising existing energy interrelationships and developing least-cost solutions to energy constraints. As of September 2018, CAREC had invested around USD 7.1 billion in 47 projects, aimed mostly at expanding bilateral electricity trade and improving the regional power network to support growth in ongoing trade.[47]

Among the many other discussions and initiatives linking energy and electricity markets in Central Asia are the Energy Council of the former Commonwealth of Independent States (CIS) countries, the Eurasian Economic Union Cooperation Framework and the CASA-1000 transmission project between Afghanistan, the Kyrgyz Republic, Pakistan and Tajikistan.[48]

South Asia

The South Asian Association for Regional Cooperation (SAARC) Energy Centre was created in 2006 with an energy co-operation programme aimed at converting energy challenges into opportunities for development. The platform involves officials, experts, academia, environmentalists and NGOs to tap co-operation potential across areas including the development of hydropower, other renewables and alternative energy. The Energy Centre also promotes technology transfer, energy trade, energy conservation and efficiency improvements in the region, enabling stakeholders to come together to meet the energy challenges faced by SAARC member states.[49]

In 2000, the US Agency for International Development (USAID) launched the South Asia Regional Initiative for Energy Integration (SARI/EI) programme, covering the eight countries of Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka. The first three phases of the programme focused on cross-border energy trade, energy market formation and regional clean energy development, while the most recent phase focuses largely on advancing regional market integration.[50]

Southeast Asia

ASEAN has sought to foster energy collaboration among the 10 Southeast Asian economies[i] that form its membership. The ASEAN Centre for Energy was established in 1999 as an intergovernmental organisation to accelerate the integration of energy strategies within ASEAN by providing relevant information and expertise to ensure that the necessary energy policies and programmes are in harmony with the economic growth and environmental sustainability of the region.[51] An ASEAN Plan of Action for Energy Cooperation 2016-2025 was adopted in October 2015 and contains a range of initiatives for co-operation in achieving a transition to clean and affordable energy systems across the region.[52]

Many other bilateral and sub-regional groupings exist in Southeast Asia for energy co-operation, including subsets of ASEAN countries and island nations such as Indonesia and the Philippines that have similar needs related to grid connectivity and decentralisation of energy management. For example, the five countries that comprise the Greater Mekong Subregion – Cambodia, Lao People's Democratic Republic (PDR), Myanmar, Thailand and Viet Nam – have a significant collaboration on energy in partnership with southern China, much of which is based on co-operation and power trade from the hydroelectric potential available and used along the Mekong River.[53]

The Pacific

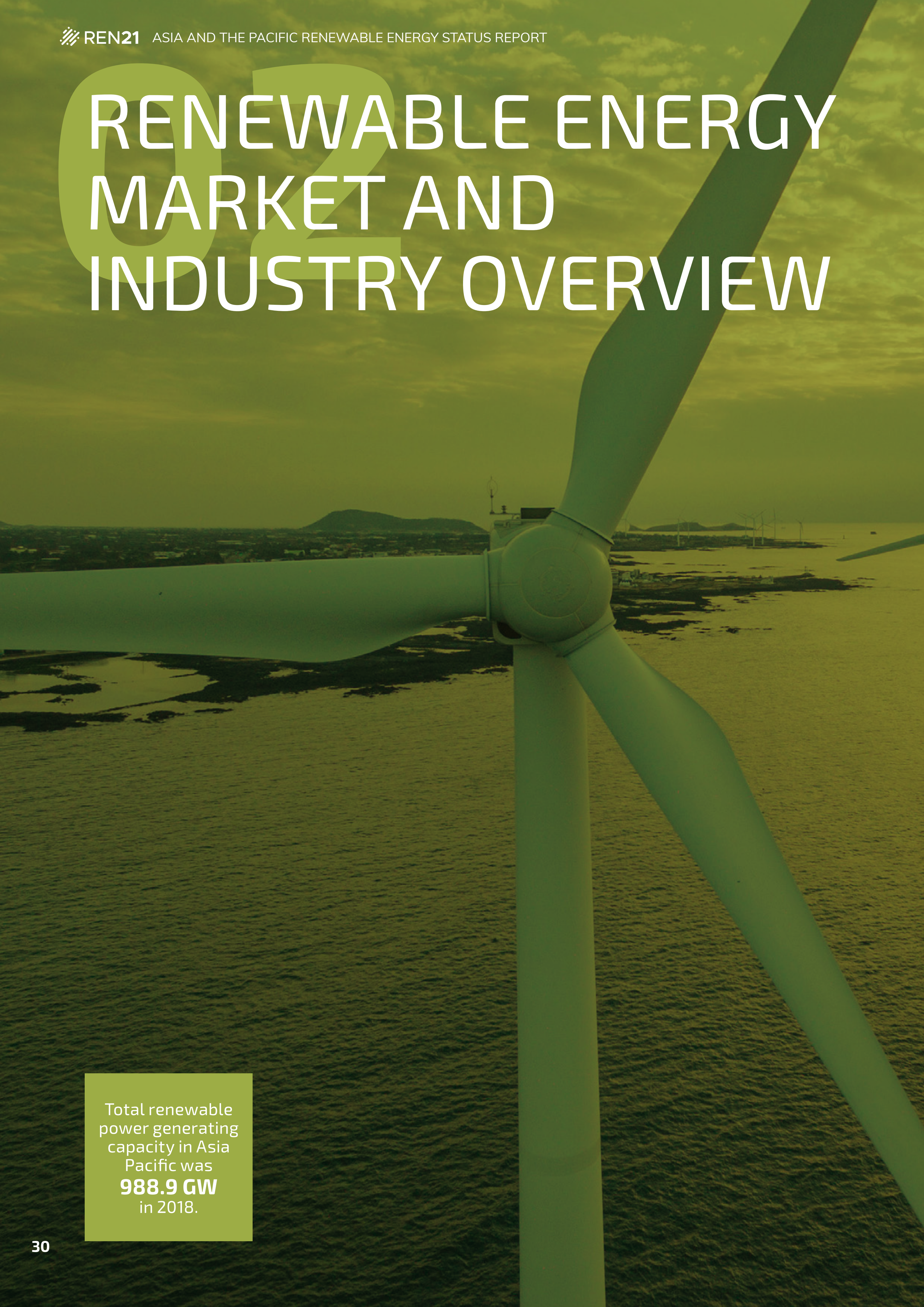
The Secretariat of the Pacific Community is the principal platform for cross-sectoral regional development co-operation in the Pacific and is a founding member of the Council of Regional Organisations of the Pacific, chaired by the Pacific Islands Forum Secretariat. The Secretariat's objectives are to strengthen engagement and collaboration, share technical and scientific knowledge and expertise, and enhance the capabilities of Pacific governments, systems and processes.[54] Its Geo-resources and Energy programme is committed to understanding and leveraging the use of energy resources in the Pacific to ensure sustainability and reduction of environmental impact.[55] The programme is committed to reducing the carbon impact of existing energy networks and usage, and focuses on governance, technical assessment and capacity development. In conjunction with the government of Tonga, the Secretariat also co-hosts the recently inaugurated Pacific Centre for Renewable Energy and Energy Efficiency (PCREEE).[56]

Among other initiatives in the sub-region, the Pacific Power Association is an inter-governmental agency that promotes the direct co-operation of Pacific island power utilities in technical training, exchange of information, sharing of senior management and engineering expertise, and other activities of benefit to the members.[57] In addition, the University of the South Pacific, a regional university owned by 12 member countries, is responsible for providing higher education and sustainability research for the Pacific region and has a number of activities that support renewable energy expansion.[58]

REGIONAL OVERVIEW

i ASEAN member economies include Brunei Darussalam, Cambodia, Indonesia, the Lao PDR, Malaysia, Myanmar, the Philippines, Singapore, Thailand and Viet Nam.

02 RENEWABLE ENERGY MARKET AND INDUSTRY OVERVIEW



Total renewable power generating capacity in Asia Pacific was **988.9 GW** in 2018.

02

02

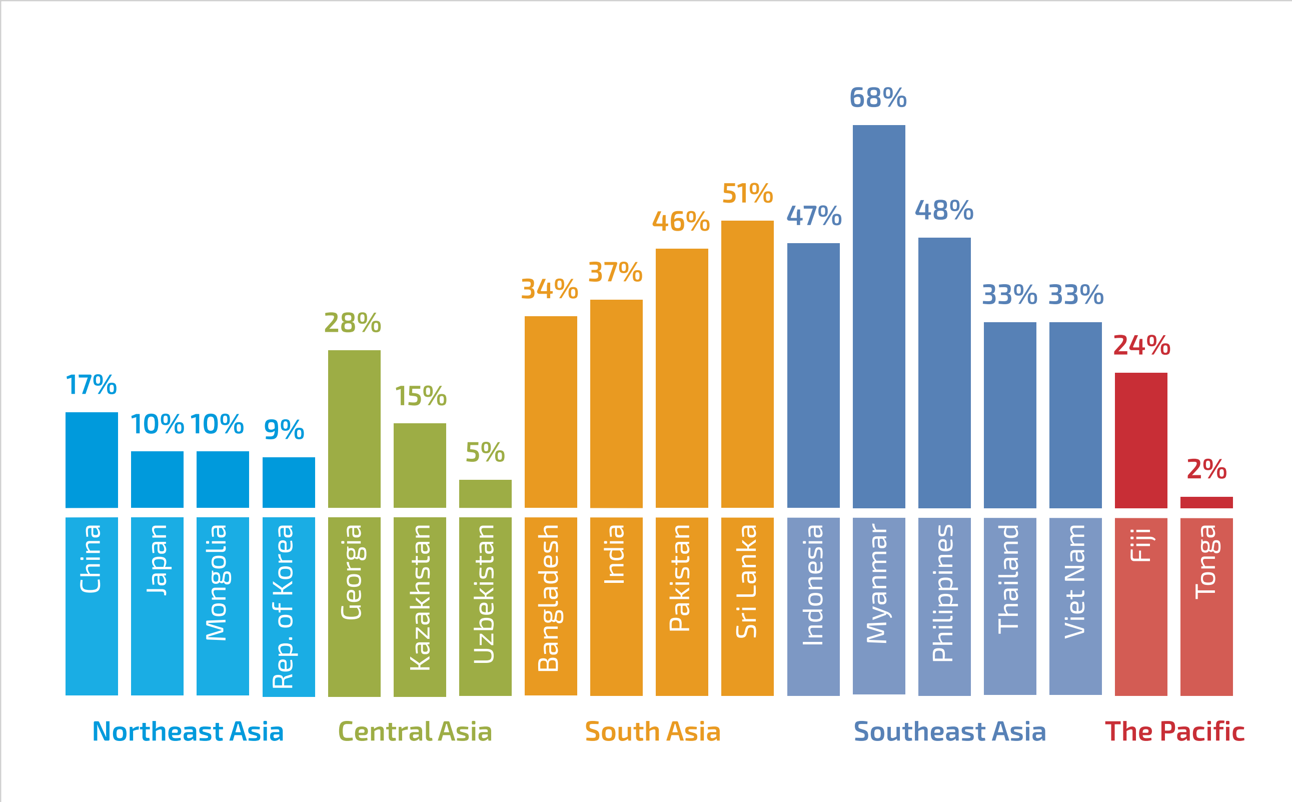
RENEWABLE ENERGY MARKET AND INDUSTRY OVERVIEW

The Asia Pacific region has demonstrated considerable progress in deploying renewable energy capacity in recent years and shows strong potential for future developments. Of the 18 selected countries, 5 had renewable shares in total final energy consumption (TFEC) exceeding 45% in 2016, driven mainly by hydropower and bioenergy.[1] However, the overall picture of renewables requires considering renewable energy deployment against the background of energy supply dynamics. TFEC continues to grow sharply in the region, and although the total installed capacity of renewables is increasing, this is occurring at a slower rate than for fossil fuels such as natural gas and coal. In addition, there is large untapped potential to use renewable energy in the heating, cooling and transport sectors.

FINAL ENERGY CONSUMPTION

The share of renewables in total final energy consumption varies widely across the selected countries, with the average share (including traditional biomass) reaching 28.8% of TFEC in 2016 (→ see Figure 3).[2] The countries with the highest shares of renewables in TFEC were Myanmar (68%), Sri Lanka (51.3%), the Philippines (47.5%), Indonesia (47%) and Pakistan (45.8%), whereas shares in Uzbekistan and Tonga were below 5%.[3] By sub-region, the highest shares of renewables in TFEC on average were in Southeast Asia (45.7%) and South Asia (42%), compared to much lower shares in Central Asia (16.2%), The Pacific (13.2%) and Northeast Asia (11.7%).

FIGURE 3. Renewable Share in Total Final Energy Consumption in the Selected Asia Pacific Countries, 2016



Note: Figure is calculated using IEA data on renewable energy and the related definitions; here, renewable energy includes traditional biomass.

Source: See endnote 2 for this chapter.

Hydropower (including large-scale hydropower) and bioenergy (biomass, biogas and liquid biofuels for heating, cooking and electricity) account for the largest share of renewable energy use in the selected countries. The contribution and uptake of modern renewables, such as solar PV and onshore wind power, are growing exponentially but remain small compared to fossil-based energy sources. In 2016, the industrial sector accounted for 46% of total TFEC in the 18 selected countries, but the renewable share of TFEC in industry was only 8.6%.[4] Overall, renewable energy deployment in the region remains low.

Although absolute TFEC rose sharply in the region between 1990 and 2016, the share of renewables decreased.[5] This occurred in part because the use of traditional biomass[i] – the most common renewable energy source at the beginning of the period – was gradually replaced by non-renewable energy sources such as coal, oil and natural gas.

RENEWABLE ENERGY CAPACITY

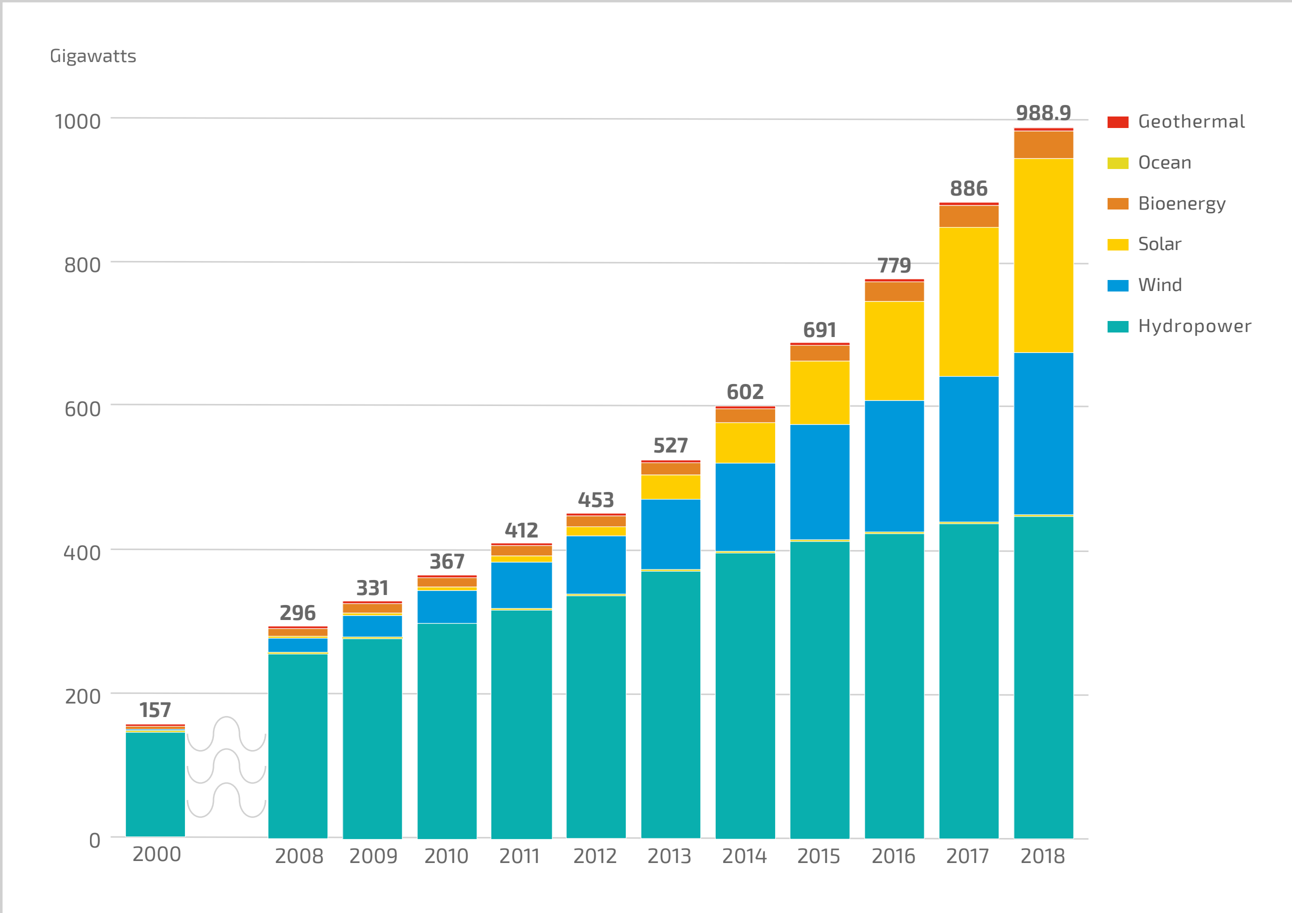
Power Generation

In recent decades, the renewable power generation capacity in the 18 selected countries has grown steadily, and the range of technologies has diversified (→ see Figure 4).[6] Most of the renewable power capacity in the region in 2018 – 92% – was concentrated in just three countries: China had the bulk of the capacity at 71%, followed by India (12%) and Japan (9%) (→ see Figure 5).[7]

In 2000, hydropower (primarily large-scale) accounted for 95% of the combined 157 GW of renewable power capacity in the region, with the rest dominated by geothermal, bioenergy and wind power.[8] By 2018, the renewable power capacity had grown six-fold, to 988.9 GW, due to accelerated deployment of wind and solar technologies.[9] Although hydropower still held the largest capacity share, at 46%, the shares of solar PV and wind power reached 28% and 23%, respectively.[10] Bioenergy was around 3%, and geothermal (mainly in China, Indonesia, Japan and the Philippines) accounted for 0.45%.[11] The Republic of Korea and China had small ocean power capacities of 255 MW and 4.3 MW, respectively.[12]

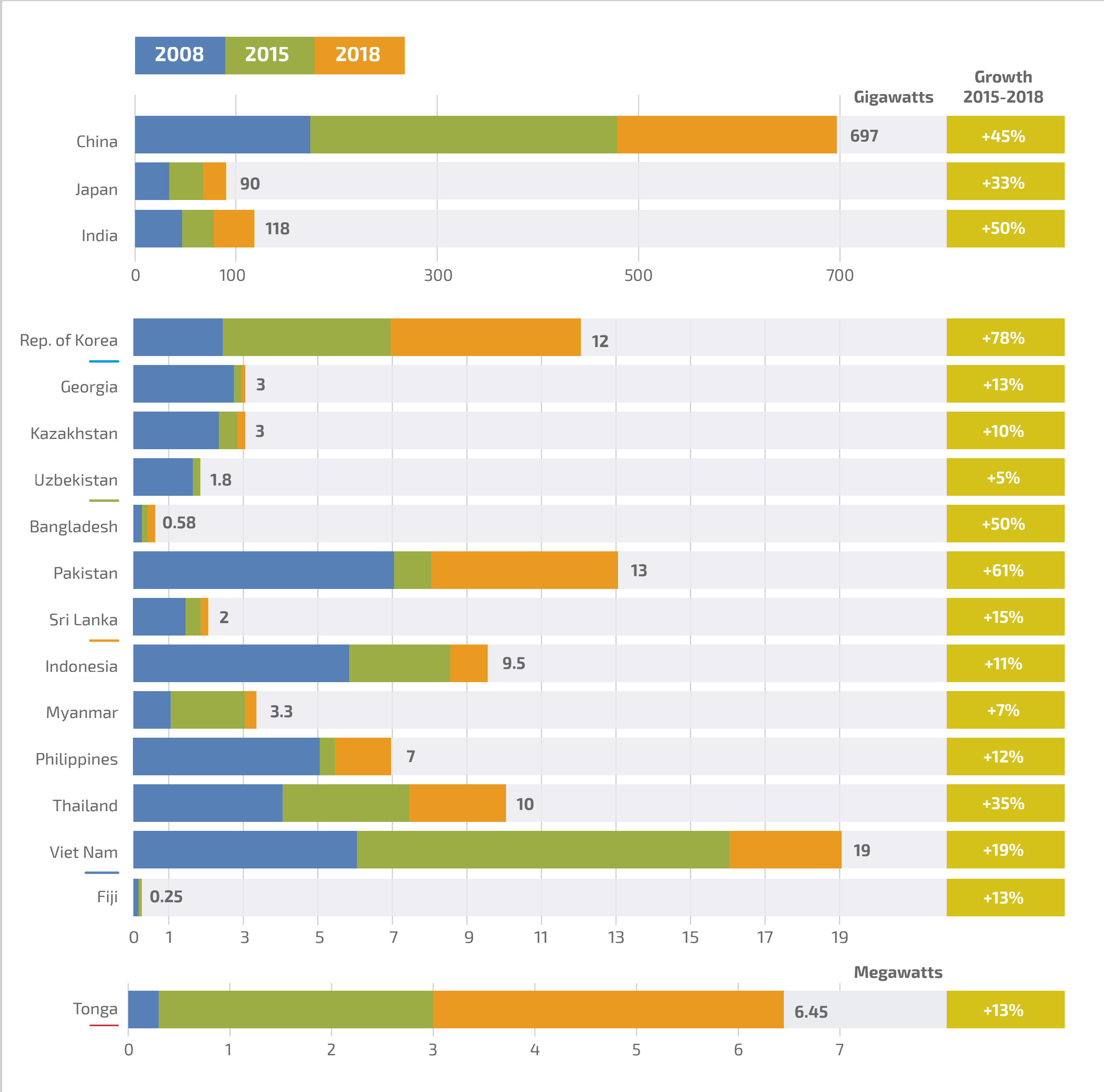
i In the push to improve access to clean fuels, efforts are being made to reduce the use of traditional biomass sources such as fuel wood, charcoal, agricultural and forest residues, and animal dung, which can have negative effects on local air quality and people's health, and the supply of which is often unsustainable.

FIGURE 4. Renewable Power Generation Capacity in the Selected Asia Pacific Countries, by Technology, 2000 and 2008-2018



Source: See endnote 6 for this chapter.

FIGURE 5. Renewable Power Generation Capacity in the Selected Asia Pacific Countries, 2008, 2015 and 2018



Source: See endnote 7 for this chapter.

Countries in **Northeast Asia** account for much of the renewable power capacity. Of the 300 GW of capacity additions in the Asia Pacific region between 2015 and 2018, the highest share (28%) occurred in China, due to strong progress on the country's 13th Five-Year Plan, which included targets for increasing domestic renewable capacity by 2020.[13] China's total power generation capacity (renewable and non-renewable) grew from 480 GW in 2015 to just under 700 GW in 2018 – an increase of 217 GW – driven largely by solar PV additions until the country shifted its PV policy in May 2018.[14]

Japan's renewable power capacity grew 22.5 GW during 2015-2018 to reach 90 GW, with solar PV accounting for nearly all of the additions.[15] This includes both utility and rooftop installations as the country diversifies its energy mix away from nuclear power. Renewable power capacity in the Republic of Korea nearly doubled during 2015-2018, from 6.8 GW to 12.2 GW.[16] Mongolia's capacity was stagnant for four years between 2013 and 2017, at 84.6 MW, before it jumped in 2017 and 2018 to reach 247.74 MW at year's end.[17]

In **Central Asia**, Kazakhstan's renewable power capacity exceeded 3 GW at the end of 2018.[18] Most of this (2.25 GW) was large-scale hydropower, and of the remaining 830 MW of capacity, 500 MW was small-scale hydropower projects.[19] The country's solar PV installed capacity reached 209 MW following completion of the 100 MW SES Saran plant and the 50 MW Burnoye plant in 2018.[20] Onshore wind power capacity totalled 121 MW after completion of the 9 MW Sarybulak plant.[21] Georgia added a total of 365 MW of renewable power capacity during 2015-2018, exceeding 3 GW at the end of 2018.[22] Uzbekistan did not add any capacity in 2018, ending the year at 1.85 GW.[23]

South Asia is also a stronghold of renewables deployment in the region. In India, the government's efforts to put in place supportive policy conditions in recent years were a major factor contributing to the 40 GW increase in the country's renewable power capacity between 2015 and 2018, to 117.8 GW.[24] Half of the additions were from solar PV, and 30% were from onshore wind power.[25]

Tonga's renewable power capacity nearly doubled to reach **6.45 MW** in the last 3 years.

In Bangladesh, the installed renewable power capacity at the end of 2018 was 579 MW, including both on-grid and off-grid installations.[26] Of this total, solar PV accounted for 59.5%, small-scale hydropower constituted 39.7%, and the remaining capacity was bioenergy, specifically biomass and biogas for electricity.[27]

Sri Lanka had more than 2 GW of renewable power capacity in 2018.[28] Large-scale hydropower accounted for 65% of this (1,350 MW), and small-scale hydro totalled some 400 MW.[29] The country also had 159 MW of solar PV capacity, 146 MW of wind capacity (with an additional 100 MW under construction at the Mannar Island wind park, slated for completion in 2020) and 42.5 MW of bioenergy capacity (29.5 MW of biomass, 13 MW of agricultural waste and 0.08 MW of biogas).[30] Pakistan ended 2018 with 13 GW, having added 3.7 GW that year – the most capacity added in the country compared to the period 2010-2017.[31]

In **Southeast Asia**, Viet Nam had 19.1 GW of renewable power capacity at the end of 2018.[32] Most of this (18.5 GW) was in large- and medium-scale hydropower facilities.[33] Of the remaining 570 MW of capacity, 240 MW (43%) was wind power, 227 MW (41%) was biomass-to-electricity and 106 MW was solar PV, as a newly inaugurated 100 MW cluster of solar plants came into operation.[34] Thailand added 2.6 GW of renewable power capacity between 2015 and 2018, reaching the 1 GW mark at the end of 2018.[35] The Philippines had 7.1 GW of capacity in 2018, having added negligible capacity (45 MW) that year.[36] Indonesia's capacity grew by nearly 1 GW and Myanmar's grew by 225 MW during 2015-2018, to reach 2018 totals of 9.5 GW and 3.3 GW, respectively.[37]

Countries in **The Pacific** also have seen growth in renewable generation. Fiji's renewable power capacity totalled 245 MW in 2018, more than half of which was hydropower.[38] The remainder includes 87 MW of bioenergy used for electricity, 9 MW of off-grid solar capacity and a 10 MW wind farm on Viti Levu island.[39] Tonga's renewable generation capacity nearly doubled from 3.3 MW in 2016 to 6.45 MW in 2018, but increased only minimally (up 45 kW) from 2017 to 2018.[40]

In addition to utility-scale power plants, distributed renewable energy generation is increasing in the region. Distributed renewables, combined with the deployment of smart meters and demand-response management technologies, can play a substantial role in ensuring reliable electricity supply, allowing autonomy from national grids as well as grid reinforcement when surplus electricity from distributed sources can be fed to the network.

Distributed renewables can be particularly valuable in the industry sector: in 2017, the manufacturing sectors and rapid industrial development in Asia and the Pacific overall attracted 39% of global foreign direct investment and created significant opportunities for economic growth, underscoring the need for reliable and competitively priced electricity supply.[41] The main target markets for decentralised energy technologies are countries in South Asia and Southeast Asia, while Northeast Asia has invested in manufacturing facilities and technology improvements to drive down costs and improve efficiency.

Heating and Cooling

Renewables can play an important role in the heating and cooling sector, including through direct use of biomass (modern and traditional), direct use of geothermal and solar thermal, and the use of electricity generated from renewable sources.[42] In most Asia Pacific countries with warm climates, air conditioning units are powered by electricity. The use of renewables for heating and cooling differs widely among the selected countries, ranging from advanced markets such as China to those with very limited renewables use in the sector, including island nations like Fiji.

The direct use of renewables for heating and cooling occurs mainly in China, where solar thermal and bioenergy are used to heat and cool buildings. As of 2015, more than 9% of the country's heat consumption in buildings came from renewables, and the solar thermal capacity installed on Chinese buildings increased more than 200% between 2008 and 2015.[43] Four other Asia Pacific countries – India, Japan, the Republic of Korea and Thailand – also use solar thermal for heating and cooling.[44]

In India, the bulk of the country's large renewable heating capacity is from bioenergy use in the industry sector.[45] Renewable heat is used in particular for industrial heat production in the sugar industry, with bagasse as the feedstock.[46]

Many Asian countries have vast geothermal resources, which have been applied in the heating and cooling sectors. The direct use of geothermal occurs mainly in China, India, Japan and the Republic of Korea, while Indonesia, Japan and the Philippines also use geothermal energy for power generation. The combined geothermal heating capacity in the selected countries was 22.4 GW_{th} in 2017.[47]

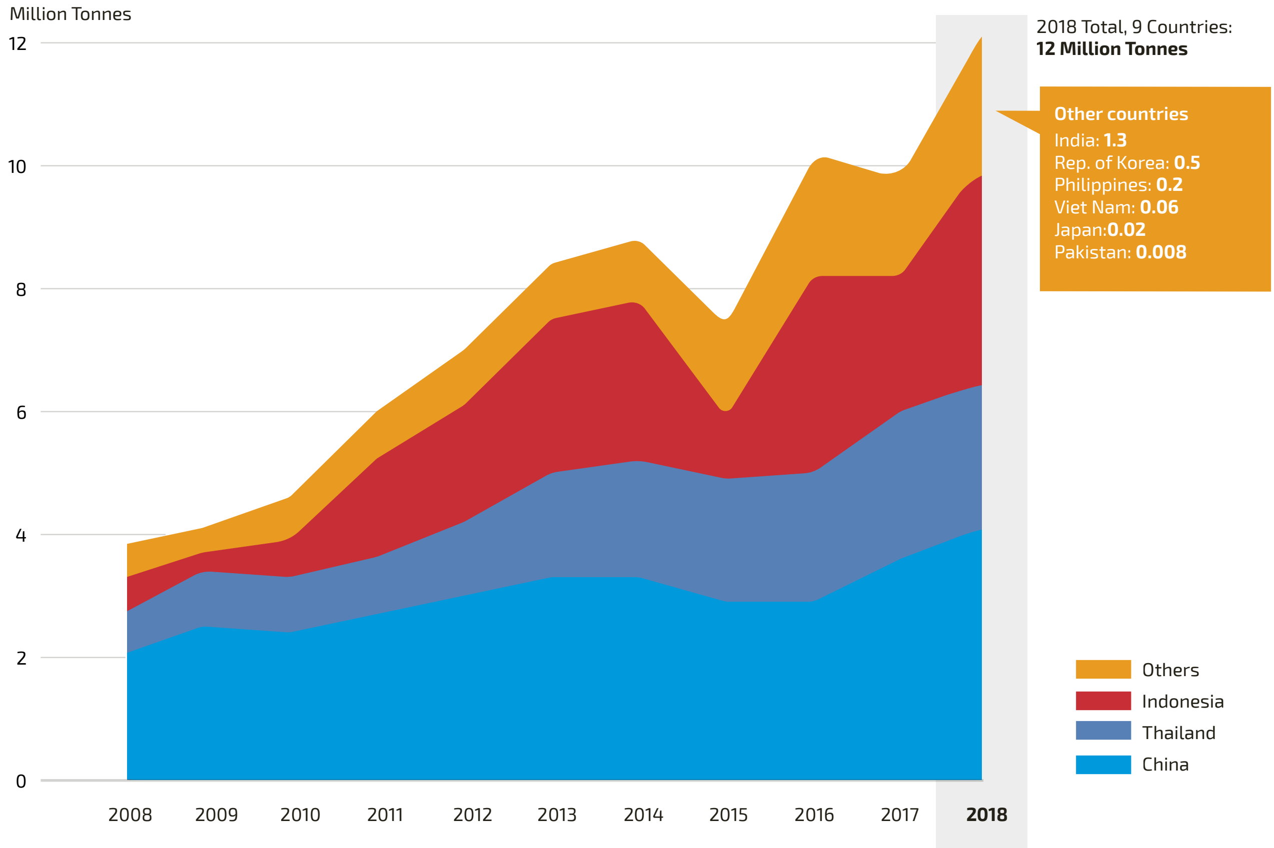
In China, the use of district heating systems is growing due to rapid urbanisation and the potential of district energy to provide cost-efficient heating services, especially to new urban development. China's district heating network, supplied from central locations, is the world's largest, but only around 1% of the heat supply is from renewable sources (biomass and geothermal).[48] Increasingly, China is turning to wind power from the wind-rich west to supply its district heating systems: the excess power generated by wind turbines is sold directly to the district heating utility through retrofitted heating networks.[49] Given that China faces curtailed renewable energy generation, leading to wasted production, conversion of electricity to district heating offers a scalable solution.

Transport

Biofuels for transport are produced in 9 of the 18 countries,with the largest contributions from China, Indonesia, Thailand, India, the Republic of Korea and the Philippines (→ *see Figure 6*).[50] The four leading producers in the region – China, Indonesia, Thailand and India – are also among the world's top biofuel-producing countries.[51] Production in the nine countries totalled 12 million tonnes in 2018, up 25% from the previous year.[52] Fuel ethanol accounts for around 45% of this production, and the remaining 55% is FAME biodiesel[i].[53]

i Fatty acid methyl ester (FAME) biodiesel is produced by the transesterification of vegetable oils. In principle, biodiesel is suitable for the operation of diesel engines.

FIGURE 6. Biofuels Production in the Selected Asia Pacific Countries, 2008-2018



Source: See endnote 50 for this chapter.

Electrification of road transport is gaining ground in the region. Although electromobility is not directly linked to the uptake of renewables, it represents a step away from fossil fuel consumption. The overall impact on emissions depends on how large the renewable share is in a country's electricity supply mix.

In the **Northeast Asia** sub-region, China is a world leader in the adoption of EVs, with an estimated 2.3 million EVs on the roads in 2018, or around 45% of the global fleet.[54] EV sales in China increased 80% in 2018 compared to the previous year, and sales volumes for the year totalled 1,161,000 plug-in passenger vehicles and 119,000 plug-in medium and heavy vehicles (→ see Sidebar 3).[55] In Japan, more than 52,000 EVs were sold in 2018, bringing the domestic fleet to 246,390 vehicles.[56] In the Republic of Korea, new EV sales reached 32,000, for a total of 57,400 EVs by the end of the year.[57]

SIDEBAR 3. China: An Electric Vehicle Market Leader for the Next Two Decades

China is a global leader in EV deployment. The country's EV fleet has expanded rapidly in recent years, and in 2018 around 2.3 million of the more than 5.1 million passenger EVs worldwide (around 45%) were in China. Another 5 million vehicles in the country were so-called low-speed EVs, which are smaller than passenger cars and have less stringent approval and registration requirements. Low-speed EVs, along with China's more than 300 million two- and three-wheelers, are popular in larger cities such as Beijing, Chengdu, Guangdong and Shanghai, where vehicle ownership is approaching saturation. In general, cars in China are used mostly for urban commuting, whereas planes and high-speed trains are used for longer-distance travel.

China also has the world's largest fleet of electric buses, and since 2009 the government has prioritised the electrification of public transport in an attempt to deal with rapid urbanisation and rising oil imports. Of the nearly 425,000 e-buses globally in 2018, an estimated 421,000 were in China. Almost one-fifth of the country's bus fleet was electrified by the end of 2018, and the plan is to electrify all buses in regional municipalities, provincial capitals and selected cities by 2020.

Charging infrastructure for EVs has evolved at a similar pace, with 777,000 publicly accessible chargers available in 2018. The IEA estimates that the electricity required to power EVs of all categories – two- and three-wheelers, passenger and light commercial vehicles as well as buses – in China totalled 47 terawatt-hours in 2018, around 80% of global EV power consumption. Although the renewable share of power generation is only around 12.5% in China, the IEA estimates that the country's EV fleet avoided around 30 megatonnes of carbon dioxide-equivalent emissions that year.

Development and innovation in China's EV industry has been influenced largely by government policies, including national mandates for zero-emission vehicles, fuel economy standards, manufacturer subsidies and other fiscal incentives. As a result, the industry has grown rapidly, with some 240 companies now building EVs, components or electric motors, and 190 battery companies listed in a catalogue of recommended models of new energy vehicles maintained by the Ministry of Industry and Information Technology. BYD, BAIC, SAIC, Geely, Roewe and Chery are some of the most popular automakers in China, while BYD, Yutong and CATL are popular battery manufacturers.

In an attempt to consolidate the auto industry, the Chinese government has instituted a variety of changes, including restricting investment in new manufacturing plants for internal combustion engine vehicles and a proposal to tighten fuel economy standards in 2025. The new incentive scheme for auto manufacturers – in the form of a credit system – sets a threshold for sales of new energy vehicles at 10% in 2019 and 12% in 2020. If this quota is missed, the manufacturer must purchase a credit from another manufacturer who is in a surplus. With changes to the sale subsidies for zero-emission vehicles in 2018, the range threshold for receiving subsidies increased to 250 kilometres in July 2019, and vehicles with longer range had their subsidies cut by 40-50%.

In addition, the incentives now favour fuel cell EVs rather than fully battery EVs. At the end of 2018, China was home to nearly 2,000 mostly commercial fuel cell vehicles (13% of the global fleet), including more than 400 buses and over 400 trucks. Fifteen refuelling stations were supplying hydrogen to these vehicles as of 2018.

Source: See endnote 55 for this chapter.

In **Central Asia**, Georgia is prioritising the promotion of low-emission transport and was home to more than 3,000 EVs and around 150 charging stations by the end of 2018.[58] The cities of Tbilisi and Batumi aim to use municipal electric buses starting in 2020, and an EV factory being built in the western city of Kutaisi is slated to begin vehicle production both for the local market and for export in 2020.[59] The Georgian government has ambitious plans to replace the country's entire vehicle fleet with electric cars in 10 years.[60] Kazakhstan is manufacturing both EVs and electric buses and was home to an estimated 200 electric cars in 2018.[61] In addition, 700 electric buses have been deployed in the country to date and the capital city plans to introduce its first fleet of 100 electric buses by the end of 2020.[62]

In **South Asia**, there is a big push to increase electric mobility across India, although the conversation on battery charging infrastructure is still in its infancy.[63] Installing charging infrastructure is part of Phase II of the government's Faster Adoption and Manufacturing of Electric Vehicles programme, targeted at electric mobility promotion.[64] Recent announcements from the state government of Punjab and power companies such as Magenta Power and Fortum include plans to build solar charging stations in the country, further linking EVs to renewable electricity.[65]

Bangladesh's Rural Electrification Board is building solar charging stations for battery-assisted EVs (Auto Rickshaw, Easy Bike), with an average capacity of 20 kilowatts-peak and funding from the Sustainable Energy Development Authority.[66] The country was preparing Electric Vehicle Registration and Operation Guidelines as of 2018.[67]

With increasing urbanisation and urban density, countries of **Southeast Asia** are increasingly supportive of EVs, recognising the large societal, economic and environmental benefits. Five major automobile-producing countries – Indonesia, the Philippines, Thailand and Viet Nam – account for more than 4 million vehicles (of all types) in production, and the region represents the largest global market for cars after China and India.[68] However, production of EVs at scale has not yet picked up.

Thailand, where the automobile industry contributes 10-11% of GDP, is considered one of Southeast Asia's more mature auto markets, but the EV share is only 2%.[69] Pilot initiatives have resulted in the installation of public charging stations, and the country provides electric buses for public transport as part of its nationwide plan for EV use.[70] Japanese automakers such as Honda and Toyota are looking to expand the EV market in Southeast Asia, starting with plans to build plug-in and hybrid offerings in Thailand.[71] Mazda, Mitsubishi and Nissan also plan to produce EV components and to assemble hybrid vehicles.[72] Meanwhile, Viet Nam's first car manufacturer, Vinfast, aims to produce 250,000 electric scooters a year and plans to release its own electric car in the coming years.[73]

In **The Pacific**, after the government of Fiji reduced and/or removed duties on hybrid vehicles, the number of alternative fuel vehicles in the country increased.[74]

RENEWABLE ENERGY TECHNOLOGIES

BIOENERGY

Bioenergy[i] – in the form of solid fuels (biomass), liquids (biofuels) or gases (biogas or biomethane) – can be used to produce electricity as well as to generate heat for cooking and for space and water heating in the residential sector, either in traditional stoves or in modern appliances such as pellet-fed central heating boilers. Liquid biofuels such as ethanol and biodiesel are used as transport fuels.

Bioenergy for Heating, Cooling and Cooking

Many countries in the Asia Pacific region use biomass, primarily traditional biomass, as a principal heating source. In India, household energy use accounts for 40% of the country's primary energy demand and is met mainly with traditional biomass sources, resulting in harmful levels of indoor air pollution.[75] Only 0.4% of rural Indian households use biogas as a cooking fuel, and nearly 5 million biogas digesters have been installed.[76] The National Biogas and Manure Management Programme provides subsidies for family biogas plants to encourage the uptake of biogas for cooking and lighting.[77]

In Sri Lanka, biomass is used for 72% of industrial heating, and in Indonesia biomass fuel (wood chips and briquettes) is used for heating, for domestic cooking and for some traditional large-scale food processing.[78] Viet Nam has around 126 MW of biomass capacity for heat production.[79] In the country's south, low-cost technology based on flexible balloon digesters has supported successful biogas uptake; the digesters have a lower upfront cost than fixed-dome plants and are well suited to the pig manure that dominates the rural feedstock supply.[80]

i Obtaining accurate data on the bioenergy sector, especially on biomass for traditional use, is difficult because a sizeable amount of bioenergy is used informally and not reported.

In China, the use of biomass for heating is seen as a way to reduce local pollution by replacing coal in heating applications and to provide heat in the country's colder northern regions during periods of natural gas shortage. China is a global leader in the direct use of biogas for heat, accounting for 90% of biogas installations worldwide; by the end of 2016, the country had installed an estimated 42.6 million units.[81]

The use of biogas for cooking has continued to increase in South Asian countries, such as Bangladesh, as well as in Southeast Asian countries like Indonesia. In Bangladesh, Infrastructure Development Company Limited (IDCOL) runs a biogas programme that supports the construction of biogas plants to provide cooking gas as well as organic fertiliser for crops and fish ponds, and IDCOL has financed the construction of more than 48,500 brick cement-based plants and fibreglass biodigester-based plants.[82]

Traditional biomass is the main energy source for cooking in Myanmar, particularly in rural areas. The country's 2014 census, the first conducted in decades, showed that 86.2% of rural households relied on fuelwood for cooking food, in addition to feedstocks such as sugarcane bagasse, palm leaves, cotton and sesame stalk, rice husk, sawdust and bamboo.[83] Although biomass use in Myanmar has likely declined due to increased electrification and a switch to kerosene and LPG, it is still a major fuel source for local people.

In Georgia, where no central heating/cooling infrastructure is in place, people burn fuelwood for heating, and only a small percentage of the population has switched to using biomass briquettes or pallets.[84] In The Pacific, more than 80% of Fijian households used LPG, kerosene and open fires (fuelwood) for cooking in 2017; electric cookstoves accounted for 15%, while penetration of biogas for cooking was minimal.[85]

Bio-power

Significant bio-power capacity additions have occurred in the Asia Pacific region, with 11.3 GW added in the 18 selected countries between 2015 and 2018 for a total capacity of 33.4 GW by the end of 2018.[86] Solid biomass – such as fuelwood, agricultural and forestry residues, and animal dung – accounts for 31.6 GW of this capacity, or 95% of the total.[87] The largest use of solid biomass for electricity generation occurs in China, which added 5 GW of capacity during 2015-2018 for a total of 12.6 GW, and in India, which added 4.5 GW for a total of 10.1 GW.[88]

10 of the 18 countries generate electricity from biogas.

During the three-year period, Chinese solid biomass capacity rose by around 1.7 GW annually on average, while India added the bulk (3.4 GW) of its capacity in 2015, with subsequent years increasing by 0.5 GW and 0.6 GW, respectively.[89] Further additions of 0.6 GW came from the Republic of Korea in 2016 and 2018, and Thailand and Japan added 340 MW and 220 MW, respectively, in 2017.[90] By the end of 2018, Thailand had 3.3 GW of solid biomass capacity, Japan had 2.1 GW, and Indonesia had 1.8 GW.[91]

In Myanmar, companies are experimenting with generating electricity from rice husk, with the local firm MAPCO opening a 0.5 MW, USD 4.7 million facility with a foreign partner in May 2018.[92] In Fiji, 87 MW of biomass capacity is used for electricity.[93] The 12 MW Nabou Biomass Plant, commissioned in July 2017, has faced operational challenges due to a lack of feedstock and has been closed since December 2018.[94] The government plans to add 70 MW of biopower capacity by building a 24 MW wood pellet plant and four more biomass power plants with a combined capacity of 46 MW.[95]

In addition, 10 of the 18 Asia Pacific countries generate electricity from biogas, and their combined biogas generation capacity increased from 900 MW in 2015 to 1,384 MW in 2018.[96] China added 176 MW of biogas capacity in 2018, for a total of 630 MW, and had the largest capacity share at 45.5%.[97] Thailand had the second largest share, at 36.1%, and the country's biogas capacity reached 500 MW in 2018, with progressive growth since 2003 and accelerated growth between 2015 and 2018.[98]

The Republic of Korea's biogas capacity has increased gradually since 2001, adding 7 MW in 2018 for a 10% share of the regional total.[99] The country also uses liquid biofuels for power generation and had 360 MW of capacity at the end of 2018 (largely unchanged since 2014 when it started operations).[100]

Bio-power capacity in Bangladesh includes 0.4 MW of biomass and 0.68 MW of biogas.[101] As of mid-2019, IDCOL had financed nine biogas-based power plants in the country.[102]

Liquid Biofuels

Biofuel production in the selected Asia Pacific countries increased in 2018 to around 5.8 million tonnes of ethanol and 6.4 million tonnes of biodiesel.[103] China and India produce a substantial amount of biofuels, primarily ethanol, and Indonesia has been a significant biodiesel producer. In 2018, China's ethanol production increased 24% to 3.2 million tonnes, and Indonesia's biodiesel production rose to 3.6 million tonnes.[104] The Philippines (biodiesel) and Thailand and Viet Nam (ethanol) also have increased their biofuel production, although the scale remains modest. Several countries have established mandates or targets for biofuel use in recent years (→ see Policy Landscape chapter).

In Thailand, liquid biofuels accounted for almost 17% of total transport fuels in 2016.[105] Thailand is aiming for 4.1 billion litres of ethanol consumption by 2036 (up from 1.18 billion litres in 2015), and 5.1 billion litres of biodiesel consumption by 2036.[106]

In Fiji, the main feedstocks for biofuel production are coconut oil, pongamia, jatropha, palm oil and molasses.[107] The government has established nine renewable diesel plants on the islands of Koro, Cicia, Rotuma, Gau, Lakeba, Vanuabalavu and Rabi, with a total capacity of 2 million litres per year.[108] Fiji's Sugar Corporation plans to build an ethanol plant at its Rarawai Mill sugarcane facility with a potential for 20 million litres of capacity.[109]

The use of biofuels to meet growing energy demand in the Asia Pacific region and elsewhere has been criticised because of concerns about the wider impacts of feedstock production. Most current biofuel production is based on first-generation biomass derived from feedstocks such as maize and wheat, which can cause increases in the price of grain and put pressure on land and resources, leaving less available for food and crops.[110] Indonesia's state oil company, Pertamina, plans to test-start the processing of crude palm oil to produce green diesel, aiming for an 80% blend and eventually 100% bio-based fuel.[111] However, the clearing of tropical forests for palm oil plantations is the biggest driver behind deforestation in Indonesia.[112]

HYDROPOWER

Hydropower capacity in the selected Asia Pacific countries totalled 451.5 GW at the end of 2018 (excluding 61.6 GW of pumped storage).[113] China accounted for 70% of this capacity, with 323 GW, while India had 10% (45 GW) and Japan had 6% (28 GW).[114] Between 2015 and 2018, hydropower capacity in the region increased by 35.3 GW.[115]

In **Northeast Asia**, China added 26.4 GW during 2015-2018, and additions of 10.2 GW in 2018 brought the country's total hydropower capacity above 351 GW, including 28.5 GW of pumped storage.[116] Pumped storage is important for countries to provide flexibility to the power system. Newly commissioned pumped storage plants in China in 2018 included the 1.2 GW Shenzhen station and the 600 MW Qiongzhong station, and construction began on the 1,200 MW Fu Kang, 1,800 MW Jurong and 1,200 MW Yongtai plants.[117] Numerous conventional hydropower projects also entered into operation in 2018 – including the 1,900 MW Huangdeng, 348 MW Sha Ping II, 920 MW Dahuaqiao and 420 MW Li Di stations – and progress was made at China Three Gorges Corporation's 16 GW Baihetan project.[118]

Hydropower capacity in Japan totalled 28.2 GW in 2018 (plus an additonal 21.9 GW of pumped storage) and has not changed significantly since 2016.[119] This includes 3.3 GW of small and medium-sized hydropower, which has increased

by 360 MW since 2012.[120] The Republic of Korea installed 1 MW of new capacity in 2018, to reach around 6.5 GW at year's end.[121] Mongolia had 23 MW of total installed capacity in 2018.[122]

In **Central Asia**, Kazakhstan had 2,750 MW of hydropower capacity as of 2018, most of it in the form of large-scale hydropower (2,250 MW) but also including around 500 MW of small-scale hydro plants.[123] The country completed the 28.5 MW Korinskaya Hydropower Plant in 2018.[124] Uzbekistan had 1.7 GW of total installed capacity in 2018, with no reported pumped storage.[125]

Hydropower capacity in Georgia increased to 3.2 GW in 2018, with 340 MW of this coming online since 2016.[126] The additions were mostly from small-scale projects but also from the 27 MW Kirnati and 21 MW Old Energy hydropower stations.[127] Modernisation is under way at the ageing 1,300 MW Enguri dam.[128] The Georgian Energy Development Fund, set up by the government to facilitate investment in renewables and to identify potential hydropower sites, is developing several projects jointly funded with private investors.[129] Project development has been driven not only by domestic demand, but also by the prospect of electricity exports to Turkey.[130]

In **South Asia,** India's hydropower capacity increased by 3 GW during 2015-2018.[131] More than 1.9 GW of this was added in 2017, including from the commissioning of the 1.2 GW project on the Teesta River.[132] A further 0.5 GW of hydropower capacity was installed in 2018, bringing India's total hydropower capacity to 45.3 GW (not including the 4.8 GW of pumped storage, which remained unchanged).[133] Hydropower in India receved a boost after the government included large-scale hydropower projects in its Renewable Purchase Obligations scheme.[134]

Pakistan's hydropower capacity was 9.9 GW at the end of 2018.[135] The country increased its capacity by 2.7 GW during 2015-2018, with the completion of smaller projects such as the 147 MW Patrind Plant in 2017 and the entry into operation of three larger projects in 2018 with a combined capacity of 2.5 GW.[136] The development of another 800 MW through the Mohamand Dam was foreseen in 2019.[137] Sri Lanka added 66 MW of hydropower capacity in 2018.[138]

Southeast Asia has seen strong growth in hydropower. Viet Nam's installed hydropower capacity increased 2.1 GW during 2015-2018 to reach 18.6 GW.[139] Half of the additions came online in 2016, and a further 0.7 GW was completed in 2017 – including the World Bank-funded 260 MW Trung Son Plant – followed by 0.2 GW in 2018.[140] Viet Nam has a large number of hydropower projects under construction, including 143 large to mid-sized projects with a total installed capacity of 1.8 GW, and 290 small-scale hydropower projects with a total installed capacity of 2.8 GW.[141]

Thailand added 28.5 MW of hydropower capacity in 2018.[142] Indonesia added 61 MW of capacity (including pumped storage) in 2018 and produces in total around 5.45 GW of power from hydropower plants including mini- and micro-hydro plants.[143] Myanmar and the Philippines had 3.3 GW and 4.3 GW, respectively, of installed hydropower capacity at the end of 2018.[144]

Solar power generation capacity in the region **tripled** from 2015 to 2018.

In **The Pacific**, Fiji had 125 MW of hydropower installed capacity (including pumped storage) as of 2019, and Hydro Fiji Ltd. has a 30 MW hydropower plant in the pipeline.[145] Half of the country's power is supplied by the 83 MW Monasavu Hydro Scheme, which was commissioned in 1983 and is still operational today.[146] Tonga is reported to have no hydropower capacity to date.[147]

SOLAR ENERGY

Solar technology has become very popular in the selected Asia Pacific countries and is used as a power source for homes, irrigation systems and lighting as well as for heating and cooling. In the power sector, countries are installing utility-scale solar PV systems connected to the grid as well as smaller, distributed systems such as rooftop solar that can feed energy into the grid when needed. A variety of off-grid solar systems also are being installed to extend energy access to unelectrified populations (→ *see Distributed Renewables chapter*).

Solar Power

Solar power generation capacity in the 18 countries more than tripled during the three-year period 2015-2018, increasing from 88.3 GW to 271.7 GW.[148] Almost all of this capacity was solar PV (271.5 GW), although concentrating solar power (CSP) installations accounted for 248 MW.[149] In 2018 alone, the 18 countries added a combined 64.2 GW of solar PV capacity.[150]

Solar PV capacity in **Northeast Asia** is growing rapidly. China installed some 132 GW during 2015-2018, increasing its capacity from 43 GW to 175 GW.[151] The country had the largest solar PV addition in the region in 2018, at 44.4 GW.[152] Japan added 21 GW during the three-year period and had the third largest addition in 2018 (6.5 GW).[153] The Republic of Korea added 2.8 GW of capacity in 2018, driven by a government support that aims to reach 10 GW of solar PV capacity by 2020.[154] Mongolia's installed solar PV capacity grew rapidly during 2018-2019, bringing total installed capacity to around 63 MW.[155] At least four new plants were brought online, including a 16.4 MW project financed by ADB and the Leading Asia's Private Sector Infrastructure Fund.[156]

In **Central Asia**, Kazakhstan's solar PV installed capacity rose to 209 MW in 2018 after adding 150 MW from the newly completed 100 MW SES Saran plant and the 50 MW Burnoe plant.[157] Georgia's first solar farm, Udabno, with a planned capacity of 5 MW, is in the construction stage, but off-grid solar PV is already in use in the country.[158] Small solar rooftop systems have been installed in Georgia with development assistance from the EU and the Japan International

Cooperation Agency (JICA), and a 2016 Net Metering Regulation encourages small-scale renewable energy systems (wind, solar, biomass and hydropower) with a capacity of up to 100 kW.[159] The country's largest rooftop installation so far, a 316 kW system at Tbilisi airport, generates 40% of the airport's consumption.[160] In general, however, the growth of renewables in Central Asia is slow, as countries rely on their large fossil fuel reserves.

In **South Asia**, India added 21 GW of utility-scale solar PV during 2015-2018 and had the region's second largest capacity addition in 2018, at 9.2 GW.[161] The country is focused on installing solar rooftop systems to achieve its ambitious solar PV targets. Rooftop solar was India's fastest growing renewable energy market in the 2018-19 fiscal year, adding a record 1.8 GW for a total capacity of more than 4 MW across the commercial, industrial and public sectors and residential projects, or 14% of the cumulative solar installation in India.[162] Commercial and industrial customers have driven the growth – increasing 116% between 2012 and 2018 – incentivised by the decline in the levelised cost of electricity for rooftop solar and by favourable policies and corporate social responsibility programmes.[163]

Bangladesh has an estimated 1.14 GW of solar PV potential, and as of mid-2019 the country had some 345 MW of installed capacity and a further 557 MW under construction.[164] Only 15% of the existing capacity – around 51 MW – is connected to the grid.[165] Net metering regulations support 20 MW of this on-grid capacity, in the form of rooftop solar, and the government plans to install rooftop systems on all educational institutions to feed additional solar power to the grid.[166]

The rest of Bangladesh's solar PV capacity is off-grid, with an estimated 233 MW of this in the form of solar home systems (5.5 million units).[167] Between 2003 and January 2019, IDCOL's solar home systems programme installed 4.13 million systems, resulting in more than 200 MW of off-grid rooftop solar capacity and supplying energy to 18 million people or 12% of the population.[168] By 2021, the number of solar home systems is projected to reach 6 million, with an estimated installed capacity of 220 MW.[169]

Solar PV also is used to pump irrigation water in rural areas of Bangladesh (a total of 28.27 MW or 1,337 units).[170] These mostly off-grid solar pumps bring irrigation to areas with difficult access to electricity and replace diesel pumps, lowering the costs of farming and helping to reduce poverty and increase quality of life.[171] Further uses of solar PV in Bangladesh are for drinking water systems (1.55 MW or 152 units) and to power an estimated 1,933 telecom towers (8.1 MW) and more than 100,000 street lamps.[172]

Pakistan added 0.8 GW of solar PV capacity in 2018.[173] Sri Lanka had over 100 MW of installed capacity in 2017, motivated in part by the accelerated solar rooftop programme, started in 2016.[174]

In **Southeast Asia**, solar PV capacity in the Philippines grew from 165 MW in 2015 to 896 MW in 2018.[175] With a significant pipeline of projects approved or under development, the use of solar PV in the country is expected to grow significantly, and an estimated 3 GW of installed capacity is projected by 2022.[176] Viet Nam added 100 MW of solar PV in 2018.[177] Indonesia's installed solar PV capacity was around 80 MW at the end of 2018, lagging behind other Southeast Asian countries.[178]

With support from a public company, Myanmar added 30 MW of solar PV capacity in Minbu Township, Magway, in 2018, for a total of 55 MW.[179] There are plans to build two 150 MW solar PV plants near Mandalay.[180] An increase in the grid electricity tariff has made distributed generation more financially attractive in Myanmar, particularly for commercial and industrial customers, but so far only around 2 MW of rooftop solar projects, ranging between 60 kilowatts (kW) and 500 kW, has been installed in the country, by a local company with an 80% market share.[181] This is only a fraction of the rooftop solar capacity in other countries in the subregion, such as Thailand (2.6 GW) and Viet Nam (4.5 GW).[182]

The Pacific countries have smaller levels of solar PV capacity, with Fiji adding 9.5 MW and Tonga adding 6.2 MW in 2018.[183] Fiji is home to 9 MW of off-grid solar PV, most of it solar home systems installed under a Department of Energy programme starting in 2000.[184] In Tonga, ADB is financing the installation of a new solar mini-grid on the country's most remote island, Niuatoputapu, as part of a project to build nine solar PV plants with a combined capacity of 1.25 MW in remote island areas.[185] Some of the plants will feature storage systems to power households and public and medical facilities.[186]

CSP capacity in the selected Asia Pacific countries has remained unchanged since 2014, when India's capacity rose to 229 MW following the entry into operation of the 125 MW Dhursar linear Fresnel plant and the 50 MW Megha parabolic trough plant.[187] Five more CSP plants with nearly 300 MW of combined capacity are under construction in the country.[188] China had 14 MW of CSP capacity in 2018, and the country's first utlity-scale CSP plant – the 50 MW Delinha plant built with financing from ADB – became operational in early 2019, bringing the total to 64 MW.[189] Thailand's 5 MW parabolic trough CSP plant has been operational since 2012.[190]

Asia also is a global leader in floating solar PV (FPV) projects, and China, Japan and the Republic of Korea are the top three countries globally for FPV capacity additions.[191] Indonesia's IPP, a subsidiary company of the national utility PLN, is developing a large FPV system, the 200 MW peak Cirata project, and in Sri Lanka a 100 MW FPV project is planned to be installed in the Maduru Oya Reservoir.[192] Bangladesh serves as a testing ground for FPV innovations: in November 2018, ADB approved USD 2.34 million in technical assistance to develop a 50 MW FPV power plant on Kaptai Lake, and a demonstration project funded by the Global Environment Facility (GEF) is testing a fleet of solar boats in the country to replace fossil fuel use in vessels.[193]

Solar Thermal Heating and Cooling

Solar thermal heating and cooling capacity in the 18 selected countries was 362.2 GW_{th} at the end of 2017.[194] Around 97% of this capacity was in China, with the rest mainly in India, Japan, the Republic of Korea and Thailand.[195] In 2017, 11.8 GW_{th} of capacity was added in the region, although installations decreased from the previous year; most of the newly installed collecters were evacuated tube collectors.[196]

China has the world's largest solar thermal market, with 334.5 GW_{th} of capacity at the end of 2017, or 74.4% of the global total.[197] The country has made numerous high-profile commitments to replace coal as a primary source for heating, including instituting a coal ban in 28 cities, promoting the enhanced role of renewables and establishing several renewable heating-related targets in the 13th Five-Year Plan.[198] China also is home to one of the world's two largest solar district heating plants, a 52.5 megawatt-thermal (MW_{th}) parabolic trough collector system that started operation in 2016 and heats 500,000 square metres (m^2) of living and commercial space in the town of Baotou.[199] In addition, the world's largest new solar thermal heating system for industrial heating was completed in China in 2017.[200]

India has the second largest installed solar thermal capacity, and additions in 2017 were up 26% from the previous year for a total installed capacity of 8.0 GW_{th} (11.43 million m^2).[201] In 2017, the country installed 36 new industrial solar process heat systems with a total collector area of 15,313 m^2.[202] The solar thermal capacities of Japan and the Republic of Korea grew only marginally in 2017, to 2.9 GW_{th} and 1.3 GW_{th}, respectively, while Thailand's remained unchanged at 0.1 GW_{th}.[203]

Elsewhere in the Asia Pacific region, solar thermal water heaters were introduced in Bangladesh in 2017.[204] Sri Lanka has no district cooling or heating facilities, but solar thermal projects under construction amount to 20 MW of capacity by 2020.[205] Indonesia uses some solar water heating systems in homes, Myanmar uses some solar thermal for industrial heat, and some homes in Fiji use solar water heating systems, but no clear data are available.[206]

Solar thermal air conditioning and cooling remained a niche market in 2017. The Asia Pacific region was the largest market for thermally driven chillers, and solar thermal cooling installations were commissioned in China and India.[207] India's first solar thermal air conditioning system (1,575 m^2) in a public building was completed in 2017, and China has set ambitious targets for solar cooling with solar thermal energy to cover 2% of the cooling load in buildings by 2020.[208]

WIND POWER

Wind power has strong potential in the Asia Pacific region, as confirmed by a variety of new project developments. Almost all of the wind energy potential (98%) is from onshore wind.[209] In the 18 selected countries, the combined capacity of onshore and offshore wind power totalled 228.1 GW in 2018, up 66.4 GW from 161.7 GW in 2015.[210] During the three-year period, the countries added 62.5 GW of onshore wind capacity, increasing by around 20 GW annually for a total of 223.5 GW by the end of 2018.[211] Offshore wind capacity was 4.8 GW in 2018, with most of this in China, followed by Viet Nam, Japan and the Republic of Korea.[212]

Offshore wind development in the region has been slow in comparison to European countries due to technological challenges, particularly in Japan where deep-water coastal areas and geographic and climatic risks (i.e., earthquakes, extreme weather and river delta seabed sediments) have limited the available areas for installing fixed turbines.[213] Cost concerns, legal uncertainties and grid availability also impede developments in the region.[214] Floating wind technology offers the potential to expand the areas where offshore wind power is viable and economically attractive, and could alleviate some of the logistical and environmental difficulties associated with fixed foundations. However, floating technology has yet to be fully proven, and several technical challenges need to be resolved.

In **Northeast Asia**, China had 184.7 GW of installed wind power capacity at the end of 2018, of which 180.1 GW was onshore and 4.6 GW was offshore.[215] The country dominates onshore wind power installations in the Asia Pacific region, accounting for 79% of the additions in the 18 countries over the 2015-2018 period.[216] For offshore wind, China added 4 GW of capacity during this period, including 1.8 GW in 2018 alone.[217] The country has a target to install 10 GW of offshore wind by 2020.[218] The 300 MW Huaneng Rudong offshore wind project, China's largest, became operational in 2017.[219] The following year, construction began on the 400 MW Yangjiang offshore wind farm off the coast of Guangdong province, with completion expected in 2020.[220] Jiangsu province has approved 24 offshore wind projects with a total capacity of 6.7 GW, which were expected to come online before 2021.[221]

Japan had 3.65 GW of wind power capacity in 2018, with 65 MW installed offshore; the country has gradually increased its offshore wind capacity since 2005.[222] The Republic of Korea had 1.27 GW of onshore wind power capacity and 45.5 MW of offshore capacity in 2018, following construction of its offshore wind farm in 2016.[223]

Japan and the Republic of Korea also are home to 3 of the 13 initial floating offshore wind projects announced globally.[224] The Japan Wind Power Association has ambitious plans to increase the country's wind power capacity to 36 GW by 2030, with 4 GW from floating offshore wind.[225] The Fukushima floating offshore wind farm demonstration project, commissioned in 2015, included three floating offshore turbines with capacities of 2 MW, 5 MW and 7 MW.[226] In addition, the 3 MW Hibiki offshore wind turbine, being built off the coast of Kitakyushu, has the objective of validating the floating technology with a view towards equipping future commercial floating wind farms in Japan by 2030.[227] The Republic of Korea is exploring floating offshore wind and plans to develop a commercial 200 MW project off the coast of Ulsan City.[228]

Mongolia's wind power capacity increased by 50 MW in both 2017 and 2018, for a total of 156 MW at the end of 2018.[229] The 51 MW Salkhit wind farm, near the capital Ulaanbaatar, was the country's first wind energy project and was built in 2009 with financing of USD 47.5 million each from the European Bank for Reconstruction and Development (EBRD) and the Dutch development bank, FMO.[230] A second 50 MW wind farm (Tsetsii) in the country's south, also financed by the EBRD, became operational in 2017.[231] A third EBRD-financed project, the 55 MW Sainshnd Mongolei wind park in the Gobi, reportedly entered commercial operation in 2019. [232]

In **Central Asia**, wind power capacity in Kazakhstan rose to 121 MW in 2018 after completion of the 2 x 4.5 MW Sarybulak power plant.[233] Additional wind farms under construction include the 49.4 MW Badamsha farm in Aktobe and the 50 MW Shelek farm in Almaty.[234] Georgia's first wind power plant, with 20.7 MW of capacity in Kartli, became operational in 2016.[235]

Uzbekistan's wind power potential is estimated at 520 GW.[236] Plans exist for at least two new wind farms: the Turkish company Etko Co Enerji A.S is building a 600 MW plant in the Surkhandarya region, which is expected to be commissioned in 2020, and Germany's Siemens aims to build a 100 MW plant in the Zarafshan district of the Navoi region via a public-private partnership.[237]

Wind power in **South Asia** is growing rapidly. India's installed capacity increased by 2.2 GW in 2018 to reach 35.1 GW, the world's fourth largest installed wind power capacity.[238] During the 2015-2018 period, India increased its onshore wind capacity by 10 GW.[239] Several new projects were expected to add a further 1.6 GW of capacity in 2019.[240] In total, 9.2 GW of wind power projects were in the pipeline in India but were facing obstacles and delays.[241] The country also has an offshore wind policy, and a call for expression of interest to develop a 1 GW offshore project near the coast of Gujarat in the Gulf of Khambhat received responses from more than 35 companies.[242] Another tender is planned for a 1 GW offshore wind plant near the coast of Tamil Nadu in the Gulf of Mannar.[243]

In Pakistan, an additional 396.6 MW of wind power projects entered commercial operations in 2018, bringing the total installed capacity to nearly 1.2 GW.[244] Four large wind power projects contributed 300 MW as part of the China Pakistan Economic Corridor scheme: the Dawood project (50 MW), the Sachal Energy wind farm (50 MW), the Three Gorges second wind farm project (100 MW) and the UEP wind farm project (100 MW).[245] Three wind power projects added 20 MW of capacity in 2017, and six projects with a combined capacity of 285 MW became operational in 2016.[246]

Wind power capacity in Bangladesh was 3.18 MW in 2018.[247] A mapping study of the country's wind energy potential, conducted by the US National Renewable Energy Laboratory (NREL) and financed by USAID, concluded that "for wind speeds of 5.75-7.75 m/s, there are more than 20,000 km^2 of land with a gross wind potential of over 30,000 MW".[248] No further wind projects are planned, however, as the country focuses on developing solar power.

In **Southeast Asia**, Indonesia's first and only operating wind power project – the 75 MW Sidrap wind farm located in South Sulawesi – entered into operation in July 2018.[249] A second wind farm, with 72 MW of capacity, is under construction in Jeneponto.[250] Indonesia's total wind potential is estimated at 9.29 GW, and the government is aiming for 1.8 GW of installed wind capacity by 2025.[251] In Myanmar, the Ministry of Electricity and Energy and China's Three Gorges Corporation signed a memorandum of understanding for the country's first wind power project in March 2016; the 30 MW project is now under construction in the Chaung Tha area of the Ayeyarwady region.[252]

The installed wind power capacity in the Philippines was 427 MW in 2018, but no new installations have occurred since 2016.[253] Although the country has an estimated wind power potential of 76 GW, the government has set a target for only 2.3 GW by 2030.[254] Luzon accounts for most of the installed capacity, at 337 MW, and the Visayas account for the remaining 90 MW.[255] The country's first wind farm, Bangui in the northern province of Ilocos Norte in Luzon, was built in 2006 with 33 MW of capacity and then expanded in 2014 to 51 MW.[256] The country's largest wind farm, the 150 MW Burgos project in Luzon, received USD 20 million in funding from ADB and was built in 2015.[257] Two additional wind farms built in Luzon that year added a further 135 MW.[258]

Thailand's wind power capacity was 648 MW in 2018.[259] Projects totalling 425 MW of capacity entered into operation during 2016 and 2017.[260] Viet Nam had 237 MW of installed wind capacity at the end of 2018, including 138 MW onshore and 99 MW offshore.[261] As of the end of 2018, new wind power capacity of 263 MW was under construction and another 412 MW was in the process of appraisal and approval.[262]

Viet Nam's Bac Lieu offshore wind project, often referred to as a near-shore or intertidal wind farm, has been built in phases in the Mekong Delta region, with 16 MW operational since September 2013 and 83.2 MW commissioned in December 2015.[263] A further 142 MW of capacity is in the final stages of construction, and another 158 MW is planned.[264] In 2019, Enterprize Energy received a licence from the government to explore the options for a new 600 MW offshore wind farm, the first project in a planned large offshore wind complex off Binh Thuan and Ba Ria-Vung Tau provinces.[265]

In **The Pacific**, Fiji's 10 MW Butoni wind farm is located on Viti Levu island.[266] Tonga's first wind power project, in Niutoua Village, has a capacity of 1.3 MW and was commissioned in 2019.[267]

GEOTHERMAL

Geothermal energy can be used directly for heating (for example, in district heating applications) and also can be used for power generation. The geothermal direct use capacity in the 18 selected countries was 22.4 GW_{th} in 2017 and increased only slightly in 2018.[268] For power generation, the geothermal capacity increased from 3.9 GW in 2015 to 4.4 GW in 2018.[269] Geothermal power generation is concentrated in Indonesia and the Philippines, whereas the direct use of geothermal heat occurs mainly in China, India, Japan and the Republic of Korea.

Geothermal Heating

Of the 18 selected countries, China has the largest geothermal resources for direct use, with a total heating capacity of 17.9 GW_{th}.[270] Half of this is used for bathing and swimming, and the remainder is used for district heating, agricultural drying, fish farming, greenhouse heating and industrial process heat.[271] Japan uses 2.19 GW_{th} of geothermal heat directly, mainly for bathing, although around 10% is allocated to heat pumps, which are used for heating and cooling, domestic hot water and snow melting.[272] India and the Republic of Korea each have around 1.0 GW_{th} of geothermal direct use capacity, which is used mostly for bathing and balneological purposes.[273]

Relatively small geothermal resources for heating also are used in Georgia, Mongolia, Pakistan, Thailand and Viet Nam. Mongolia is home to some 43 geothermal areas with a total capacity of 20 MW_{th}, much of which is used for heating, bathing and medicinal purposes.[274] In Viet Nam, 31.2 MW_{th} of capacity is used as industrial process heat and for bathing and swimming, while Thailand's 129 MW_{th} is used mostly for crop drying and public bathing.[275]

Geothermal Power

For geothermal power generation, large plants of 1.9 GW capacity each were installed in Indonesia and the Philippines in 2018, and capacity also existed in India (536 MW), China (25.8 MW) and Thailand (0.3 MW).[276]

Indonesia is second in the world for installed geothermal power generation.[277] Of the country's total geothermal capacity of 1,948 MW in 2018, 99.8% was used for electricity generation, while direct use for heating comprised only 0.2% (2.3 MW).[278] Around 61% (1,194 MW) of Indonesia's geothermal power capacity is based in West Java, where seven geothermal power plants are in operation, and the Cibuni plant is expected add 30 MW when it comes online.[279] ADB has financed some of the country's geothermal projects.[280]

The Philippines has the world's third largest installed geothermal power capacity, but geothermal development has been slow in recent years. Aside from one small new geothermal power plant (30 MW Nasulo) in 2014, two other plants were rehabilitated or slightly expanded (10 MW Bacman, 12 MW Maibarara), there was no significant development since the enactment of the 2008 Renewable Energy Law. The country's geothermal power capacity totalled 1,918 MW as of June 2018.[281]

≈ OCEAN POWER

Ocean power accounts for the smallest share of renewable energy capacity in the selected Asia Pacific countries, totalling 259 MW at the end of 2018.[282] This capacity has remained unchanged since 2011. In 2016, the installations produced an estimated 507 gigawatt-hours of electricity.[283]

The region's ocean power capacity includes the 254 MW Sihwa tidal barrage plant in the Republic of Korea, which generates power from incoming tides and was completed in August 2011. Located 20 kilometres south of Incheon, the plant is the first and only of six large power plants planned by the government in 2008 to harness the ocean's energy; construction of the other five plants was halted for environmental reasons and never resumed.[284] The country's 1 MW Uldolmok Tidal Power Station was commissioned in 2009 and is still in operation.[285]

Of the remaining ocean power capacity, 4.3 MW comes from two projects in China. The 4.1 MW Jiangxia Tidal Power Station, commissioned in 1980, is a tidal barrage facility with bulb-type tubular turbines located in Yueqing Bay in the East China Sea, near the city of Wenling.[286] Also still operating is the older and smaller 0.25 MW Haishan Tidal Power Plant near Maoyan Island in Zhejiang Province, commissioned in 1975.[287] In addition, the 3.4 MW LHD Tidal Current Energy Demonstration Project is under development near Xiushan island in Zhejiang province, and the first two of seven turbines (400 kW and 600 kW) are already operational.[288]

In Japan, a 100 kW ocean thermal energy conversion plant near Okinawa has been operational since 2013.[289] In addition, several tests of small pilot ocean energy plants have been carried out in the region since 2015. In Indonesia, a 2 kW tidal power system was tested near the island of Flores, and a 20 kW wave power system was tested near the island of Madura.[290] The status of a planned 500 MW tidal project in the San Bernardino Strait is unclear.[291] A 100 kW wave-powered navigational buoy is being built near Chennai in India.[292]

03

DISTRIBUTED RENEWABLES FOR ENERGY ACCESS

Distributed renewables are playing an instrumental role in achieving universal access to modern energy.

03 DISTRIBUTED RENEWABLES FOR ENERGY ACCESS

Access to affordable, reliable and sufficient modern energy is a crucial enabler of socio-economic development. The Asia Pacific region has made important strides in expanding access to electricity, with the average electrification rate rising from 80% in early 2000 to 92% in 2017.[1] Clean cooking solutions, however, have progressed more slowly, and only 60% of the region's population had access to clean cooking as of 2016.[2]

Traditional centralised approaches to electrification are being disrupted as distributed renewable energy technologies become more cost competitive, reliable and efficient. Distributed renewables, coupled with innovations in delivery and financing models, will play a critical role in any solution to achieve universal access to modern energy by 2030.

Expanding the central electricity grid to rural areas of developing countries is often economically prohibitive and may take decades to materialise. Even after remote communities are connected, the electricity supply may not be reliable because of insufficient centralised generation and weak transmission and distribution networks, resulting in high losses. Moreover, grid connectivity does not guarantee the resolution of another important energy challenge: access to sustainable heating and cooking. For rural, remote and isolated communities, distributed renewables for energy access (DREA) systems (→ see Box 1) offer an alternative opportunity to access modern energy services.[3]

DREA technologies include small-scale electricity generation systems and mini-grids for lighting, battery charging, communications, water pumping and a variety of processing and other productive uses. In addition to improving access to affordable and reliable electricity service for households, DREA systems can provide sustainable alternatives for household heating, cooling and clean cooking as well as energy provision in the public sector – including electrifying schools and health clinics – largely because it is cheaper and more convenient than diesel generators. Other DREA applications include powering telecommunications towers in remote areas and community micro- and mini-grids.

Innovative, modular and locally relevant DREA solutions can be designed to adapt more quickly to the changing energy needs of individuals and communities, while also increasing energy security, lowering fuel-related costs, easing the burden of collecting fuelwood, and reducing indoor air pollution from kerosene lamps and inefficient stoves.

The average electrification rate in the Asia Pacific region rose to **92%** by 2017.

BOX 1. Distributed Renewables for Energy Access, as Defined by REN21

In the absence of an industry-unified definition of decentralised energy access, REN21, in its *Renewables 2014 Global Status Report*, defined this sector as distributed renewables for energy access (DREA) systems. These are "renewable-based systems (stand-alone and off-grid systems as well as mini-grids) that generate and distribute energy independently of a centralised electricity grid". The energy access services provided by DREA systems range from lighting and the use of appliances to cooking, heating and cooling, in both urban and rural areas of the developing world.

DREA systems represented around 6% of new electricity connections worldwide between 2012 and 2016, mainly in rural areas. In places where the national electricity network does not reach or is unreliable, DREA technologies can provide viable, cost-attractive solutions for generating electricity and mechanical power, heating water and space, electric cooking, baking and enabling productive use activities. DREA systems providing rural electrification in Asia have more than doubled from 3 GW in 2008 to more than 6 GW in 2018, benefiting 95 million people or 2% of the region's population.

REN21 defines clean cooking using the methodology of the Clean Cooking Alliance, encompassing as indicators the health and environmental impacts of cooking, regardless of the type of stoves or fuels being used. LPG, for example, is counted alongside modern renewable fuels, and LPG stoves continue to make up the majority of clean cook stoves on the market.

Source: See endnote 3 for this chapter.

STATUS AND TRENDS IN ENERGY ACCESS

Worldwide, 840 million people lived without access to electricity in 2017.[4] Although countries in Asia and the Pacific have made significant progress in connecting their populations – the region is home to three-quarters of the 570 million people worldwide who gained electricity access between 2011 and 2017 – an estimated 350 million people across developing Asia[i] still lack access.[5] One of the greatest successes has been India, which announced complete electrification of its villages in 2018; however, this does not guarantee that 100% of households in the country are connected (→ see Sidebar 5).

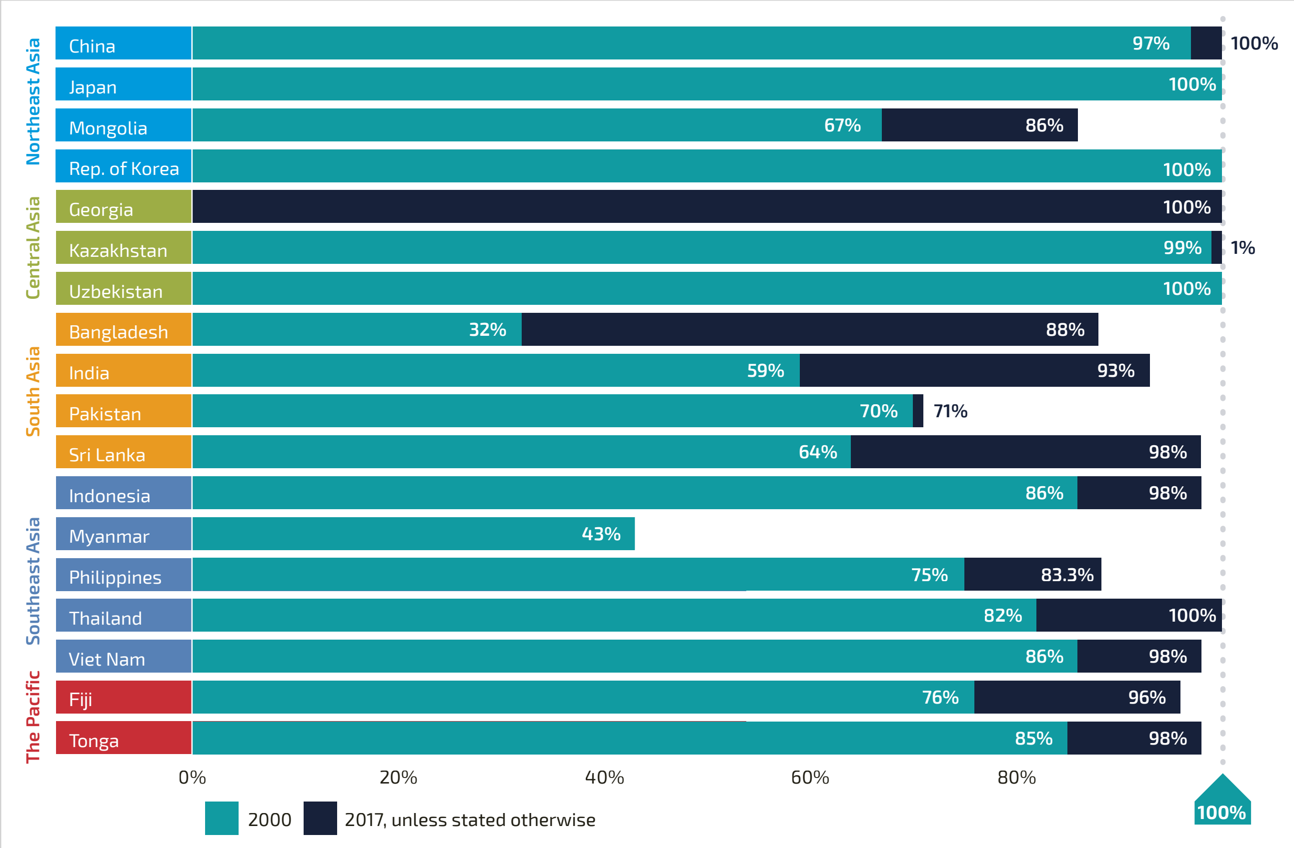
Of the 18 countries covered in this analysis, several report that the majority of their populations are now fully electrified, including countries in Central Asia (Georgia, Kazakhstan, Uzbekistan), most of Northeast Asia (China, Japan, the Republic of Korea) as well as Sri Lanka, Thailand and Viet Nam (→ see Figure 7).[6] However, other countries have a long way to go. In Mongolia, Indonesia, the Philippines and The Pacific (Fiji and Tonga), the remaining few percent of the population still needs to be connected as last-mile customers, according to official statistics.[7]

> India announced the **complete electrification** of its villages in 2018 but still faces issues with blackouts.

Power reliability continues to be a challenge in many places, and people may remain unconnected even when the national electricity network reaches their village. For example, India still faces issues with blackouts in places where the national grid has arrived, while many households remain off the grid.[8] Pakistan, Bangladesh and Myanmar, which have the lowest electrification rates in the South Asia and Southeast Asia sub-regions, face considerable challenges in providing 20-50% of their populations with access to modern electricity services.[9]

i As defined by the IEA, "developing Asia" includes China, India, Indonesia, other Southeast Asia (Brunei Darussalam, Cambodia, the Lao PDR, Malaysia, Myanmar, the Philippines, Singapore, Thailand, Viet Nam), other developing Asia (Bangladesh, Korea DPR, Mongolia, Nepal, Pakistan, Sri Lanka) and other Asia (unspecified).

FIGURE 7. Electricity Access in the Selected Asia Pacific Countries, 2000 and 2017



Note: The 64% figure for Sri Lanka is as of 2001; the 43% figure for Myanmar is as of October 2018.

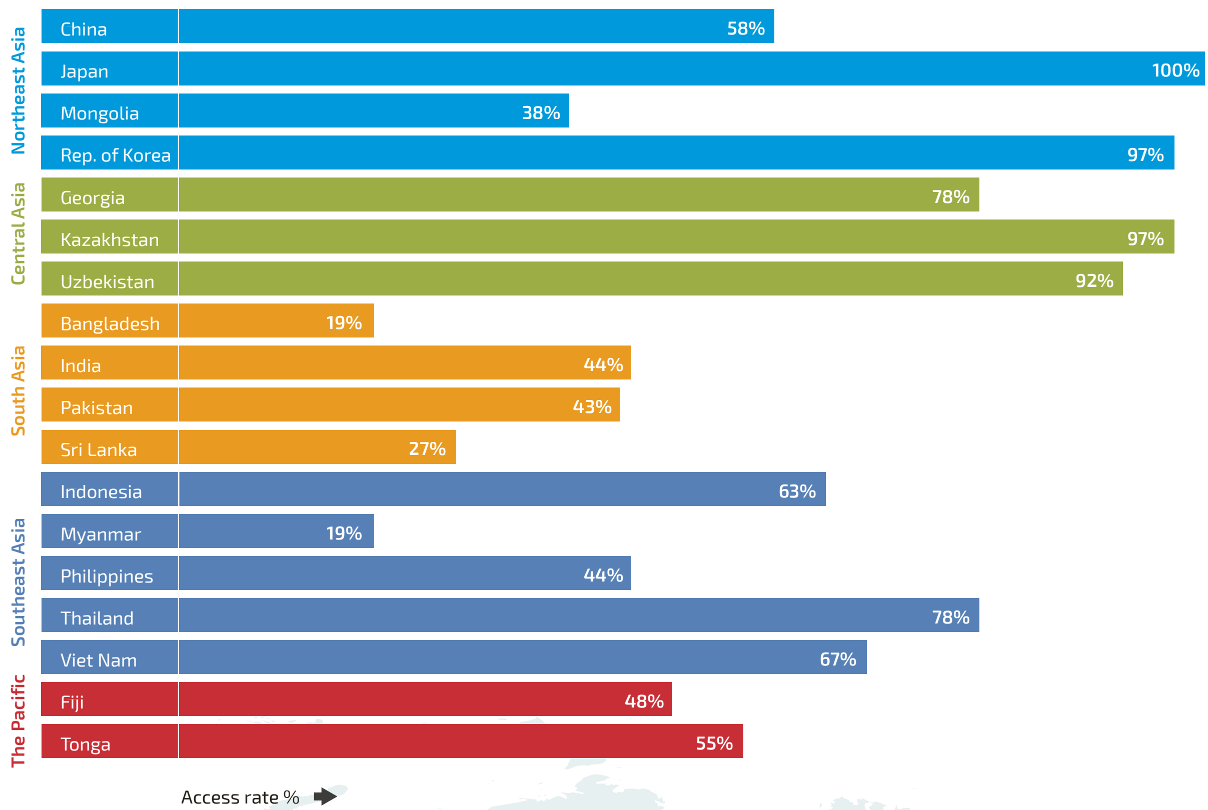
Source: See endnote 6 for this chapter.

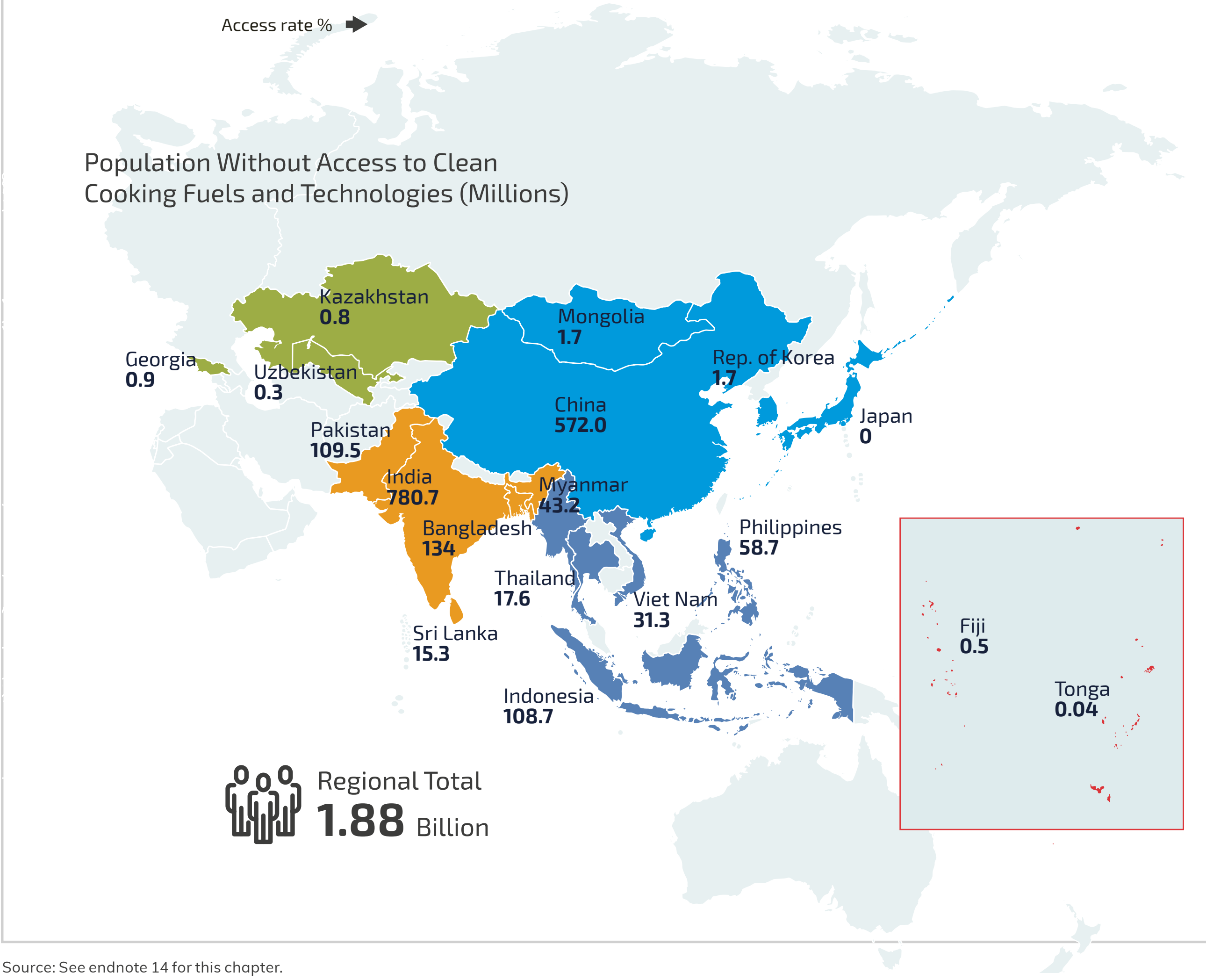
Meanwhile, developing Asia is home to 65% of the global population that lacks access to clean cooking facilities.[10] Cooking with polluting fuels – wood or cow dung – is a major global health issue, causing indoor air pollution that claims 92 premature deaths per 100,000 people worldwide and more than 125 premature deaths per 100,000 people in India.[11] Most of the 1.8 billion people in developing Asia who rely on traditional biomass for cooking – 40% of the population – live in five countries: China (more than 570 million people), India (more than 780 million), Indonesia and Pakistan (around 110 million each) and Bangladesh (more than 130 million).[12] In the past decade, significant progress has been made to provide clean cooking access to more than 400 million people – primarily in India and China – as a result of programmes to promote the use of LPG as well as policies to support clean air.[13]

In the 18 selected countries, half of the population – or just under 2 billion people – still relies on traditional biomass, coal and kerosene for cooking (→ see Figure 8).[14] The highest access to clean cooking fuels and technologies is in Japan, the Republic of Korea, and the Central Asian countries of Kazakhstan and Uzbekistan, whereas the lowest access is in Bangladesh, Myanmar and Sri Lanka.[15]

Mongolia, with its dispersed nomadic population, is the only country in **Northeast Asia without** 100% electrification.

FIGURE 8. Access to Clean Cooking Fuels and Technologies in the Selected Asia Pacific Countries, 2016





Source: See endnote 14 for this chapter.

Progress in Electricity Access

Thanks to strong institutional support and rural electrification policies, several countries in Northeast Asia (China, Japan, the Republic of Korea) and in South Asia and Southeast Asia (Sri Lanka, Thailand, Viet Nam) progressed rapidly towards 100% household electricity access in the last 10-15 years.[16] Mongolia, with its dispersed nomadic population, is the only country in **Northeast Asia** without 100% electrification, although it is inching towards this target by 2020 (→ see Sidebar 4). The **Central Asian** countries (Georgia, Kazakhstan, Uzbekistan) were fully electrified as early as 1990.[17]

In China, it took 13 years to electrify the last 4.6 million households, primarily in remote areas of the western provinces, which was achieved in 2015.[18] China's power sector has undergone major reforms in recent decades, including large public investments in rural electrification. The Township Electrification Programme (2001-2005) and the Village Electrification Programme (2005-2010) both focused on remote villages, emphasising the use of distributed generation from renewable sources such as solar PV-battery and small-scale hydropower mini-grids.[19] Electrification of the remaining population was a priority during the 12th Five-Year Plan (2011-2015), and in the last three years of that period, the National Energy Administration led collective efforts to connect 2.7 million people through grid extension and solar PV stand-alone systems, totalling 583 projects and CNY 29.4 billion (USD 4.2 billion) in investment (→ see Sidebar 4).[20]

SIDEBAR 4. Advancing Rural Energy Access: Good Practices from the Asia Pacific Region

China's Electricity for All Plan

In 2015, China announced that it had achieved full electrification of its population of 1.4 billion, even in the most remote villages. Erdaoqiao, in the rural mountains of south-west China, was the last village to receive power under nationwide electrification, which has brought electricity to 90% of the country (nearly 900 million people) since the founding of the People's Republic in 1949. China tackled rural electrification in two waves. The first wave provided electricity to 97% of the population by the late 1990s through a combination of grid extension to around 80% of rural Chinese and small hydropower and small coal-fired power plants (up to 50 MW) integrated into local micro-grids where resources were available.

To electrify the final 3% of the population, China focused on extending and renovating rural grids to improve supply reliability and reduce losses. In places where the grid could not reach everyone cost effectively, the government used off-grid renewables and in 2012 issued a Three-Year Action Plan for Comprehensively Solving Electric Usage Problems for Rural Residents (2013-2015) to connect the final 2.7 million people. The programme was successful due to strong policy leadership and investment, with local authorities playing a key role in co-ordinating highly decentralised electricity systems. The central government provided investment support ranging from 20% to 80% (in the poorest regions). In very remote areas, where grid expansion would cost an estimated USD 16,000 per household, depending on the terrain and distance to the sub-station, distributed and individual solar PV systems were provided.

In areas that were prohibitive to serve with any system, the government relocated people to more hospitable terrain. China embedded electrification in its poverty eradication strategy, mainly through the Infrastructure to Every Village Project, which covered power, roads, water and telecommunications. This process was hastened by policies such as China's "home appliances to the countryside" programme, which subsidised purchases of televisions, washing machines and mobile phones for rural customers. To fund the ongoing maintenance of off-grid systems and close the funding gap created by soaring renewable generation, China collects 1.9 RMB cents (0.3 US cents) per kWh in the nationwide renewable energy fund.

Viet Nam's Rural Electrification Programme

Rural electrification in Viet Nam occurred as a result of the country's dedicated grid extension strategy, which boosted the household electrification rate from 2.5% in 1975 to 96.3% in 2009, increasing access for more than 80 million people. A number of development partners supported the government, with the World Bank releasing more than USD 700 million under its First and Second Rural Energy Projects (including extension) and Rural Distribution Project. Rural electrification prioritised rice production areas, bringing modern irrigation and industrial processes to support local rice farmers and small rural industries, the effects of which can be felt today as Viet Nam has become the world's second largest rice producer.

In the late 1990s, electrification targets and priorities shifted from agricultural areas and businesses towards poor households, remote communes and villages. Viet Nam's programme for economic renovation, Doi Moi, initiated in 1986, issued tax exemptions for farmers, allowing them to use their financial resources to build rural electricity networks. Tariff reform in 2009 introduced uniform tariffs throughout the country, and network rehabilitation enabled reliable energy access for all rural and urban customers. *Continued →*

South Asia has made remarkable progress in electricity access in the last two decades. In Bangladesh, electricity reached 88% of the population in 2017, up from only 20% in 2000.[21] This can be attributed to a steep rise in grid connections: since 2015, the country has added on average 3.5 million new rural connections annually, with a view towards achieving universal access by 2021.[22] Around 12% of the population relies on individual solar home systems, with around 4.2 million systems deployed providing service at Tier 1 and above[i], according to the IDCOL database (→ see Sidebar 4).[23]

In India, rapid growth in electricity access has been propelled by the country's USD 2.5 billion electrification scheme, Saubhagya, which aimed to connect the last 40 million households and achieve universal electrification by December 2018.[24] The Indian government announced on Twitter that all Indian villages were connected as of April 2018; however, household electrification is ongoing (→ see Sidebar 5).[25]

i The Multi-Tier Approach was introduced in the 2013 Global Tracking Framework to classify energy access and services in tiers. Tier 0 implies no service, while Tier 5 means full service. See endnote 60 for this chapter.

(continued from previous page)

Viet Nam's rural electrification success is based on three key factors: 1) strong commitment by the central and local governments as well as the state-owned utility companies to provide electricity access; 2) sharing roles and responsibilities, including the costs of electrification, by all stakeholders, supported by development institutions; and 3) the introduction of unified national technical standards for electricity networks. Starting in 2000, the use of off-grid systems, such as small-scale hydropower, increased in rural areas, and the government continues to work towards its target of 100% electrification of rural households in mountainous areas by 2025. According to statistics, Viet Nam invested VND 48.3 trillion (around USD 2 billion) in developing and improving the rural power grid between 2000 and 2015.

Bangladesh's Solar Home System Programme by IDCOL

Bangladesh's experience illustrates the importance of institutional capacity and government accountability in accelerating energy access in rural and remote areas. The country is home to the world's largest domestic solar power programme, covering 12% of the population as of mid-2019. In partnership with the World Bank, the government of Bangladesh set up IDCOL in 1997 to provide funding and technical assistance to private companies and consumers of renewable energy infrastructure projects, including distributed generation. As of mid-2019 IDCOL's total investment in these efforts neared USD 700 million, including grants and loans to 56 partner organisations.

IDCOL launched its solar home system programme in 2003 to provide electricity to remote villages with no grid infrastructure. In 2009, IDCOL added solar irrigation pumps, and a year later it began supporting private entrepreneurs in setting up solar mini-grids in remote locations. In 2012, improved cook stoves were added to reduce indoor pollution and the use of cooking fuels.

As of mid-2019, IDCOL had installed 4.2 million solar home systems benefiting 18 million people. These systems have mostly replaced kerosene for lighting, and IDCOL estimates that the programme has prevented the consumption of 1.14 million tonnes of kerosene. In addition to this, IDCOL has installed 1,000 solar irrigation pumps, 13 mini-grids and 1 million cook stoves, together with 46,000 biogas plants to provide clean cooking solutions to more than 200,000 people. IDCOL aims to add another 50,000 solar pumps (1.25 GW capacity), 6 million solar home systems (200 MW estimated capacity) and 50 mini-grids for continuous improvements in electricity access by 2025, and to replace every traditional cook stove in the country by 2030.

Mongolia's Nomads Champion Distributed Solar

Around 800,000 of Mongolia's 2.8 million people still live a traditional nomadic lifestyle that has remained unchanged for generations. Nomads, who along with other remotely located inhabitants total around 27% of the population, are still not connected to electricity. To power their portable homes, they rely on candles, coal and yak dung, as well as motorcycle batteries and diesel generators in some affluent families. In a country with an abundant solar resource in the range of 5.5 to 6.0 kWh per m^2 per day (more than 250 sunny days a year), the government launched the National 100,000 Solar Ger Electrification Program in 2000 to improve energy access through distributed solar PV technology. In 2013, with USD 12 million in funding from the World Bank's International Development Association and the government of the Netherlands, the programme distributed more than 100,000 portable solar PV systems to almost 7% of Mongolia's nomadic population, enabling the use of televisions and phones.

Source: See endnote 20 for this chapter.

SIDEBAR 5. India's Last Village Electrified

The Indian government considers a village to be fully electrified if basic power infrastructure, such as a transformer and distribution line, is provided to the locality and at least 10% of its households and public buildings (schools, health centres, government offices, village councils and community centres) are connected to the national grid. Based on this definition, in April 2018 Prime Minister Narendra Modi tweeted that every single village in India had received access to electricity. However, not all households in the country are fully electrified.

While most of India's villages (96%) had electricity access before Modi took office, in 2015 his government launched an initiative to electrify some 18,000 villages still off the grid. According to official data from census villages, all 597,464 have now been electrified. The rural electrification initiative, Deen Dayal Upadhyaya Gram Jyoti Yojana, was later supported by the USD 2.5 billion (INR 16 billion) Saubhagya scheme, launched in 2017 to fund electrification of every remaining rural household – nearly 40 million – by March 2019. According to the Saubhagya website, as of June 2019 only 18,737 households in four districts of Chhattisgarh had yet to be electrified.

The Indian government's electrification target is to ensure an uninterrupted and reliable electric supply to all electrified households, which is particularly challenging in rural areas. Even in villages connected to the national grid, the supply is erratic, and reliability remains an issue: only 6 out of 29 states receive a 24-hour electricity supply, and just under half of villages have more than 12 hours of domestic electricity a day and one-third receive between 8 and 12 hours, according to government data. Densely populated states receive between one and four hours of electricity a day, corresponding to the lowest tiers of energy access.

In 2018, news outlets reported that Leisang, in the north-eastern state of Manipur, was the last Indian village officially electrified. However, a year after receiving electricity, the power came on for only 5-6 hours daily (on a good day), and issues took days to fix. On one occasion, the village was disconnected for three months because of difficulties accessing the village.

Source: See endnote 25 for this chapter.

In Pakistan, the formal grid connection rate is 82.4%, although other sources estimate electrification at 71%.[26] The government's focus is on expanding electricity access through utility-scale projects, and 95% of new connections since 2000 have occurred via the grid.[27] However, provincial governments have spearheaded local rural electrification initiatives with renewable energy, using public finance (such as the Pakistan Poverty Alleviation Fund) as well as support from development partners.[28] Sri Lanka reported achieving universal electricity access in December 2016 through a combination of grid expansion and rural electrification initiatives using small-scale hydropower.[29]

Southeast Asia also has made significant progress towards universal electrification. Indonesia reached 98.3% electricity access in 2018, up from only 50% in 2000, reducing the population without access by 75 million.[30] Most of the villages without electricity are concentrated in East and Central Java, East Nusa Tenggara and Papua, with significant differences in population densities and economic status.[31] The government plans to bring basic electricity access to unserved villages through off-grid solutions while also working to provide electricity infrastructure that would stimulate economic development in the medium to long term, with the aim of achieving 99.9% village electrification by the end of 2019.[32]

Myanmar's official grid connection rate in May 2019 was 43%, and of the remaining off-grid population, around 30% relies on decentralised energy solutions such as solar electricity, diesel generators, micro-hydropower and biomass/biogas.[33] The Philippines aims to achieve universal electrification by 2022, up from 88.3% in 2017.[34] Alongside international donor funding for solar home systems in unelectrified areas, the government is offering grants to electric co-operatives to support rural electrification projects and incentivising private developers to provide renewable energy solutions in partnership with local communities.[35]

In **The Pacific**, the remaining unelectrified population generally lives in remote regions and outer islands. Fiji's Department of Energy plans to electrify the 4% of the population without electricity access through 15,000 solar home systems, at a total cost of USD 25 million.[36] Tonga's off-grid rural electrification plan focuses on providing electricity to communities outside the grid network using solar PV technology (mini-grids and solar home systems); however, an assessment from the Energy Planning Office revealed that less than half of these systems provide reliable electricity supply.[37]

The Challenge of Last-mile Electrification

The work towards electrifying the "last mile" is challenging for countries in the Asia Pacific region, as most of the remaining households without electricity access are located in very remote areas such as mountains, islands or isolated hamlets or villages. For these locations, individual household solar PV solutions and decentralised systems are often the most efficient means of electrification. The right mix of decentralised electrification solutions based on solar, wind, biomass or hydropower will depend on local resource availability, demand for electricity services and willingness to pay in these regions.

Even countries with officially reported 100% electrification rates are still working to connect their most remote regions. In 2014, the World Bank recognised Viet Nam as the developing country with the highest rural electrification rate in the world, and in 2017 the national grid reached a reported 99.98% of countryside communes and 98.83% of total households, which is very close to universal electrification.[38] However, the effort to fully electrify the country continues. To ensure that the remaining households in rural, island, and remote or mountainous areas have access to light and power by 2020, the government has launched a countryside electrification programme for the period 2013-2020.[39]

The costs associated with rural household connections are often prohibitively expensive, particularly in remote regions with no existing grid infrastructure. The estimated cost for connecting a household to a national grid line in island countries ranges from around USD 900 in Fiji to an estimated USD 300 to USD 1,760 in Indonesia.[40] In some regions, alternative electricity provision in rural areas using diesel power generation and other fossil fuels sets the electricity price below the actual cost, with the difference subsidised by the national utility.

Under the Philippines' national "missionary electrification" policy, the National Power Corporation (NPC) is mandated to supply island areas outside the main grids through its Small Power Utilities Group. To subsidise this off-grid power supply, the country's grid-connected electricity consumers are required to pay a universal charge for missionary electrification of PHP 0.0025 (USD 0.00005) per kWh.[41] The Department of Energy recently announced an increase in the total annual missionary electrification requirement from PHP 7,784 billion (USD 153 million) in 2011 to PHP 28,373 billion (USD 550 million) by the end of 2021.[42] To provide power to rural customers in Palawan, a 1.4 MW peak solar microgrid with a 1.2 MW back-up diesel system and a 2.4 MWh lithium-ion battery energy storage system was planned to enter operation in mid-2019.[43] Households and businesses in Palawan have traditionally relied on diesel gensets to provide electricity at a high cost of USD 0.6 to USD 1.0 per kWh.[44]

In Myanmar, rural communities have borne the cost of last-mile electrification. The government provides no financial support, so communities must raise their own funds to connect to the main transmission line, using the self-reliant electrification approach "Ko Htu Ko Hta Mee Lin Yae".[45] This has led to the development of more than 5,600 micro- and mini-hydropower units with capacities below 1 MW and over 10,000 biomass gasifiers powering rice mills and rural villages.[46] Under the National Electrification Plan (NEP), the cost of connection for each household is estimated at USD 700 to USD 1,700, depending on the location.[47] As a result, a large share of the population remains without electricity access even within villages connected to the national grid.

For very remote areas, **household solar PV** solutions are often the most cost-effective means of electrification.

Under the off-grid component of Myanmar's NEP, households in villages with recently installed solar mini-grids must pay average one-time connection fees of USD 200.[48] The mini-grid programme, managed by the Department of Rural Development and financially supported by the World Bank with technical assistance from Germany's GIZ, supported 37 mini-grids in 45 rural villages as of mid-2019, providing a 60% subsidy to private developers with the remaining 40% coming proportionally from the developers and the communities.[49] The community contribution is collected in the form of household connection fees as well as in-kind contributions of labour or land. Locally based organisations, such as Smart Power Myanmar, have provided interest-free loans to households unable to pay upfront, enabling full electrification in a number of villages.[50]

TECHNOLOGIES AND MARKETS

The market for DREA systems is growing rapidly in Asia and the Pacific, and a wide range of technology options are available. This section focuses on the use of off-grid renewable energy technologies for rural electrification as well as on clean cooking opportunities, renewable heating and cooling technologies, and innovative business models linked to mobile payments.

Electricity Access

With large pockets of the population unelectrified in the Asia Pacific region, the market for decentralised energy access technologies – including solar lanterns, solar home systems, and micro- and mini-grids – is substantial. In 2018, the newly installed capacity of small-scale, off-grid solar systems (solar lanterns and solar home systems) in the region exceeded 20 MW.[51] Local commercial markets are driven largely by component-based sales, although more-efficient off-grid packaged systems are also emerging. The largest DREA technology category sold in the Asia Pacific region in 2018 was portable solar lanterns, with the highest growth being in sales of lanterns with mobile charging capabilities.[52]

The market for off-grid solar has not been homogeneous, stagnating in some sub-regions while growing in others. South Asia has seen particularly strong growth, with more than 1.2 million off-grid solar lighting products sold in the second quarter of 2018, mainly in India and Bangladesh.[53] However, uncertainty around India's new safeguard duty for solar cells imported from China and Malaysia contributed to an overall 23% decline in the volume of off-grid solar product sales in the country between 2016 and 2018.[54] In Southeast Asia, the largest markets for off-grid solar are Myanmar and the Philippines, with 30,000 to 40,000 units sold in the second half of 2019.[55] In the island market of Fiji, sales totalled around 40,000, mainly in lighting products with mobile charging.[56]

In Myanmar, government procurement has driven significant sales of off-grid solar products, resulting in the distribution of nearly 230,000 units with capacities of 30 to 100 watts peak.[57] Pay-as-you-go multi-light systems[i] have made progress in the country, and several companies secured investment to scale up their operations, distributing more than 30,000 such systems as of mid-2019.[58] A key challenge in the country, however, is competition from low-quality products available at local markets at lower cost with limited warranty or after-sale service, as customers are highly price sensitive.

Compared with stand-alone off-grid solutions, micro- and mini-grids are perceived to be a more viable solution for providing electricity in off-grid areas that have high population densities and large energy demand. In recent years, government agencies, donors and local communities have widely deployed renewable energy-based mini-grids (hybrid systems with small-scale hydropower and solar PV). Overall, Asia and the Pacific countries are home to more than 16,000 installed mini-grids (both renewable and diesel-based), or 85% of the global total, with the highest numbers in Afghanistan (not covered in this report; 4,980 mini-grids), followed by Myanmar (3,988), India (2,800), China (1,184), the Philippines (896) and Indonesia (583), benefiting more than 15 million people in the latter five countries.[59]

An increasing number of energy access companies are partnering with development agencies and local governments to provide innovative business models and technologies to meet the power needs of rural customers. Their offerings range from distributing small portable solar kits for individual household use to operating village-scale microgrids that can supply electricity to larger businesses and cellular infrastructure (→ see Table 4).[60] Many of these efforts are backed by large investors at the global scale (→ see Investment and Financing section on page 66).

i Multi-light systems are stand-alone solar PV systems supplying several lighting and mobile charging points, with module capacity typically under 11 watts, as indicated by GOGLA.

TABLE 4. Innovative Business Models and Technologies for Electricity Access in the Asia Pacific Region

Business model / Technology	Description	Prime customers	Examples
Portable solar products	Portable solar kits, solar lanterns and charging stations that provide basic lighting and phone charging.	Households – very low consumption, Tier 1	d.light (India), Greenlight Planet (Myanmar), Omnivoltaic (Bangladesh, India), EcoEnergy (Pakistan)
Pay-as-you-go solar	Individual solar home systems, sold with a financing plan, that use programmed technology to switch the system off in case of non-payment; consumers often pay for the service via mobile money.	Households – Tier 2-3	SolarHome (Myanmar) – serving 30,000 rural customers
Peer-to-peer electricity marketplace	Technology connecting individual solar home systems where people can sell excess electricity to consumers on the network.	Communities – Tier 2-3	SolShare (Bangladesh), Mera Gao (India) – direct current systems
Micro and mini-grids (community-scale)	Micro and mini-grids providing direct current coupled power or alternating current power, ranging in size from 100 watts to a few hundred kW. Community-scale power systems are often built and operated by start-ups, which supply electricity through a local distribution network. Consumers pay for the amount of electricity they use, often through prepaid models.	Communities – Tier 2-4	Husk Power (India), Electric Vine Industries (Indonesia), Okra Solar (Cambodia, Philippines), Mandalay Yoma (Myanmar)

Continued →

Micro and mini-grids (anchor tenant)	Micrgrids and mini-grids providing power to an anchor tenant, often a telecom tower, with an opportunity to extend the grid network to a nearby community.	Anchor tenant + communities	OMC (India), Yoma Micropower (Myanmar)
Charging kiosks	Mobile or stationary kiosks, powered by solar or other renewable resources, where customers can charge their phones or portable batteries.	Individuals	
Grid extension	Distribution companies boost legal electricity connections and revenue collection in informal urban areas through targeted outreach or financing plans.	Households	Tata Power Delhi (India)

Note: For an explanation of the tiers of energy access, see endnote 60.

Source: See endnote 60 for this chapter.

Clean Cooking

Reducing indoor air pollution and improving the health of rural residents are among the main objectives of clean cooking programmes in the Asia Pacific region. However, with the exception of several countries that have a strong institutional focus on access to improved cook stoves and fuels, difficulties persist in bringing clean cooking technologies – such as LPG, biogas, electric, advanced biomass cook stoves and solar cooking – to consumers. In general, countries across the region need to step up their efforts to prioritise clean cooking initiatives and investments. Underinvestment in the sector will likely cause the region to fall short of the target for universal access to clean cooking fuels and technologies by 2030 set out in the United Nations' Sustainable Development Goal 7.[61]

The Asia Pacific region has several successful examples of replacing traditional wood or fossil fuel-based cooking techniques with clean cooking technology. These include IDCOL's work in Bangladesh (→ see Sidebar 4) and Indonesia's LPG Megaproject, which has helped to replace kerosene with LPG in 72% of the country's households (→ see Sidebar 6).[62] In India, the Ujjwala scheme has provided LPG connection to more than 70 million rural households since 2016.[63] The scheme, which originally targeted rural women – the segment of the population most affected by indoor air pollution and the drudgery of fuelwood collection – was extended in 2018 to provide LPG access to all poor households, with the goal of covering 100% of the population.[64]

SIDEBAR 6. Indonesia's LPG Megaproject

In 2001, the government of Indonesia launched the LPG Megaproject, a large-scale clean cooking initiative to replace kerosene and other traditional fuels with LPG to reduce indoor air pollution. Households were offered a free initial package, the government reduced subsidies for kerosene, and new LPG terminals were constructed as distribution centres. In just two years, from 2007 to 2009, the number of LPG stoves increased from 3 million to more than 43 million, extending clean cooking practices to nearly 70% of the population. The programme outperformed its target of converting 42 million households and micro businesses, reaching more than 50 million households by 2012. This reduced kerosene use from 36.6% in 2007 to only 3.8% in 2016, and increasing LPG use from 10.6% in 2007 to 72.4% in 2016.

As of 2016, LPG had effectively replaced kerosene as the main cooking fuel for 72% of Indonesian households across many regions of the country. However, the rest, nearly 18 million households (70 million people), still use traditional cooking fuels including fuelwood, kerosene and charcoal. Because most of these households are in rural and remote areas, establishing the appropriate supply chain infrastructure is challenging.

The LPG programme relies on government subsidies, with an average of USD 2.3 billion spent annually between 2013 and 2016. The subsidies for residential LPG use – comprising 14% (in 2016) of the total government subsidy – have been instrumental in improving clean cooking access in Indonesia. However, the continuous pressure on the budget – which has increased the national deficit from 1.1% of GDP in 2011 to 2.5% of GDP in 2016 – raises concerns. Moreover, the subsidy scheme, originally designed for poor citizens, allows the wealthy to purchase subsidised LPG easily. The government plans to replace the indirect subsidy with a direct subsidy scheme to ensure that the subsidies end up only in the hands of eligible beneficiaries.

Source: See endnote 62 for this chapter.

In some cases, locally based NGOs are overseeing initiatives to increase access to improved cook stoves, with support from international donors. In Myanmar, where most of the population relies on fuelwood for energy and lives in rural areas close to bioenergy resources, GERES and Mercy Corps have worked with the government to develop improved cookstove standards and to support local manufacturers in improving the designs of traditional stoves. Both organisations provide mentoring to manufacturers and sales agents and organise awareness campaigns to increase the rural dissemination of fuel-efficient stoves. A Mercy Corps campaign that resulted in sales of 22,000 cook stoves in Myanmar will continue until 2021 under the auspices of the Ministry of Natural Resources and Environmental Conservation.[65]

The use of biogas for cooking has expanded in several of the Asia Pacific countries, including Bangladesh, Indonesia and Viet Nam.[66] Although biogas production for cooking has decreased in China and India, large numbers of people in these two countries still cook with biogas (more than 111 million in China and nearly 10 million in India).[67]

Indonesia's Domestic Biogas Programme supports the deployment of biogas digesters in rural island regions that engage in livestock farming. Alongside traditional development finance assistance, the programme uses market-based solutions to help local farmers access private credit to install the digesters.[68] The costs are covered in part through a public subsidy of 30%, as well as funding from local financial institutions.[69] As of 2016, the programme had supported the installation of more than 20,000 biogas digesters in rural areas and had partnered with 46 credit providers to help 8,500 farmers gain access to credit.[70]

The biogas programme in Viet Nam, with funding from several development agencies, has facilitated the construction of around 250,000 biogas digesters since 2003, addressing the waste management challenge of the country's growing livestock population and improving living conditions for more than 1.2 million people.[71] A flat-rate subsidy of VND 1.2 million (around USD 52) per digester was offered initially to minimise the upfront cost for households, which was replaced by a results-based financing (RBF)[i] mechanism in mid-2016 to incentivise suppliers to take additional risks and execute extra tasks and responsibilities in supplying the market.[72] RBF resulted in 16,500 biodigesters constructed in the first year. The biogas programme, which recently entered its final phase to 2020, has contributed to the emergence of a commercial domestic biogas sector. The programme was initiated by the Dutch government and Viet Nam's Ministry of Agricultural and Rural Development in partnership with SNV Netherlands Development Organisation and has been managed by Energising Development (EnDev) since 2013.[73]

Heating and Cooling

Countries in Central Asia as well as parts of Northeast Asia witness among the coldest winters in the world. In remote and less-developed towns in western Mongolia, where temperatures fall below minus 50 degrees Celsius and much of the population relies on costly and carbon-intensive electricity imports, a new development initiative will build a 40.5 MW distributed renewable energy system using solar PV and wind power with advanced battery storage technology to provide clean and reliable electricity for power and heating.[74] The project, approved in late 2018, was co-financed with USD 60 million in loans and grants from ADB, the Strategic Climate Fund and the Japan Fund for the Joint Crediting Mechanism.[75]

In the hot and humid climates of South Asia and Southeast Asia, demand for cooling technologies, such as refrigeration and air conditioning, is high, particularly as temperatures increase with climate change. Off-grid solar fans are the most attractive consumer demand product in Bangladesh.[76] Solar refrigeration helps many households, small stores and farmer collectives across the region manage the temperature of perishable products from farm to table. In India, where the dairy industry is dominated by small farmers that depend on the cold chain, several milk chiller pilot projects, which use thermal energy battery packs that charge on solar power or grid electricity, are being deployed.[77]

Mobile Payments

More than half of the world's **mobile subscribers** live in the Asia Pacific region.

With the increasing global penetration of mobile devices and networks, more than half of the world's mobile subscribers live in the Asia Pacific region, mostly in China and India.[78] The construction of telecommunications infrastructure, along with declining smartphone prices, has made integrating mobile and wireless network infrastructure into decentralised business models paramount in efforts to provide energy access.

A key way that mobile technology enables electricity access is through PAYG solar, which allows low-income customers to purchase solar products through their mobile devices, either via credit or instalment plans or by paying a small fee for continuous use.[79] Unlike in Africa, the PAYG market in the Asia Pacific region is still in its infancy. However, with the region's large unelectrified populations, as well as the rising accessibility of off-grid solutions, there is an untapped market for integrating energy access technologies with mobile money.

South Asia has seen the most progress with PAYG in the region, despite being dominated by largely cash-based economies. Simpa Energy, a leader in providing affordable solar power in India, was a pioneer in PAYG pricing for rooftop

i Financing for which disbursement of funds is contingent on the delivery of pre-determined results.

solar with its patented SmartPanel technology, providing clean energy access to more than 250,000 people across three Indian states by November 2018.[80] In Bangladesh, the rise of solar home systems through IDCOL's initiatives enabled the company SolShare to develop a peer-to-peer solar energy trading platform, integrating mobile money payment, data analytics and grid management services.[81] The International Finance Corporation's (IFC's) Lighting Asia programme – active in Bangladesh, India and Pakistan as well as in Myanmar – focuses on eliminating market barriers for private companies in order to provide access to modern energy services utilising PAYG technologies in rural markets.[82]

Community-based Approaches to Extend Electricity Access

Many local governments, international NGOs, civil society organisations and community development organisations work with communities on self-electrification as an integral part of rural development, building on communities' cohesion and ownership. The success of community-based energy access programmes depends on a number of factors, including having existing networks in the local area to work closely with the communities; addressing financial barriers, such as the upfront cost of acquiring technologies, which typically prevent aspiring entrepreneurs from starting; and the provision of training in technology, business skills/financial management, sales, marketing and leadership.

Bangladesh's rural electrification offers a successful example of how community co-operatives played an important role in **South Asia.** In 1980, when only 13,000 people in the country had access to electricity, the Bangladesh Rural Electrification Board, with assistance from the US National Rural Electric Cooperative Association, established rural co-operatives called *palli bidyut samitis* (PBSs) with the authority to sell electricity to member customers, set tariffs, provide sub-station maintenance and handle customers' complaints.[83] Today, 80 PBSs serve 100 million customers (70% of the population) across Bangladesh, covering 6.2 GW of peak demand.[84] During the start-up period, PBSs with losses receive subsidies for up to six years and benefit from a revolving fund. Distribution losses within PBS areas are around half those of the national utilities, and the collection efficiency rate is over 95%.[85]

For more than 20 years in Sri Lanka, voluntary community organisations called Electricity Consumer Societies (ECSs) have provided rural households with access to electricity in villages not yet connected to the main grid. With financial support from the government and the World Bank, ECSs have built, owned and managed more than 260 pico- and micro- individual, run-of-the-river hydropower projects ranging from 3 kW to 55 kW, each supplying electricity to 20-150 rural households within a three-kilometre radius.[86] Over the two-decade period, ECSs have installed an estimated 4 MW of total generating capacity and provided electricity to around 10,000 rural households.[87] As the main grid progressed to these villages, however, these isolated mini-grids were abandoned and the national utility, the Ceylon Electricity Board (CEB), became the new electricity supplier. Only three community-owned mini grids converted to grid-connected small power producers (SPPs), with significant technical support from NGOs. These SPPs no longer provide retail service to customers; their sole source of revenue comes from bulk sales of electricity to the CEB.[88]

In **Southeast Asia**, Kopernik's *Ibu Inspirasi* (Wonder Women) economic empowerment initiative in western Indonesia has supported women to become successful micro-entrepreneurs, selling solar lanterns, water filters and fuel-efficient cook stoves in their communities. Kopernik, a non-profit organisation, works with women to reach very remote communities that are unserved by traditional supply chains. Since 2011, more than 600 women entrepreneurs have sold over 27,000 clean energy technologies to more than 120,000 people in the poorest remote provinces who lack access to electricity, clean water and modern cooking methods.[89]

Another community-based energy access initiative in Indonesia, the Sumba Iconic Island project, invested more than IDR 135 billion (USD 9.5 million) in renewable energy, provided more than 4,000 households with access to electricity, developed numerous training programmes and created more than 30 renewable energy research and development projects.[90] During the initiative, launched by the international NGO Hivos in partnership with 40 to 50 different international and local stakeholders, the electrification rate on Sumba increased from 24.5% in 2010 to 42.67% in 2015, with nearly 17% of the power generated by renewables.[91] The goal is to increase the electrification rate to at least 95%, with all of the electricity produced from renewable resources by 2025.[92]

POLICIES, REGULATIONS AND TARGETS

Strong policy leadership and support is necessary to create partnerships at the regional, national and community levels and to facilitate greater access to low-cost financing for distributed renewables, while also addressing the commercial viability of developing a strong pipeline of bankable projects. Up to an estimated USD 52 billion per year will be required globally to achieve universal electricity access for all, depending on the level (or tier) of energy access that governments aspire to in their national electrification strategies.[93]

Despite putting significant efforts into improving rural energy access (→ see Table 5), many Asia Pacific countries are hampered in their progress towards 100% electrification due to weak policy and institutional mechanisms as well as insufficient national budgets.[94] Rural electrification plans are multi-dimensional and often include extension of the existing grid as well as the promotion of micro-hydropower and off-grid solar technologies, in addition to solar-diesel hybrid and isolated diesel generators.

In the area of clean cooking, neither quantifiable targets nor specific policies have been widely adopted in the region. Only Bangladesh, through its national Improved Cook Stove programme, has set a target to increase access to improved cook stoves, which it exceeded by 50%, distributing 1.6 million cook stoves as of mid-2019.[95]

TABLE 5. Rural Electrification Rates, Targets and Plans in the Selected Asia Pacific Countries (Countries with Less Than 100% Electrification)

Country	Target year for universal access	Share of total population electrified	Share of rural population electrified	Population lacking electricity	Rural electrification plan
Northeast Asia					
Mongolia	2020	86%	56%	1.32 million	National Renewable Energy Program (2005-2020)
South Asia					
Bangladesh	2021	88%	81%	31.3 million	Bangladesh Rural Electrification Board's 100% Electrification Program
India	March 2019 (reportedly achieved)	93%	89%	93.7 million	Deen Dayal Upadhyaya Gram Jyoti Yojana
Pakistan	N/A	71%	63%	57 million	N/A
Southeast Asia					
Indonesia	2020	98%	96%	5.3 million	RUPTL 2019-2028 Rural Electrification Program (LisDes)
Myanmar	2030	43% (October 2018)	40%	16 million	National Electrification Plan
Philippines	2022	88.3%	83%	12.3 million	Philippine Development Plan 2017-2022 Missionary Energy Development Plan (2016-2022)
Viet Nam	2020	98%	98%	1.9 million	Rural Electrification Plan Decision 428: Approval of the Revised National Power Development Master Plan for the 2011-2020 Period with the Vision to 2030; Decision No. 2081 QD-TTg on the Approval of Electricity Supply Programme for Rural, Mountains area and the Islands, Period 2013-2020
The Pacific					
Fiji	2020	96%	91%	0.03 million	Fiji National Energy Policy (2013-2020)
Tonga	N/A	98%	98%	0.02 million	N/A
Total for 10 Asia Pacific Countries		**86%**		**219 million**	

Note: Data provided are for 2017 unless indicated otherwise. N/A = data not available.

Source: See endnote 94 for this chapter.

In **South Asia**, India, Sri Lanka and Bangladesh are leaders in improving energy access, with an innovative mix of strategies and an effective combination of grid extension and off-grid electrification programmes. Light-handed regulations at the national and/or sub-national levels in these countries attempt to streamline private investments in small to medium-scale renewable energy-based rural electrification projects. This enables electricity providers to set retail tariffs for micro/mini-grids without government review and approval, providing space for developers and electricity distributors to design cost-recovery tariffs and lower revenue risks.[96] However, policy makers need to establish a clear policy framework for developing and potentially integrating on- and off-grid energy access solutions, to safeguard mini-grids and related investments as the central grids expand to remote areas.

The Indian government, while committed to extending the central grid to every household, has realised that a combination of grid extension and off-grid solutions is critical in order to achieve universal access to reliable, affordable electricity. The recently approved third phase of the country's Off-grid and Decentralised Solar PV Application Programme targets an additional 118 MW of off-grid solar PV capacity by 2020, at an estimated total cost of INR 18.95 billion (USD 283 million).[97] Central Finance Assistance will provide INR 6.37 billion (USD 90 million) for solar streetlights, solar study lamps and an aggregate 100 MW of solar PV capacity, with up to 25 kWp for individual public installations in areas without grid access or reliable power.[98] This component is aimed mainly at providing electricity to schools, hostels, village councils, police stations and other public service institutions.[99]

In February 2019, the Indian government also approved financial support of more than USD 6.48 billion by 2022 for a residential solar scheme aimed at farmers, group housing societies and resident welfare associations.[100] The scheme will subsidise 40% of the cost of rooftop solar systems up to 3 kW, and 20% for larger systems up to 10 kW.[101] In addition, the Ministry of New and Renewable Energy (MNRE) provides financial assistance to private solar developers under the Grid-Connected Rooftop and Small Solar Power Projects Program. In Tamil Nadu, a subsidy of up to 30% is helping the Ministry achieve its target of 3,500 MW of rooftop solar in the region by 2022.[102]

In the area of mini-grids, India's MNRE, under its Draft National Mini-Grid Policy, has set a target for the installation of 10,000 renewable energy-based mini-grid systems (average size of 50 kW), with a total capacity of 500 MW by 2021 and an estimated capital investment of USD 350-400 million.[103] The Indian state of Uttar Pradesh adopted a mini-grid policy in 2016 that supports private developers in setting up mini-grid power projects smaller than 500 kW.[104] The policy guarantees the developers either an agreed tariff for the electricity generated from the plant by distribution companies or, based on the cost-benefit analysis of the installed project, the project might be transferred to the distribution company at a cost determined mutually by the distribution company and the developer.

In some South Asian countries, legal challenges hinder private participation in the energy sector. In Pakistan, where distributed generation could close the gap for the 20 million people who lack access to electricity, it is illegal for private parties to sell electricity directly to private individuals.[105] The current policy for renewable power development, as well as the 2015 regulation for distributed generation using alternative and renewable energy, allow distributed generation from renewables under 1 MW to be set up for self-consumption, or for purchase/sale to the power utility through net metering.[106] Similarly, in Sri Lanka, the provisions of the Electricity Act give monopoly status to the Ceylon Electricity Board in power generation and thus make it illegal to develop distributed grids except under special approval of the Public Utilities Commission (for example, for very small, remote micro grids unlikely to be connected to the central grid in the near future).[107]

In **Southeast Asia**, where the public utility is the main electricity provider, the degree to which private players are able to participate in power generation varies by country. Thailand was one of the first countries in the sub-region to cover its rising electricity demand by adopting effective regulatory frameworks that allow the private sector to sell electricity directly to industrial and/or residential customers not served by the national utility. The Small Power Producer (SPP) Program adopted in 1992 enabled private companies to supply provincial and metropolitan authorities through distributed generation with capacity below 90 MW.[108] As transmission and distribution infrastructure progressed, the Very Small Power Producer (VSSP) Program, introduced in 2002, enabled distributed renewable energy generation (below 10 MW) to sell power back to the national grid.[109] The programmes have proven successful in reinforcing the national electricity system as well as in providing power in hard-to-reach areas –deep forest, remote mountainous villages and islands. SPP power generation capacity accounted for 20% (9.6 GW) and VSSP for 9% (4 GW) of Thailand's total installed capacity in 2019.[110]

The government of the Philippines allows private sector participation in rural electrification in missionary areas through two schemes: 1) the Qualified Third Party Program in which private sector companies, accredited by the Department of Energy based on financial and technical criteria, provide small-scale electricity supply in rural areas that have been waived by the distribution utility, and 2) the New Private Power Provider Program, which allows private companies to take over the power generation assets of the state utility, NPC, through a competitive process.[111] In the missionary electrification areas, electricity is also served by the Small Power Utilities Group managed by NPC (NPC-SPUG). As of mid-2019, there were more than 270 off-grid generation units operated by NPC-SPUG and over 40 non-NPC small power plants, with total installed capacity of 530 MW (dependable capacity of 417.5 MW), representing 2% of the installed capacity in the Luzon, Visayas and Mindanao regions.[112]

In Myanmar, according to the National Electricity Plan, off-grid solutions are considered as "pre-electrification" of remote and hard-to-reach areas before the national grid reaches these areas. A framework regulating the integration of mini-grids upon the arrival of the national grid is in the draft stage. The government encourages private developers to build mini-grids at a distance greater than 16 kilometres from the existing network on a build-own-operate-transfer basis, offering a subsidy of up to 60% of the project cost.[113] National electrification plans, however, need to reflect the changing nature of the sector, including technology development, cost reductions, regional development and discrepancies between the projected demand and reality to successfully integrate both centralised and decentralised initiatives.

In Indonesia, in the past, favourable ministerial regulations promoted small and medium-scale distributed renewable energy projects (below 10 MW) in remote locations by setting higher cost-recovery ceiling tariffs, and allowed them to sell their power production or surplus power to the local grid (if readily accessible).[114] However, the newer Ministerial Regulation No. 50 of 2017, on the use of renewable energy for power supply, is seen as disincentivising.[115] It does not differentiate energy sources and allows the maximum price ceiling to be set at only 85% of the area's basic cost of electricity generation, which is set annually based on recommendation from the state utility, PLN.[116] Investors also must transfer their renewable energy projects to PLN at the end of their power purchase agreements.

In Indonesia's latest 10-year Electricity Supply Business Plan (2019-2028 RUPTL), renewable energy and gas developers with projects below 10 MW can propose directly to PLN without being included in the annual RUPTL to enable rapid additions of small-scale capacity.[117] The 2018 regulation from the Ministry of Energy and Mineral Resources governs the general requirements and procedures for the installation of rooftop PV systems by PLN customers.[118]

INVESTMENT AND FINANCING FOR ENERGY ACCESS

According to IEA estimates, achieving universal access to electricity worldwide by 2030 will require investments of up to USD 52 billion annually, depending on governments' commitments, while universal access to clean cooking fuels and technologies may require USD 3 billion annually.[119] The current investment in these sectors in the Asia Pacific region is below what is needed. However, ascertaining accurate levels of investment in off-grid energy access remains challenging: aside from the larger investments reported in the region, financial reporting is inadequate because of limited information from national budgets and private sources, and because energy access programmes are wide ranging and are often integrated with other priority areas.

Global investment in off-grid solutions, including mini-grid technologies, increased from an estimated USD 210 million in 2013-2014 to USD 380 million in 2015-2016.[120] However, this accounts for only a tiny fraction (1.3%) of the total energy investment worldwide.[121] More than half of the global investment in off-grid solutions in 2013-2014 went to three countries in the Asia Pacific region: Bangladesh, India and the Philippines.[122] In India, of the total USD 10 billion in electricity-related investments in 2015-2016, only 2% – or around USD 200 million – went to off-grid solutions.[123] Nearly all of the financing for mini-grids and off-grid solutions in the region has come from international sources, mainly bilateral and multilateral development financial institutions, private equity investments and venture capitalists.[124]

> Global investment in off-grid solutions accounts for **only a tiny fraction (1.3%)** of total energy investment worldwide.

Although a combination of public and private finance is addressing the gap in financing for decentralised energy projects, financing for end-users remains a challenge in the Asia Pacific region. Because of the resource-intensive nature of DREA projects, solutions often remain in the hands of non-profit organisations and social enterprises. In South Asia, the non-profit Grameen Shakti has promoted solar home systems in Bangladesh through a rural network of microfinance branches and has developed a sales strategy to boost consumer access to finance with a low interest rate.[125] In India, the private social enterprise SELCO has used a "lease-to-own" approach to promote solar home systems in the south.

In Bangladesh, China, Indonesia and Mongolia, the World Bank has piloted result-based financing to help private companies enter clean cookstove markets, advancing technologies, performance levels and delivery models for high-quality improved stoves.[126] The four-phase Indonesia Clean Stove Initiative, a collaboration between the World Bank and the government of Indonesia, was launched in 2014 to incentivise market-based solutions for clean cooking, and targets and rewards market aggregators that demonstrate successful delivery of these solutions. Between 2014 and 2016, the initiative attracted 10 private businesses to participate in the pilot and was successful in stimulating innovation in technology and business models for delivering clean cooking solutions at the local level.[127]

In Myanmar, the IFC's Lighting Global initiative is in the process of introducing RBF to promote quality-verified off-grid solar products, with initial funding of USD 3.45 million, aiming to replace the highly subsidised distribution of solar products under the existing government off-grid programme.[128] The country's solar market is attracting private companies – such as SolarHome, Greenlight Planet, Niwa, ovSolar and d.light – that need support in reaching out to remote rural customers.[129]

The Asia Pacific region also has attracted investments in rural electrification from large energy players and corporations, many of which enter the market by providing venture and impact equity investment in energy start-ups (→ see Table 6).[130] For example, Shell and Engie, along with Swedfund, have invested in India-based Husk Power, and Engie also recently backed a private company, Mandalay Yoma, installing commercial solar rooftop projects and community-based mini-grids in Myanmar.[131] Schneider Electric's Access to Energy programme, in addition to facilitating investment transactions, partners with companies in India, Myanmar and the Philippines to develop local mini-grid markets through technology solutions and skills development.[132]

In the state of Jharkhand in India, Azure Power, one of the largest developers and operators of utility-scale solar assets in India with a market capitalisation of just under USD 400 million, joined large corporations (Mitsui, Engie and E.ON) in entering the mini-grid market.[133] Azure, under its M-Power programme, was awarded its first mini-grid project by Jharkhand Renewable Energy Development Agency to electrify 320 households across 11 villages in the state, where 3 million households still lack access to electricity.[134]

Current investment levels are below what is needed to achieve **universal electricity access** in Asia by 2030.

TABLE 6. Key Investments in Off-grid/Mini-grid Companies in the Selected Asia Pacific Countries

Company	Investment Raised	
ME SolShare (Bangladesh)	USD 1.66 million	Innogy New Ventures LLC, Energias de Portugal and Singapore's IIX Asia Growth Fund
	USD 1 million	UN DESA Award, 2018
Azure Power (India)	USD 135 million	IFC, Dutch development bank FMO, Société de Promotion et de Participation pour la Coopération Economique (Proparco), and Oesterreichische Entwicklungsbank AG (OeEB), 2018
	USD 30.5 million	FMO, 2017
	USD 20 million	US Overseas Private Investment Corporation, 2016
Husk Power (India)	USD 20 million	Royal Dutch Shell, Engie and Swedfund International, 2018
	USD 5 million	Bamboo Finance, Acumen Fund and LGT Venture Philanthropy, 2012
Mera Gao (India)	USD 2.5 million	ElectriFI, Engie Rassembleurs d'Energies and Insitor, 2017
	USD 500,000	Interchurch Cooperative for Development Cooperation, 2015
	USD 300,000	Seed funding (USAID Development Innovation Ventures (DIV), 2011
OMC Power (India)	USD 9 million	Mitsui & Co, 2017
Simpa Energy (India)	USD 2 million	Equity (ADB, 2013)
	USD 968,000	USAID DIV (2013)
	Undisclosed (2018)	90% acquired by Engie and subsequent investment
Mandalay Yoma (Myanmar)	Undisclosed	Estimated investment size in realm of USD 2-5 million (Engie)
Solar Home (Myanmar)	USD 10 million	In debt (Crowdcredit, Trine, 2018)
	USD 4.2 million	In convertible note funding (TRIREC, Insitor Impact Asia, Beenext and a group of Singapore-based family offices, 2018)
	USD 1 million	Equity funding (TRIREC, 2019)
Yoma Micropower (Myanmar)	USD 28 million	Equity and debt (IFC, Norfund, Canada and Yoma Strategic Holdings)

Source: See endnote 130 for this chapter.

Public Financing and Development Assistance

Public capital can play a key role in providing early start-up financing to off-grid energy access projects to reduce the risks and barriers to enable private commercial capital to enter the energy access market at scale.

In **South Asia**, the Indian government has created various instruments for accelerating energy access, including the recently introduced scheme *Kisan Urja Suraksha evam Utthaan Mahabhiyan* (KUSUM) for farmers to harness solar energy for better financial and water security. With a budget of INR 344 billion (USD 5 billion), the scheme plans to install decentralised grid-connected renewable power plants as well as off-grid and on-grid solar water irrigation pumps, for a total solar capacity of 25.75 GW by 2022.[135] Under KUSUM, farmers and agricultural collectives can set up solar power plants ranging from 500 kW to 2 MW on barren or cultivable land and sell power to distribution companies at feed-in tariff rates determined by the respective State Electricity Regulatory Commission. The scheme is designed to provide stable and continuous income for rural landowners, while distribution companies will receive performance-based incentives of INR 0.40 (USD 0.056) per unit for five years.[136]

Administered by MNRE, the Indian Renewable Energy Development Agency (IREDA) provides financing to renewable project developers, funded by the Indian government with financial and technical support from the German development bank KfW, the French development bank AFD, the Nordic Investment Bank, the European Investment Bank, JICA, the World Bank, ADB and other international financial institutions, agencies and investors. Eligible renewable energy and energy efficiency project developers have access to the following financial programmes: concessional loans up to 70% of the project costs of energy-efficient equipment; 0.5% to 1% interest rate rebates on renewable energy projects; financial assistance through a 50% discount on the initial costs of project implementation, including processing, inspection, legal and front-end fees related to renewable energy installations; credit lines from IREDA to eligible intermediaries to lend and/or lease energy-saving equipment; and various tax benefits.[137]

Countries in **Southeast Asia** are recognising that government support is critical for deploying DREA systems. Thailand has established several financial programmes to encourage energy efficiency and renewable energy-related projects in the public and private sectors. The country's Energy Conservation Fund (ENCON Fund) supports energy conservation-related programmes and activities, including energy efficiency improvement, renewable and alternative energy development, research and development projects, human resources development, and public awareness and education campaigns.[138] It also funds tax incentives, the Energy Service Company Fund and the Energy Efficiency Revolving Fund. The ENCON Fund has engaged commercial banks to develop and streamline procedures for appraising and financing energy efficiency projects – helping to unlock a bottleneck in energy efficiency financing – by providing them with a credit line with 0% interest and seven-year final maturity as an incentive to lend for energy efficiency projects at a maximum interest rate of 4%.[139]

In 2018, the Department of Energy of the Philippines issued guidelines for the operationalisation of a Renewable Energy Trust Fund for research, development and promotion of renewable energy sources.[140] The funds will be obtained from various sources, including emission fees, grants, contributions and donations. With some of the highest tariff electricity rates in the region, combined with government incentives for off-grid electrification, the Philippines' off-grid market is particularly attractive for private investment.[141]

In **The Pacific**, ADB is supporting Tonga in its ambitious transition to a cleaner and more sustainable energy mix. Tonga plans to develop wind and biomass generation sources and to integrate these with multiple units of battery energy storage under the Tonga Renewable Energy Project.[142] Through a USD 12.2 million grant, together with grants from the Green Climate Fund (CGF) (USD 29.9 million) and the government of Australia (USD 2.5 million), the country aims to reduce its dependency on imported diesel.[143]

Barriers to Financing Off-Grid Energy Access

> Countries are recognising the need for **government support** to foster off-grid energy access projects.

The primary reason for the lack of private sector interest in building electricity generation and distribution systems in remote areas with challenging terrain and low energy demand is the high capital cost. In the Philippines, for example, despite high electricity tariffs and government incentives for rural electrification, private companies are not showing strong interest in energy access initiatives. In some cases, complicated permitting processes and the associated costs and time required for permitting dampen private sector interest in investing in electrification.[144]

Although off-grid solar markets are active globally, a major issue is the absence of an appropriate investor class, which can support the sector by propelling the growth phase of the existing off-grid players. In addition, there is a lack of early-stage equity investors that could support the emerging off-grid players. Table 7 lists the key barriers that off-grid providers face in accessing capital.[145]

TABLE 7. Key Barriers for Off-grid Solar Providers in Accessing Capital

Barrier	Description
High off-taker credit risk	• High cost of debt financing due to rural customers being off-takers with low levels of income and uncertain levels of demand • Lack of financial performance data for credit evaluation • Assets are not being accepted as collateral
Lack of project finance	• High cost for feasibility studies borne by the providers • Off-grid, small-scale systems are difficult to finance
Lack of capacity	• Providers lack the capacity and resources to access grants or concessional finance • Lack of capacity on the investors' side to identify suitable projects
Scale of investments	• Small ticket sizes of the projects lead to high transaction cost
Exit options/liquidity	• Uncertainty in long-term commercial viability due to lack of long-term operational and performance data and subsequent phasing out of public capital • No standard exit options for equity investors
Policy/Regulatory risks	• Concerns about long-term sustainability of off-grid systems, especially mini-grids as the main grid expands • Lack of dedicated policies and regulations on long-term integration of off-grid infrastructure, especially risks associated with licensing provision, tariff setting, main grid arrival and design of public financial support for mini-grids
Other commercial/market barriers	• Lack of tools in predicting demand and end-user financing, resulting in uncertainty of realised output of the off-grid business models • Excessive market volatility due to longer investment horizons for off-grid provision • Lack of mature mobile money market for advancement of innovative end-user financing

Source: See endnote 145 for this chapter.

04 POLICY LANDSCAPE

Sometimes linked to climate policies, renewable energy policy frameworks **vary greatly in size and ambition** across the region.

04 POLICY LANDSCAPE

Policy support for renewable energy in Asia and the Pacific is diverse because of the wide-ranging income levels, GDP growth and economic development across countries. Policy makers have the opportunity to design an effective mix of support policies tailored to their respective jurisdictions, which would evolve as the costs of renewable technologies decline, particularly due to rapid development in countries such as China and India.

National renewable energy policy frameworks vary greatly in scope and comprehensiveness, with some linked to countries' decarbonisation commitments and climate policies. Regionally, ASEAN member states jointly outlined in the Plan of Action for Energy Cooperation (2016-2025) aspirational targets to achieve a share of 23% renewables in the ASEAN energy mix by 2025 and to reduce energy intensity 20% by 2020 based on 2005 levels.[1]

High-income countries in **Northeast Asia** – Japan and the Republic of Korea – have adopted targets to increase the share of renewables in the electricity generation mix and to improve energy efficiency. In countries with rapidly growing industries – such as China, India, the Philippines and Thailand – policies are aimed at reducing the carbon intensity of economic development. Other countries across the region have adopted some degree of supportive policies, regulations or fiscal incentives to boost the renewable energy sector. Countries in **Central Asia** and **The Pacific** that have rich fossil fuel resources or dependencies – as well as outliers like Myanmar that have weak support for renewables from policy makers – have seen more limited progress, and the sector continues to struggle.

OVERVIEW OF POLICIES AND TARGETS

Renewable energy support policies and targets were present at various levels of government in all 18 selected countries in the Asia Pacific region as of mid-2019. In most countries, they are combined with energy efficiency targets. FITs are the most common support mechanisms in these countries but are gradually being phased out or replaced with renewable energy auctions. Quotas or mandated targets are less common, and net metering has been introduced in some countries. With regard to fiscal incentives and public financing, countries have in place capital subsidies or grants, investment tax credits and customs duty exemptions, as well as public loans and grants. Energy production payments remain the least common policy support tool.

A detailed overview of policy support and incentives for renewables in the region is provided in Table 8.[2]

In 2016 ASEAN member states pledged to achieve a target of **23% renewables** in the ASEAN energy mix by 2025.

TABLE 8. Overview of Policy Support and Incentives for Renewables in the Selected Asia Pacific Countries

Country		Regulatory Policies							Fiscal Incentives and Public Financing				
	Renewable energy law / act	Renewable energy targets	Energy efficiency targets	Biofuel blend obligation/mandate	Feed-in tariff/ premium payment / renewable energy certificates	Tendering / auctions	Electric utility quota obligation / renewable portfolio standard (RPS)	Net metering / billing	Public investment, loans, grants, capital subsidies or rebates	Investment or production tax credits / tax breaks / customs duty exemptions	Reductions in sales, energy, CO_2, VAT or other taxes	Energy production payments	Public Investment, loans, grants
Northeast Asia													
China	●	●		●	●	●	●			●	●	●	●
Japan	●	●	● B	●	●	●			●	●	●		●
Mongolia	●	●	●		●				●	●	●		D
Republic of Korea	●	☆		●	●		●	●	●	●	●		●
Central Asia													
Georgia			● B,T,I					●					
Kazakhstan	●	● P	● B, A, T, I		●	☆		●	●		●		●
Uzbekistan	★	●	●			★				★	★	★	
South Asia													
Bangladesh		●	●	●		●	●	●	●	●	●		●
India		● BF	● B, H	●	●	●	●	◖	●	●	●	●	●
Pakistan		D			D	D		●	●		D		●
Sri Lanka	●	● P	● B		●	●		●		●	●		●
Southeast Asia													
Indonesia		● P, BF	D, B	●	Price Cap	●	●	●		●	●		●
Myanmar		●				●					●		●
Philippines	●	● P, BF	● B, A, H, C	●	☆ (April 2019)		●	●	●	●	●	●	●
Thailand		☆			☆ (2019)	●		★		●		●	●
Viet Nam		●	●	●	★	D	●	●	●	●	●	●	●
The Pacific													
Fiji		● P, BF		●	●				●	●			●
Tonga		●	●	●									

Legend: ★ = New; ☆ = Revised; D = Drafted

Policies: ● = Existing **national** policy or tender framework (could include sub-national); ◖ = Existing **sub-national** policy or tender framework (but no national)

Renewable Energy Targets: P = Power; H = Heating; BF = Biofuel mandates

Energy Efficiency Targets: B = Building standards; A = Appliance standards; H = Heating; C = Cooling; T = Transport; I = Industry

Source: See endnote 2 for this chapter.

POLICY LANDSCAPE

POWER SECTOR

Most countries of the Asia Pacific region have given considerable attention to renewable power as a means to improve energy security, reduce air pollution and provide cost-effective electricity access (→ see Distributed Renewables chapter). This section provides an overview of adopted policies and renewable energy targets for the power sector, highlighting countries' specific plans and roadmaps for achieving them. See also Table 9 for an overview of national targets and plans.[3]

All 18 countries currently have renewable energy **policies and targets** in place.

TABLE 9. Overview of Renewable Energy Plans and Targets in the Power Sector in the Selected Asia Pacific Countries

Country	Renewable energy targets	Plans related to achieving the targets
Northeast Asia		
China	• 15% non-fossil fuel-based primary energy consumption by 2020, including installed capacity of: 210 GW wind, 110 GW solar, 340 GW hydro, 15 GW biomass, 0.55 GW other renewables • 20% non-fossil fuel-based primary energy consumption by 2030	• 13th Electricity Development Five Year Plan (2016-2020) • Strategic Energy Action Plan (2014-2020) • Renewable Portfolio Standard plan (draft) • 13th Renewable Energy Development Five-Year Plan (2016-2020)
Japan	• 22-24% renewables in the energy mix by 2030	• Strategic Energy Plan (authorised by Cabinet in 2018)
Mongolia	• 20% renewable generation by 2023; 30% by 2030	• State Policy on Energy, 2015-2030
Republic of Korea	• 20% renewable generation by 2030, with 58.5 GW of installed capacity (mainly solar and wind); 35% by 2040, with 103 GW to 129 GW of installed capacity (proposed revision)	• 3rd National Energy Basic Plan (2019) • 8th Basic Plan for Long-Term Electricity Supply and Demand (2017)
Central Asia		
Georgia	• 30% renewable generation by 2020 (proposed)	• First National Renewable Energy Action Plan (draft) • New Energy Policy (2015)
Kazakhstan	• 3% renewable generation by 2020 • New installed capacity of 1,700 MW by 2020, including 933 MW wind, 467 MW solar, 290 MW hydro, 10 MW biogas • 10% renewable generation by 2030, including 5 GW wind and 500 MW solar • 50% renewables in the energy mix by 2050	• Strategy Kazakhstan 2050: A New Political Course of the Established State • Concept for the Republic of Kazakhstan's Transition to a Green Economy (2013)
Uzbekistan	• 21% renewables in power generation by 2031, including at least 4 GW solar PV • More than 1 trillion kWh electricity generated from wind by 2030	• Action Program on Renewable Energy Development for 2017-2021

Country	Renewable energy targets	Plans related to achieving the targets
South Asia		
Bangladesh	• 10% renewable generation by 2020 (2.47 GW capacity)	• Power System Master Plan 2016
India	• 40% of installed power generation capacity from clean energy sources by 2030 • 175 GW by 2022, including 100 GW solar, 60 GW wind, 10 GW bio-power, 5 GW small-scale hydro	• Announcements in line with country's Intended Nationally Determined Contribution • MNRE Year End Review 2018
Pakistan	• 25% of generation capacity from alternative and renewable energy technologies by 2025 (including solar, wind, geothermal, biomass, biogas, syngas, waste-to-energy, storage systems, ocean/tidal and hybrids) • 30% from alternative and renewable energy technologies by 2030 • 30% large-scale hydro (more than 50 MW) in total generation	• Renewable Energy Policy 2019 (draft)
Sri Lanka	• 20% from non-conventional renewables (except large-scale hydro) by 2020; 50% by 2030	• Long Term Electricity Generation Plan 2018-2037 (draft)
Southeast Asia		
Indonesia	• 23% renewable electricity by 2025	• Electricity Supply Business Plan 2019
Myanmar	• No target adopted	• Myanmar Energy Master Plan (December 2015)
Philippines	• 50% renewable-based capacity by 2030, from 5.4 GW to 15.3 GW by 2030 (update expected in late 2019) • 81 MW of geothermal power capacity by 2021	• Renewable Energy Roadmap • National Renewable Energy Program
Thailand	• 20% renewables in power generation by 2037, adding 20.766 GW of new capacity • 3 GW of wind power capacity by 2036	• Power Development Plan (PDP, 2018-2037) • 2015 Alternative Energy Development Plan (AEDP, revision expected in late 2019) • New Energy Reform 2018-2022
Viet Nam	• 9.9% installed renewable energy capacity by 2020 (800 MW wind, 850 MW solar); 21% by 2030 (6 GW wind, 12 GW solar) • 7% renewable generation by 2020; above 10% by 2030	• National Power Development Master Plan ("PDP VII") for the 2011-2020 Period with the vision for 2030 (seventh revision, 2016)
The Pacific		
Fiji	• 80% renewable generation and 18% renewables in total energy consumption by 2020; 100% by 2030	• 5-Year & 20-Year National Development Plan • National Energy Policy 2013-2020 • 10 Year Power Development Plan 2017-2026 • Fiji NDC Implementation Roadmap 2017-2030
Tonga	• 50% renewable generation by 2020, 70% by 2030	• Tonga Energy Road Map 2010-2020

Source: See endnote 3 for this chapter.

Countries in **Northeast Asia** are diversifying their energy mixes to reduce dependence on fossil fuels. China, Japan and the Republic of Korea all have adopted mechanisms and policies and provide various renewable energy incentives towards the low-carbon transition (→ see Sidebars 7, 8 and 9 for details).[4]

Despite policies to encourage investments, the total installed renewable energy share in Bangladesh **remains at 1.5%.**

Central Asia shifted its attention to renewable energy development more strongly after 2015, focusing on wind and solar power with assistance from development institutions and banks. Mongolia amended its 2007 Renewable Energy Law in 2015 to replace unsuccessful fixed payment FITs with feed-in premiums that are added on top of the market energy price. A second amendment was proposed to the Mongolian parliament for discussion and approval in October 2018 to cap the tariffs for renewables and introduce auctions.[5] The government also improved regulation for power purchase agreements (PPAs) and developed several projects with assistance from ADB and Japan. Georgia is developing its National Renewable Energy Action Plan in compliance with EU directives to set national targets for the renewable energy share and grid standards for the integration of renewables into the national power system.[6]

In **South Asia**, national and (in the case of India) sub-national policies exist to promote increased shares of renewables in power generation. In 2008, both Bangladesh and Sri Lanka adopted policies to encourage investments in renewable energy projects, and Sri Lanka plans to install

SIDEBAR 7. Selected Countries in Transition to Renewable Energy

Pakistan's Updated Renewable Energy Policy to Be Approved

Pakistan is updating its 2006 Renewable Energy Policy, with the outcome expected later in 2019. The revised policy aims to increase the renewable share in power generation from the current 4% to a target of 25% of total installed capacity from "alternative and renewable energy technologies" by 2025 and 30% by 2030. The country holds huge renewable energy potential, particularly for wind and solar.

The technologies included in the updated policy include solar PV, wind, geothermal and biomass, as well as biogas, syngas, waste-to-energy, storage systems, ocean/tidal power and various hybrids. Large-scale hydropower is not included in the targets and is expected to account for 30% of the 2030 power generation capacity (up from 25% today). While the 2006 policy provided multiple incentives for the private sector to develop renewable energy projects, it is not clear what mechanisms and action plans will be put in place under the new policy to create a favourable environment for co-ordination among various departments dealing with the renewables sector.

Indonesia to Increase Its Renewable Generation Share

Although Indonesia's generation mix still relies heavily on fossil fuels to meet the country's energy needs, the national Electricity Supply Business Plan 2019 (RUPTL 2019-2028) promotes the use of renewable energy sources. The renewable share in the power mix is less than 15%, mainly from hydropower plants (around 8%) and geothermal plants (5%). Solar PV accounted for only 0.16% and wind for 0.13%, with installed capacities of 105.8 MW and 85.1 MW, respectively. Under the RUPTL, the country targets a 23% (5 GW) renewable share in 2025, with hydropower accounting for 10.4%, geothermal for 10.6% and other renewables for 2%. The additional installed capacity required is 16.7 GW, including 9.5 GW of large-scale hydropower, 4.6 GW of geothermal power and 2.6 GW of other renewables. Mini-hydro is forecasted to grow rapidly from a low base, with a 90% increase compared to the allocation in the previous RUPTL, adding 1.5 GW of capacity.

The RUPTL also calls for more independent power production, which will be able to feed electricity to the public grid managed by PLN, supporting the addition of 3.2 GW of rooftop solar PV capacity, as presented in the plan.

The Republic of Korea's Roadmap to Renewables

The Republic of Korea, Asia's fourth largest economy, relies on coal and nuclear energy to produce around 70% of its electricity, powering the growth of the country's energy-intensive industries. Historically, energy policy in the country was directed at supporting its industrial and economic policies; however, worsening air pollution and ambitious carbon emission targets have led it to diversify its generation mix.

In the Renewable Energy 3020 Implementation Plan, the Korean government revealed an ambitious roadmap to achieve 20% renewable energy production by 2030, up from the current 7%. In April 2019, the Ministry of Trade, Industry and Energy pledged to raise the renewable share of the country's power output to as much as 35% by 2040 to reduce dependence on coal and nuclear. The country's general principles and frameworks for energy development are renewed every five years in National Energy Master Plans outlining 20-year goals, while specific targets are mentioned in Basic Plans of Electricity Supply and Demand, published every two years.

Source: See endnote 4 for this chapter.

a total of 200 MW of solar PV projects by 2020, and 1 GW by 2025.[7] However, the total installed renewable energy shares in these countries are still low, at 1.5% and 15% (excluding hydropower), respectively.[8]

In **Southeast Asia**, Viet Nam has prioritised renewable energy in the seventh revision of its Power Master Plan.[9] In May 2018, the government issued a new decree on public-private partnership (PPP) investments, aimed at removing common difficulties and obstacles in the implementation of PPP projects.[10] Recent regulations on renewable energy (solar PV, including rooftop installations, and wind) have generated rising interest from foreign investors and potential sponsors.[11] In Indonesia, despite the large potential for renewables, tariffs for renewable energy projects are capped at 85% of the utility generation cost, which is unfavourable for the IPPs whose costs of supply differ according to the location and resource available.[12] In December 2017, the Department of Energy of the Philippines adopted renewable portfolio standards (RPS) aimed at increasing the renewable generation share to 35% by 2030, with 2019 as the transition year to allow mandated participants to prepare for full RPS compliance starting in 2020.[13]

Governments in **The Pacific**, driven by their dependence on imported fossil fuels, are setting targets to achieve 100% renewable energy generation in the power mix. Fiji's commitment to increasing renewable energy generation, as stated in the National Energy Policy of 2014 and the 10-year Power Development Plan for 2017-2026, will require FJD 2.4 billion (USD 1.1 billion) for power generation, transmission and distribution assets, for which the country plans to attract investments from the private sector as IPPs.[14]

Liberalisation and Deregulation to Enable Renewables in the Power Sector

Deregulation of utilities in the Asia Pacific region in favour of renewables is essential to enable power producers to utilise energy resources efficiently using cost-reflective tariffs within a competitive market, encouraging foreign direct investment in the development of new and smart energy infrastructure.[15] The Fukushima nuclear disaster in 2011 prompted Japan to accelerate the adoption of electricity retail competition, deregulation and renewables to ensure energy security. These measures have resulted in around 600 players entering the Japanese energy market in the past three years, including new domestic companies as well as foreign companies (→ see Sidebar 8).[16]

Utilities in **Southeast Asia** have yet to be unbundled. In the Philippines, the Electric Power Industry Reform Act of 2001 (Republic Act 9136) was enacted to institute reforms in the energy industry, mainly to privatise the generation assets of the National Power Corporation.[17] The privatisation, facilitated by the Power Sector Assets and Liabilities Management Corporation, benefited consumers in the country's urban centres, resulting in fully liberated markets.[18] However, providing competitive services to rural markets remains a challenge.

Thailand, as a part of International Monetary Fund and World Bank recommendations, unbundled the assets of the Electricity Generating Authority (EGAT) and introduced laws for market deregulation.[19] The country's National Power Development Plan for 2018-37 emphasises greater participation from private companies in power generation.[20] The plan is expected to take effect in 2019, after which four interrelated plans – on oil management, natural gas supply, alternative energy development, and energy savings and efficiency – would be drawn up and integrated under the country's energy reform plan.[21] Part of the plan is to increase interconnections with neighbouring countries.

In **The Pacific**, the main generator and distributor of grid-based power in Fiji, state-owned Energy Fiji Limited, which supplies an estimated 90% of the population with installed capacity of 316 MW, has been partially privatised.[22] The country's 5-Year & 20-Year Development Plan encourages further private sector participation in the electricity sector by developing an IPP framework.[23] Some IPPs, such as Tropik Wood Industries Limited, Fiji Sugar Corporation and Nabou Green, already operate generation plants with a combined capacity of 44 MW.[24] Hydro Fiji Ltd. has a 30 MW hydropower plant in the pipeline.[25]

SIDEBAR 8. Electricity Reforms in Japan, Post-Fukushima

Following the closure of the damaged Fukushima nuclear power plant in 2011, Japan experienced an energy crisis that resulted in skyrocketing electricity prices in the country. The government has since focused on diversifying its energy mix and increasing energy self-sufficiency by deregulating the energy market. This process, initiated in 2016, has turned Japan into one of the largest deregulated electricity markets globally, allowing private sector participation in the generation and retail business.

As a step towards greater diversification of the energy market, the government established a non-fossil value trading market, where the non-fossil value of renewable power is separated and certified by the government. Electricity retailers can purchase non-fossil certificates, and 44% or more of their sales are required to be non-fossil by 2030.

In July 2018, the administration of Prime Minister Shinzo Abe approved the 5th Strategic Energy Plan as a basic direction of Japan's energy policy to 2030. The plan focuses on strengthening energy security; implementing energy conservation and renewable energy policies; and balancing public interest issues with market liberalisation and growing competition.

Among the most ambitious goals is to raise Japan's energy self-sufficiency from around 8% in 2016 to 24% by 2030. However, the plan also revokes the previous government's policy of phasing out nuclear power and aims to restore nuclear as a key baseload electricity source, raising its share to 20-22%. Renewable energy is planned to be the major power source, comprising 22-24% of the 2030 power supply (up from less than 10% in 2016), but no clean energy roadmap is in place. The next phase of power sector reforms will come into effect in 2020, unbundling 10 major utility companies and potentially helping to boost the growth of the renewables sector.

Source: See endnote 16 for this chapter.

Grid Integration of Renewables

Several countries in the region are taking direct steps to ease the integration of renewable energy – particularly variable renewables such as wind and solar – into electricity grids. In addition to its ongoing efforts in this area, India's MNRE recently allowed off-grid solar plants to be connected to the grid with net metering capabilities, in cases where an existing off-grid solar plant was installed at a location where grid supply became available at a later date.[26] The Ministry's goal is to ensure optimal use of assets; however, conversions like this will be subject to applicable regulatory provisions, and the cost will be borne by state governments.[27]

In Myanmar, the government has been reluctant to increase the share of variable renewables (solar and wind) due to a weak transmission network. However, market research and industry experts familiar with the country's grid network suggest that 10-19% integration of renewables is possible without significant grid issues.[28] Policy makers and the industry will closely observe the country's first grid-connected solar PV plant – with 170 MW of capacity, of which the first 40 MW came online in June 2019 – as it could create a precedent for developing grid integration guidelines for renewables.[29]

In line with improving its existing legislative framework in compliance with EU directives, Georgia must harmonise its energy market with the EU standard – creating a grid code for integrating renewables into the national power system – as well as finalise its National Renewable Energy Action Plan. China, meanwhile, is facing challenges balancing its renewable energy generation with its fossil fuel power capacity, resulting in curtailment of renewables alongside overproduction from fossil fuels (→ see Sidebar 9).[30]

Japan is one of the largest deregulated electricity markets globally.

SIDEBAR 9. China Curtails Renewables While Struggling with Overproduction from Fossil Fuels

China's 13th Five-Year Plan for Energy Development (2016-2020) includes strategies for a clean energy transition, in line with the country's commitment to low-carbon development. China plans to reduce its energy consumption by 15% per unit of GDP compared to 2015 levels and to increase the renewable share in its coal-heavy power generation to 15%, up from 11.4 % in 2015. Besides increasing renewable energy capacity, the plan also supports the interconnection of wind, solar and biomass energy, one of China's biggest challenges in renewable energy development.

As a result of economic downturn and scaling down energy-intensive industries, in 2016 China saw its lowest use of existing power generation capacities since 1978. However, in 2018 coal mining and coal power generation increased in the country – and the world experienced record high coal emissions – as Chinese provinces, encouraged by economic stimulus measures, turned back to smokestack industries to boost local economies in rust-belt regions. The country's prioritisation of traditional fossil fuel power plants in combination with transmission bottlenecks and curtailment of renewable energy, particularly wind and solar in the western regions, prevents renewable electricity from reaching the grid.

Following record curtailment of wind power in 2016, when 17% of China's wind energy was wasted, the situation has improved as a result of new regulations capping curtailment levels as well as policies to expand electrification, encourage direct trade in renewables among large consumers and build new transmission lines. In April 2019, the National Energy Administration lifted the ban on building coal power plants in 11 provinces that previously had been prevented from new construction due to overcapacity concerns.

The current 13-Five Year Plan for Energy focuses on abating curtailment; shutting down inefficient coal-fired boilers; investing in new hydropower, energy storage and nuclear power projects; and increasing the network of smart grids and ultra-high-voltage power transmission. In late 2018, China re-emphasised its aim to keep wind curtailment below 10% in 2019 and 5% in 2020, and in May 2019 it released its renewable energy obligation policy to guide the mandatory quota for renewable electricity use required from different market players.

Source: See endnote 30 for this chapter.

Energy Efficiency Policies and Targets

Energy efficiency targets in the Asia Pacific region often exist as a result of political aspirations or international commitments, yet many countries lack the policies and laws necessary to realise concrete improvements in energy efficiency. However, some countries have integrated their energy efficiency strategies and enforcement mechanisms into sectoral programmes and regulatory processes.

Because the region is one of the world's most energy intense, national governments are determined to decouple GDP growth and energy consumption through strong demand- and supply-side improvements backed by policy incentives. Unlocking the region's energy efficiency potential across all sectors will require technology leapfrogging and investments in advanced energy systems, power grid upgrades and retrofitting existing plants, as well as incentivising purchases of energy-efficient equipment and appliances.

In the context of rapid economic growth, countries are focused on reducing the energy intensity of major industries. Japan's longstanding commitment to improving energy efficiency focuses on energy conservation in the residential and industrial uses of electricity.[31] The Ministry of Economy, Trade and Industry prepared a roadmap for a Net Zero Emissions House, where annual net consumption of primary energy is zero.[32] Viet Nam scores the highest in energy efficiency among all developing countries, thanks to the successful implementation of load-shedding incentives to avoid a shortage of electrical capacity, in collaboration with the public utility as well as large consumers.[33]

Feed-In Tariffs and Auctions

Traditionally, the most common mechanism in place to support renewable energy development in the Asia Pacific region has been FITs (→ see Table 10).[34] However, several countries have revised or discontinued their FITs in recent years in response to evolving market trends. In some cases, FITs were replaced by auctions to reflect recent declines in solar PV costs and to prevent over-subsidisation in markets where renewables can compete with traditional power sources.

Table 10. Selected Feed-in Tariff Schemes in the Asia Pacific Region as of 2019

Details	Solar PV (per kWh)			Wind (per kWh)		Other (per kWh)
	Ground mounted	*Rooftop*	*Other*	*Onshore*	*Offshore*	
Northeast Asia: China						
Differentiated solar FITs according to the location were updated in April 2019 and effective starting July 2019. A new wind FIT released in May 2019 will change from a fixed FIT to a bidding FIT with the upper limit set by the Chinese government as the guidance price.	RMB 0.4-0.55 (USD 0.056-0.078) Village-level PV plants for poverty alleviation: RMB 0.65-0.85 (USD 0.092-0.12)		Commercial and industrial distributed PV power generation: RMB 0.1* (USD 0.014) Residential (self-consumption plus excess feed-in/100% feed-in): RMB 0.18 (USD 0.025)	2019 guidance price: RMB 0.34-0.52 (USD 0.049-0.076) 2020 Guidance Price: RMB 0.29-0.47 (USD 0.042-0.069)	2019 guidance price: RMB 0.8 (USD 0.12) 2020 guidance price: RMB 0.75 (USD 0.11)	
Central Asia: Kazakhstan						
FITs approved by government decree No. 645 of 2014	Solar PV* installations: KZT 34.61 (USD 0.1) Solar PV installations using Kazakhstan silicon: KZT 70 (USD 0.21)			KZT 22.68 (USD 0.068)		Small-scale hydropower: KZT 16.71 (USD 0.05) Biogas: KZT 32.23 (USD 0.097)
Southeast Asia: Viet Nam						
Standardised FITs for solar to be replaced by differentiated FITs based on the regions' solar irradiance, installation type and commercial operation date.	VND 1,525-2,102 (6.67-9.2 US cents)	VND 1,803-2,486 (7.89-10.87 US cents)	Floating: VND 1,665-2,281 (7.24-9.98 US cents) *	VND 1,928 (8.5 US cents) (if commercial operation date is reached before 1st November 2021)	VND 2,223 (9.8 US cents) (if commercial operation date is reached before 1st November 2021)	Biomass: 5.8 US cents Waste-to-energy: 10.05 US cents Landfill gas: 7.28 US cents

Note: In China, commercial and industrial distributed solar PV projects for 100% feed-in will be subject to the same FiTs applied for ground-mounted systems. In Viet Nam, the proposed tariffs are exclusive of value-added tax and are subject to adjustments based on the fluctuation of USD (in US cents/kWh) in accordance with the central exchange rate between USD and VND as announced by the State Bank of Viet Nam on the last day of the previous year to calculate the power payment for the following year.

Source: See endnote 34 for this chapter.

Countries in **Northeast Asia** have used FIT schemes to support renewable energy development. In May 2019, the Price Bureau of China's National Development and Reform Commission published its revised FIT policy for solar PV and wind, which was lower than the previous year.[35] The government also published a list of the first batch of subsidy-free solar and wind pilot projects, with a total capacity of 20.76 GW in 16 provinces.[36] The grid companies are required to sign long-term contracts of more than 20 years, with subsidy-free projects at a price equal to the local coal power benchmark tariff (grid parity price), as the country prepares for subsidy-free wind and solar generation from 2021 in light of the declining cost of renewable energy.[37] Removing subsidies also aims to re-stabilise China's Renewable Energy Development Fund – managed by the central government – which reached a deficit of more than RMB 100 billion (USD 14.5 billion) by the end of 2018.[38]

After the Fukushima nuclear accident in 2011, Japan introduced FITs for solar and wind energy to promote a higher share of renewables in the electricity mix. The country has put in place a plan for auctions, increasing the burden on the national budget, with the three auctions held by the government resulting in around 500 MW of auctioned capacity for solar projects and a relatively high average price of JPY 15.01 (USD 0.136) per kWh.[39]

The Japanese government also approved a new national framework for commercial offshore wind development in areas outside ports and harbours. The Act for the Promotion of Use of Marine Areas for Development of Marine Renewable Energy Generation Facilities came into force on 1 April 2019, and, by mid-2019, 11 offshore wind areas were identified to conduct further surveys before officially designating these zones for wind power development. Following this process, the first offshore wind auctions are expected in spring 2020.[40]

With these measures in place, Japan is aiming at 2030 targets of JPY 7 (6.3 US cents) per kWh for utility-scale solar PV and JPY 8-9 (7-8 US cents) per kWh for onshore wind power.[41] However, Japan abruptly decided to cut the FIT for large-scale solar PV projects approved between 2012 and 2014 that did not reach completion by September 2019.[42]

Central Asian countries are piloting auctions to boost renewable energy capacity at cost-reflective tariffs. After a 2014 tender was awarded to a Chinese company in 2016, Uzbekistan announced a second solar tender in February 2019 for 100 MW of capacity in the country's south-west.[43] Twenty major energy companies and international financial organisations expressed interest in public-private partnership solar power projects in the country.[44] The government of Uzbekistan tasked the EBRD with providing support for development of the country's first wind energy auction.[45]

In Kazakhstan, renewable FITs approved in 2014 were the ceiling prices for the first auction in 2018, with the ceiling prices for subsequent auctions to be determined at the level of the maximum price of the previous auction winner.[46] Four solar projects, with a total of 170 MW of capacity, were tendered in October 2018 by the power market operator KOREM.[47] This was the first tender under a series of auctions that the government has planned for renewable power, with the goal of assigning 1 GW of renewable generation capacity, comprising 290 MW of solar, 620 MW of wind, 75 MW of hydropower and 12 MW of biomass projects.[48]

In **South Asia**, India is using auctions to approve large-scale renewable energy projects in an effort to reach its goal of 100 GW of solar and 60 GW of wind energy installed by 2022.[49] Until 2017, capacity additions to wind generation in the country occurred through the FIT mechanism. The country has since shifted to competitive bidding, and six reverse auctions for solar projects and seven for wind have been completed, auctioning 9.5 GW of solar capacity and more than 12 GW of wind capacity as of mid-2019.[50] The auctions resulted in the lowest-ever solar tariffs of INR 2.44 (USD 0.037) per kWh, a remarkable reduction from INR 18 (USD 25) per kWh in 2010.[51] The lowest-ever wind bid of INR 2.43 (USD 0.038) per kWh was quoted in the 500 MW Gujarat Urja Vikas Nigam Ltd. (GUVNL) auction.[52]

The first projects from India's wind auctions were connected to the grid in August 2018, and the government has outlined a trajectory of bidding 30 GW of solar capacity and 10 GW of wind capacity every year to achieve a total renewable capacity of 500 GW by 2028, in line with the country's plan to generate 40% electricity from non-fossil fuels by 2030.[53] Industry players, however, have expressed concerns about low-set tariff ceilings, a 25% safeguard duty on imported solar products and India's unclear tax environment, after several auctions in 2018 resulted in either no bids or cancellations.[54]

In **Southeast Asia**, Indonesia's Ministry of Energy and Mineral Resources replaced the favourable FIT mechanism with a new incentive scheme, setting a maximum ceiling price benchmarked against the local and national generation cost of electricity. The regulation sets the tariffs below the national supply cost of electricity (commonly referred to as the national BPP), or, where the local BPP is higher than the national level, the tariffs may be set at no more than 85% of the local BPP, which ranges from USD 0.048 to USD 0.144 per kWh, depending on the region.[55]

In the Philippines, the FITs for hydro, wind, solar, ocean and biomass energy, guided by the Energy Regulatory Commission (ERC), are based on the levelised cost of electricity, guaranteed for 20 years and adjusted annually. As of September 2018, 52 projects – solar, wind, run-of-river hydro and biomass – had signed renewable energy payment agreements.[56] The FITs are financed through a uniform FIT allowance (FiT-All) charge that all grid-connected electricity consumers pay to cover payments to renewable energy developers receiving incentives in the country. Distribution utilities, the National Grid Corporation and retail electricity suppliers serve as collecting agents, and all proceeds go to the FIT-All Fund, administered by the National Transmission Corp (TransCo).

In March 2019, the ERC approved a reduced FiT-All of PHP 0.2226 (USD 0.0042), which is calculated annually based on the suggested charge proposed by TransCo.[57] The Philippines is moving from FITs to auctions to support the build-out of large-scale solar to provide around-the-clock power supply with lower electricity tariffs, receiving the region's lowest bid of PHP 2.34 (USD 0.044) for a 50 MW solar plant in 2018.[58]

Viet Nam's Ministry of Trade and Industry will provide its FIT for solar power projects through 30 June 2021; however, the Ministry is required to submit a policy introducing an auction process and tariffs for new wind power from 2021 onwards.[59] Unlike the previous tariff set at 9.35 US cents for all solar projects indiscriminately, the new tariffs for projects achieving commercial operation before the end of June 2021 will range from 6.67 US cents to 10.87 US cents per kWh.[60] The calculations will be based on location (i.e., differentiating regions with different solar radiance) and on the type of solar technology (floating, ground-mounted, rooftop and solar with integrated energy storage).[61]

In **The Pacific**, to address energy challenges in Tonga and lower the cost of producing power on the island, Tonga Power Limited (TPL) signed a PPA with Sunergise New Zealand Limited to finance, build and operate a 6 MW solar plant – the second in the Pacific and the largest in the region – for 25 years for a very competitive FIT (undisclosed).[62] It is the second project that TPL has established with an IPP, following a 2 MW solar project with a Chinese company in 2016.[63] The plant will produce 15 GWh of electricity, or 15% of the anticipated demand in 2020, to help Tonga achieve its goals of 50% renewable energy by 2020 and 70% by 2030.[64]

Overall, the Asia Pacific region has seen several successful examples of reverse auctions[i] for renewable energy projects, resulting in competitive costs for solar and wind generation at grid parity levels. In reverse auctions, governments invite developers to submit non-negotiable bids for a certain capacity of renewable energy generation, with predetermined requirements, with the lowest price per unit of electricity to win the contract. Successful utility-scale auctions have been held in Northeast Asia (China, the Republic of Korea), Southeast Asia (Indonesia, the Philippines, Thailand, Viet Nam), South Asia (India, Pakistan) and Central Asia (Kazakhstan) (→ see Figure 9).[65] Thailand is shifting to auctions as part of its new 20-year national strategy, Thailand 4.0, which aims to strengthen and grow the economy (→ see Sidebar 10).[66]

i Type of auction in which the roles of buyer and seller are reversed. See Glossary for more information.

SIDEBAR 10. Renewable Energy as a Building Block of Thailand 4.0

The decision to shift to auctions for renewable energy development, along with the introduction of a variety of support mechanisms, is part of Thailand's new 20-year national strategy, Thailand 4.0. The aim is to strengthen and grow the economy and to build the country's competitiveness while attaining sustainable development. The Thai government initially introduced a feed-in premium/adder programme, which was later replaced by a FIT scheme and then a shift to competitive bidding in 2017. The FIT served as the ceiling price to allow the market to determine real prices and to minimise the risk of over-subsidisation of renewable energy projects.

In the last auction in 2017, 17 out of 85 proposals were awarded for a total capacity of 300 MW at an average price of 7.39 US cents. This was below the ceiling bidding price of 11.09 US cents, out of which 5.48 US cents is fixed and 5.61 US cents will be adjusted annually by core inflation. Fourteen of the projects ranging from 10 to 50 MW were biomass, and the remaining three were hybrid projects (biogas plus solar, biomass plus solar and solar plus storage), with 20-year PPAs that were expected to be signed by December 2019.

In 2019, a fourth round of bidding for a combined capacity of 8,300 MW was expected to open for IPPs, including renewable energy. Thailand was also preparing for peer-to-peer trading of renewable power, with two pilot projects ongoing. Policy makers plan to provide licences to private companies to develop solar rooftops – with a combined capacity of 100 MW – that will be able to sell electricity to the national utility.

Under the six focus areas of the Thailand 4.0 strategy, green growth is being supported through "Energy 4.0", the Ministry of Energy's policy platform for integrating the efficient use of new and renewable energy, smart grids, energy storage technology, SPPs, hybrid firms and EVs for Thailand's future growth and investment opportunities. An example is the plan to develop a smart grid in the Eastern Economic Corridor by the state-owned utility EGAT and the Provincial Electricity Authority in a bid to lower power fees and draw new investment flows. Thailand's energy strategy is guided by the National Energy Policy 2008 along with five interconnected energy plans known as the Thailand Integrated Energy Blueprint to achieve the country's top policy objectives: energy security, economic affordability and environmental sustainability.

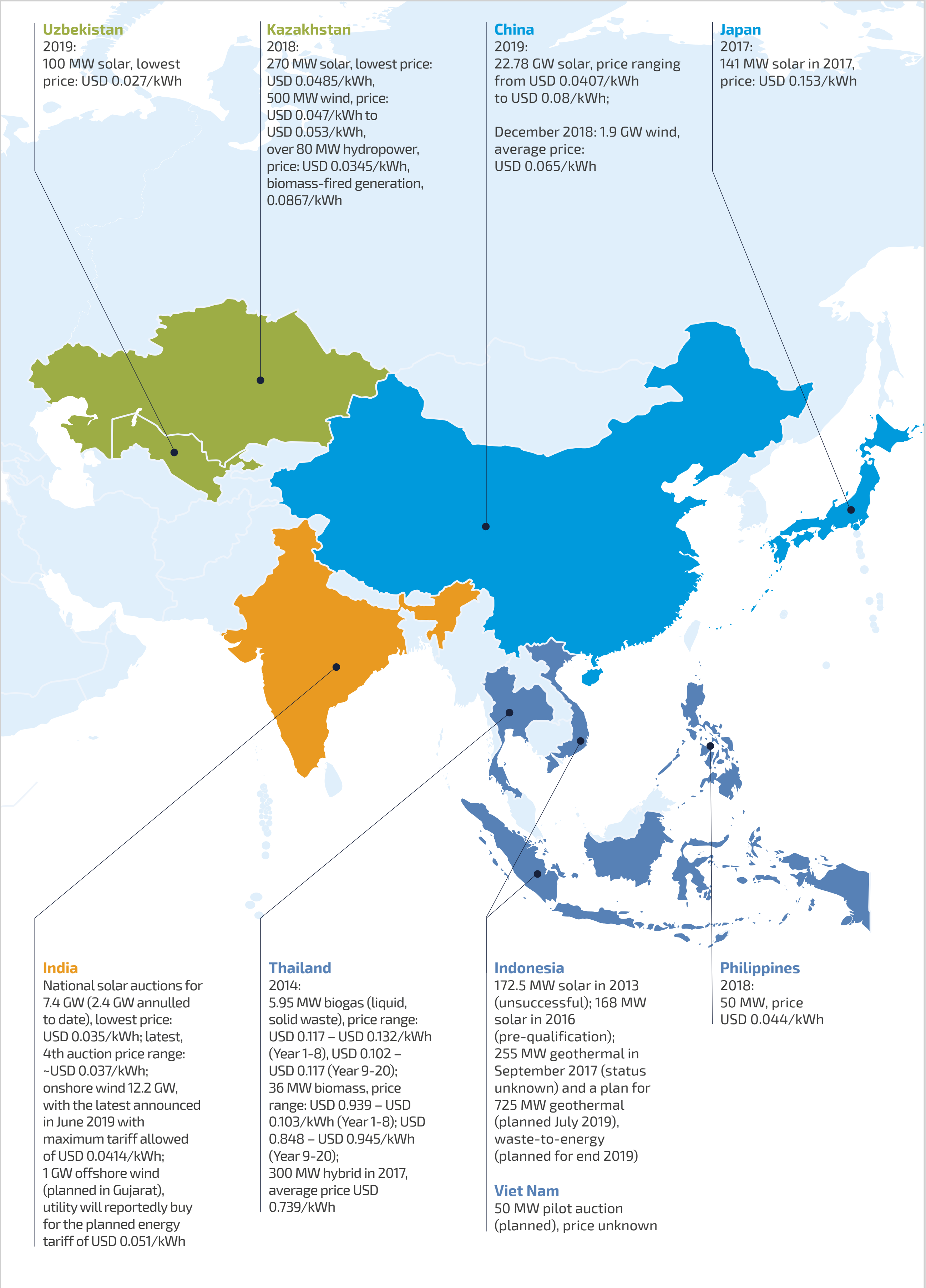
Renewable energy is further covered by the Alternative Development Plan and the 2018-2037 Power Development Plan (PDP). After approval by the Cabinet, the new PDP was expected to take effect in the second quarter of 2019, presenting numerous opportunities for renewable energy development, which is encouraging for private investments. The share of renewables in the domestic power supply is expected to increase from the current 10% to 30% by 2037, with 10% of this coming from off-grid renewables.

Besides providing a FIT to support the growth of renewables, other support mechanisms will allow private owners of small solar installations to sell surplus energy back to EGAT or to other consumers through peer-to-peer electricity trading. Off-grid installations other than solar also are encouraged, creating an opportunity for innovative business models for electricity supply. The share of power generated by EGAT will be reduced from 35% to 24%, encouraging the involvement of IPPs through the auction mechanism.

The PDP supports power capacity additions of 56,431 MW by 2037, which, in combination with 25,310 MW of retired capacity, will lead to a final generation capacity (including non-renewable capacity) of 77,211 MW by 2037. After new additions, including pumped storage and energy conservation measures, non-fossil fuel generation will represent around 45% of new capacity, while coal-fired power plants will be reduced to 12% by 2037.

Source: See endnote 66 for this chapter.

FIGURE 9. Recent Utility-scale Renewable Energy Auctions in Selected Asia Pacific Countries



Note: Information is not available for Mongolia, Republic of Korea, Georgia, Bangladesh, Pakistan, Sri Lanka, Myanmar, Fiji and Tonga.

Source: See endnote 65 for this chapter.

Net Metering

Net metering is still a nascent support mechanism in the Asia Pacific region, with fewer countries running successful net metering schemes than having in place FITs.

Net metering allows customers to feed power back to the grid and reduce their electricity bills.

In **South Asia**, Pakistan and India have adopted net metering at the national and state levels. Pakistan's National Electric Power Regulatory Authority (NEPRA) adopted a net metering regulation in 2015 to enable customers with small-scale renewable energy installations (1 kW to 1 MW) to feed power back to the distribution network and reduce their electricity bills.[67] To simplify the process of gaining net metering connections, NEPRA digitalised the application process, allowing processing of all net metering applications online in less than a month.[68]

India's rooftop solar segment has grown at a brisk pace, with cumulative installed capacity reaching 4,375 MW as of March 2019.[69] To meet the country's 2022 target of 40 GW of installed solar rooftop capacity, however, such projects need to receive more attractive financing.[70] Policy implementation for rooftop solar net metering is robust in some states (Haryana, Punjab and Rajasthan), but developers face challenges in other states (Goa, Gujarat, Himachal Pradesh, Tamil Nadu and Uttar Pradesh) and in the Delhi National Capital Region despite existing regulations.[71]

Several markets in **Southeast Asia** have introduced regulations for rooftop solar. In Thailand, most solar rooftops to date have been installed as a captive power source for self-consumption, as producers have not been allowed to sell their surplus output to the grid. However, new regulations presented by the Energy Regulatory Commission in 2019 will enable the grid to buy power from solar rooftop installations, offering a FIT of THB 1.68 (5.3 US cents) per kWh for 10-year contracts.[72]

Viet Nam is replacing net metering with the direct consumption/supply method.[73] The government recently released the third draft of its mechanism for encouraging the development of solar power, including solar rooftops applicable from 1 July 2019.[74] The draft defines four models of rooftop solar systems: 1) the power consumption model for self-consumption and selling excess output to the national grid; 2) the excess power sale model to sell parts of the output to the national grid or other consumers; 3) the entire power sale model to sell the entire output to the national grid or other consumers; and 4) direct power sale and purchase to sell to other consumers (not the utility) without directly using the national grid system. As a general guiding principle, the national utility (EVN) or the power purchaser is obligated to buy the power output sold from rooftop solar systems to the grid, consistent with the regulations and technical standards of the national electrical power industry.[75]

In Indonesia, in contrast, the solar PV framework for rooftop installations aims to protect the utility PLN from losing revenue as more consumers use rooftop systems. The long-awaited guidelines for rooftop solar, released in November 2018 under Regulation No. 49, established a net metering scheme for utility customers (residential, commercial and industrial).[76] Under the scheme, rooftop solar installations that produce excess power can sell it to the grid; however, PLN's obligation is to compensate for the electricity generated by rooftop solar at a value of up to 85% of the applicable tariff.[77]

HEATING AND COOLING SECTOR

Despite the energy intensity of the heating and cooling sector, only a few of the selected countries in the Asia Pacific region have introduced specific targets and/or supportive frameworks for the use of renewables in this sector. Such policies are often part of overall energy efficiency targets to reduce energy consumption, alongside the use of efficient lighting and appliances.

Examples of policies to support low-carbon heating technologies in industry can be found in economies with rapid economic growth. For example, in its development plan the Thai government set production targets for bioenergy, municipal solid waste and biogas for industrial heating. According to the plan, renewables for heating are expected to account for 37% of the country's total heating demand by 2036, more than double the share in 2015.[78]

China includes the development of district heating systems in several of its Five-Year Plans, including specific measures to reduce air pollution from coal-fired boilers during the harsh winters in the country's north and to transition to clean heating technologies and support investments in geothermal heat.[79] China and the Republic of Korea both have adopted renewable heat obligations, which require new buildings to obtain a certain share of heat energy from renewable sources.[80] In the Republic of Korea, new buildings with more than 10,000 m^2 of total floor space, except for residential and public buildings, must meet 10% of their heat energy demand using renewables.[81]

In December 2017, China introduced two new policies, including guidance on clean heating in winter in northern China (for the period 2017-2021) and guidelines to promote and support the development of biomass-to-heat.[82] The effort is supported by the China Biomass-to-Heat Strategic Research project, initiated by the China Energy Conservation and Environmental Protection Group and supported by the National Energy Administration and ADB.[83] The aim is to scale up and commercialise biomass-to-heat in China as a means to reduce the air pollution caused by the wintertime heat supply in northern China and to improve the policies and mechanisms to facilitate the commercialisation of biomass-to-heat.[84]

With large biomass resources available across the Asia Pacific region, governments are exploring the use of biomass heat generation and the co-generation of power and heat.

Viet Nam introduced incentives and targets for increased use of biomass for heat generation and for combined heat and power (CHP) projects to encourage co-generation.[85] In India, projects using co-generation with biomass (i.e., sugarcane bagasse) can receive renewable energy certificates, linked to states' renewable purchase obligations.[86] The city of Chandigarh has introduced mandatory use of solar water heating in industries, hotels, hospitals, prisons, canteens, housing complexes, and government and residential buildings.[87]

TRANSPORT SECTOR

To date, most policy interventions to increase the share of renewables in the transport sector have been related to biofuels. However, policies aimed at developing the electric-powered transport market – focused on the electrification of vehicles and public transport and their related infrastructures – have begun to emerge to tackle air pollution in major cities and in response to the EV manufacturing boom. EVs can play an important role in increasing the use of renewables in transport and in reducing global carbon emissions, particularly when powered with rising shares of renewable electricity.[88] However, most efforts to scale up the production and use of EVs today are not specifically linked to the use of renewable power and do not ensure that EVs support the integration of renewables into energy supplies.

Biofuel Blending Mandates

Biofuel blending mandates are a popular policy instrument to shift the transport sector away from petroleum-based products and towards a fuel mix that incentivises domestic production of biofuels. Globally, biofuel mandates are expected to more than double the use of bioenergy in the transport sector by 2040.[89] Several of the selected Asia Pacific countries have introduced national and/or provincial blending mandates for biofuels, including China, India, Indonesia, the Philippines, the Republic of Korea, Thailand, Viet Nam and Fiji.

Nine Chinese provinces already require an E10 ethanol blend (10% ethanol in petrol), and the country has a nationwide target for E10 by 2020.[90] India set a target of E20 and B5 (5% biodiesel and 95% petroleum diesel) by 2030. It removed the excise duty levied on ethanol for blending with petrol tariffs in 2015, and in September 2019 raised prices of ethanol extracted from sugarcane to blend with petrol.[91] In 2008, Thailand introduced the option of B2, which it increased to B7 in 2014, and the government is now considering a B10 mandate as part of an ambitious target to increase the share of renewables in transport by 2036, with biofuels (biodiesel, ethanol) accounting for two-thirds of the total renewable sources for the transport sector.[92]

In 2018, Indonesia, the world's largest producer of crude palm oil, increased its mandatory biodiesel blending mandate to B20 nationwide, with a target of B30 by January 2020.[93] The country began testing B30 biodiesel in passenger vehicles and trucks as well as in trains, ships and agricultural machinery; however, ship owners have opposed the higher blend due to increased operating costs and poor performance in engines.[94] In the Philippines, the existing E10 ethanol mandate is expected to increase to E20 by 2020, and the B2 biodiesel mandate is expected to increase to B10 by 2020 and B20 by 2030.[95] Viet Nam has encouraged biofuel production and use by introducing an E5 ethanol mandate and B5 biodiesel mandate in 2018.[96] However, in 2019 private companies requested that the Ministries of Industry and Trade and Finance review the policies due to declining retail sales of E5.[97] Fiji has approved voluntary B5 and E10 standards that it plans to implement as part of its efforts to promote the use of renewables in transport.[98]

Policies for Promoting Electric Vehicles

To support electric mobility, countries in Asia and the Pacific have established policies and initiatives across the value chain of EVs, from promoting consumer demand to electrifying public infrastructure and passenger vehicles (including setting safety guidelines for electric auto rikshaws, or tuk-tuks). However, while these EV policies promote reduced carbon emissions, in most cases they are not directly linked to the use of renewable electricity. Although supportive policies for electric mobility can increase the opportunities for integrating variable renewable energy resources in the transport sector, few examples exist of direct policy measures to increase the use of renewables by EVs to replace fossil fuels.[99]

Sustainable transport has been identified as a strategic area under ASEAN's Kuala Lumpur Transport Strategic Plan 2016-2025, with the goal of formulating a regional policy framework to support low-carbon modes of transport, energy efficiency and user-friendly transport initiatives.[100] Countries in the Asia Pacific region are incentivising the transition to an electric-powered transport sector through a range of fiscal incentives, public infrastructure projects and EV pilots.

Northeast Asia leads in efforts to promote the domestic manufacturing and export of EVs, both to neighbouring countries and farther afield. In some instances, the efforts to encourage electric mobility are combined with the use of renewable energy. China plans to develop a market-oriented EV programme to increase the share of domestically produced EVs globally and to place two Chinese companies among the world's top 10 for EV sales, advancing EV development in the entire auto industry.[101] China also requires automakers to manufacture EVs and provides consumers with direct financial support to offset as much as a third of the selling price of an EV.[102] With 225,100 EVs on the country's roads, China already buys more than half as many EVs as the rest of the world (at 184,700).[103]

To boost the use of EVs in Japan, the government set a target to reduce greenhouse gas emissions from passenger vehicles 90% by 2050 (from 2010 levels), with all new cars sold to be electric or hybrid as of 2018.[104] Japanese auto manufacturers Nissan and Toyota are leaders in the domestic EV market, and Toyota recently partnered with Panasonic to create a joint venture for making car batteries, including for EVs, by the end of 2020.[105]

In **Central Asia**, Georgia's policy on Eco-friendly Transport, launched in 2018, aims to develop "environmentally friendly" transport options.[106] The prime minister announced that 90% of Georgia's vehicle fleet will be replaced by electric cars within the next decade.[107] Since 2016, import taxes on hybrid cars have been around 60% lower than for petrol- or diesel-powered cars, and EVs imports are tax-free.[108] In addition to a plan to import 2,000 electric cars in 2019, the government aims to promote the production of EVs in Georgia.[109]

Countries in **South Asia** also are embracing EVs. Bangladesh plans to legalise the existing passenger EVs on its roads that previously were not allowed in a country that faces power shortages; these include motorcycles, three-wheelers, and light, medium and heavy vehicles.[110] The country's Road Transport and Highway Division has been reviewing the 2018 Electric Vehicle Registration and Operation Guidelines.[111] India has a 30% target for electric passenger cars by 2030 and announced tax cuts on EV purchases from 12% to 5% in the national budget for 2019-20.[112] In Sri Lanka, the government aims to tax a range of petrol and hybrid vehicles while exempting full EVs, with the aim of phasing out fossil fuel-powered vehicles.[113]

In **Southeast Asia**, the Philippines adopted a national energy policy and regulatory framework with various incentives for increasing the use of electric and hybrid vehicles among passenger cars and public transport, modernising jeepneys (a mode of public transport) and building charging stations nationwide.[114] In Indonesia, in support of the government's plan to develop the domestic EV industry, the state utility PLN is developing a national standard for EV charging specifications and is preparing a roadmap for EV charging stations.[115] (→ *See Sidebar 11 for more on Southeast Asia's EV revolution.*[116])

In **The Pacific**, after the government of Fiji reduced and/or removed its duties on hybrid vehicles, the number of alternative fuel vehicles in the country increased.[117] In addition, the government enacted income tax exemptions for EV charging stations with capital investment above a certain threshold.[118]

SIDEBAR 11. Southeast Asia's Electric Vehicle Revolution

Countries in Southeast Asia have seen some of the world's worst air pollution due to traffic congestion and industrial activities. Most vehicles in the region run on petrol or diesel, contributing greatly to the worsening air quality in major cities. In several countries, governments have set targets and plans for promoting EVs. While the estimated size of the market is significant and the region could see some 59 million electric two- or three-wheelers and 8.9 million electric four-wheel vehicles by 2025, there is no explicit intention to source the electricity for EVs from renewable sources.

Thailand approved a roadmap for EV development, the Electric Vehicle Promotion Plan, under its Alternative Energy Development Plan 2012-2021 and created the Electric Vehicle Association of Thailand to build infrastructure (charging stations) for both public transport and personal vehicles and to scale up the use of EVs (including hybrid cars and e-bikes) for personal use. In parallel, EVs are incorporated in the draft National Energy Efficiency Action Plan as a means of reducing the use of petroleum-based transport fuels. As a result, Thailand went from having 60,000 hybrid passenger cars and 8,000 battery-electric motorcycles in 2014 to a total of 102,308 hybrid cars and 1,394 battery EVs in 2018. For public transport, the focus is on replacing conventional two- and three-wheelers (tuk-tuks) with e-motorcycles, not only to address environmental concerns, but also to avoid increasing the market share of four-wheelers.

In 2016, Thailand's Energy Policy and Planning Office (EPPO) set up a subsidised scheme to establish 100 charging stations nationwide for infrastructure readiness and to increase public awareness of EVs. EPPO plans to replace 22,000 conventional tuk-tuks with electric tuk-tuks within five years. The first 100 electric tuk-tuks will be piloted with the support of the Energy Conservation Fund (ENCON Fund). The Thai government offered generous tax incentives to automakers producing plug-in hybrids and EVs in the country for applications submitted by the end of 2018.

The Philippines set a target in 2014 to have 1 million EVs on the roads by 2020. The Philippine Department of Energy also has collaborated with ADB to introduce electric tricycles (e-trikes) powered by lithium-ion batteries. The initiative aims to reduce the transport sector's annual petroleum consumption by 2.8% and to reduce CO_2 emissions by some 259,008 tonnes annually by shifting to 100,000 e-trikes. Indonesia, meanwhile, released in early 2019 a national roadmap for developing its automotive industry and is targeting 2.1 million two-wheeler EVs, such as electric motorcycles and scooters, and 2,200 four-wheeled EVs by 2025.

Despite their potential for electric transport, Viet Nam and Myanmar lag behind other countries in the region and have not adopted supportive policies in this area. Petrol- and diesel-powered Chinese-make motorcycles and Japanese cars are still the most common passenger vehicles on Myanmar's roads. However, the largest city, Yangon, has seen a surge in assembled battery-assisted bicycles, despite a ban on two-wheelers in the city. The government plans to install charging stations for electric cars along the country's longest highway, allowing the private sector to build and operate these stations.

Sources: See endnote 116 for this chapter.

Fiscal Incentives and Public Financing

Developing countries in Asia and the Pacific are responsible for an estimated one-third of the world's fossil energy subsidies, and in 2012 Asia was home to 10 of the top 25 countries in the world subsidising fossil fuel consumption.[119] In contrast, the region's renewable energy sector receives only a small fraction of direct public financing. Although the Group of Twenty and APEC committed themselves in 2009 to phasing out inefficient fossil fuel subsidies, there has been little progress in this regard.[120] ADB concluded that "energy subsidy reform has emerged as one of the most important policy challenges for developing Asian economies".[121] The continuation of fossil fuel subsidies impedes both clean energy development and climate action.

Countries of **Central Asia** incur a large cost of energy subsidies for fossil fuel generation – ranging from 5% of GDP in Georgia to more than 25% of GDP in Uzbekistan – while only limited support goes towards renewables.[122] In 2019, however, the Uzbeki president signed a Renewable Energy Bill into law entitling the producers of renewable power to supply local grids and to enjoy tax benefits; the tariffs for renewably generated electricity are to be set by competitive bidding.[123]

Fiscal incentives for the renewable energy sector are becoming more common in the region. In **South Asia**, India's renewable targets have been supported in the last few years by fiscal instruments such as generation-based incentives, capital and interest direct public financing, viability gap funding, concessional finance and fiscal incentives.[124] Government support for renewables has increased sharply, from INR 2,608 crore (USD 431 million) in FY2014 to INR 15,040 crore (USD 2.2 billion) in FY2017.[125] This initial support from public finance and government polices has ensured an effective transition to private sector-led renewable energy deployment. In 2010, India also introduced a support scheme for new CSP technologies. The scheme, which targets industrial process heat as well as community cooking and space heating/cooling applications, was recently extended to 2020 and aims to install 90,000 m^2 of solar collectors between 2017 and 2020.[126]

Pakistan's government recently proposed a five-year tax exemption for companies manufacturing solar and wind energy equipment in the country, in an effort to boost domestic production and use of renewable power and to overcome power shortages.[127] However, companies in the region would still likely struggle to compete with tax-free, low-priced imports of foreign-built solar panels and other renewable energy equipment, 95% of which comes from China.[128] Industry players have called for import duties on finished products and for cuts to existing duties on the import of components or certification systems for renewable energy products to help boost the domestic production of solar and other renewable technologies.[129]

In **Southeast Asia**, fossil fuel subsidies are common in several countries and represent significant budget expenditures. Indonesia spent close to 2% of its GDP in 2017 on fossil fuel subsidies, amounting to more than USD 17.5 billion, primarily for oil, while Thailand and Viet Nam spent USD 800 million and USD 260 million, respectively – approximately 0.1% to 0.2% of their GDPs – on fossil fuel subsidies, with oil and coal receiving the largest share.[130]

In **The Pacific**, fiscal incentives in Fiji are aimed at investments in renewable energy technologies, biofuel production and renewable energy projects and power co-generation.[131] Meanwhile, Tonga periodically reviews its regulatory framework with a view towards promoting the use of renewables, including fiscal measures such as duties and taxes.[132]

DECARBONISATION AND CLIMATE CHANGE POLICIES

> China, Japan, the Republic of Korea, India and Indonesia account for nearly **40%** of global emissions.

Although per capita greenhouse gas emissions in Asia and the Pacific remain below the global average, five countries in the region – China, Japan, the Republic of Korea, India and Indonesia – are among the world's largest emitters, together accounting for nearly 40% of the global total.[133] Due to rapid industrialisation, economic growth and electrification, the 18 countries covered in this report alone contributed more than 45% of the world's carbon emissions related to the combustion of oil, gas and coal in 2017.[134] India's fossil fuel-related emissions increased rapidly in 2018, by 6.3%, a rate three times higher than the previous year.[135]

Incentivising low-carbon technologies through decarbonisation and climate change policies is closely linked to the adoption of renewable energy technologies. Several countries in the region are using carbon pricing or carbon tax measures to regulate carbon emissions; these can be imposed either as a tax or via emission trading schemes, which let markets set the price of carbon allowances[i].[136]

Although fossil fuels remain the primary energy sources in **Northeast Asia**, countries in the sub-region have begun strengthening their decarbonisation and climate change policies and targets. In China, coal consumption rose for a second year in a row in 2018, and coal continues to generate nearly 60% of the country's electricity.[137] Despite that, the country managed to exceed its 2020 low-carbon energy and decarbonisation targets and has made its targets for 2030 even more ambitious.[138] China plans to greatly reduce the volume of emissions produced relative to GDP.[139]

i Carbon pricing can take various forms. Cap-and-trade systems set caps for carbon emissions that are usually revised every year. An alternative is a carbon tax where a regulating agency sets a price per unit of carbon dioxide (a tax) that all emitters pay. In the most progressive policies, governments spend their carbon tax revenues to provide more effective solutions to energy poverty and to help vulnerable populations prepare for, avoid, adapt to or recover from the impacts of climate change.

The world's third largest economy, Japan, has implemented a carbon tax since 2012 and pledged to reduce its greenhouse gas emissions 26% below 2013 levels by 2030.[140] China, Japan and the Republic of Korea all have launched emission trading schemes at the national level as well as at the sub-national level in cities and provinces.[141] The mandatory Korean Emissions Trading System commenced in January 2015 and was the first of its kind in the sub-region.[142] The scheme covers more than 500 businesses that together account for around two-thirds of the country's emissions, and the target is to reduce emissions to 37% below business as usual by 2030.[143]

In **Central Asia**, Kazakhstan relaunched its emission trading scheme in January 2018 after a two-year suspension, with new trading procedures and allocation methods.[144]

A few countries in **Southeast Asia** are considering future carbon pricing initiatives, such as emission trading systems or carbon taxes. Thailand has introduced an emission-based tax structure for motorcycles aimed at reducing emissions and promoting cleaner vehicles, which is expected to come into effect in January 2020.[145] Viet Nam is preparing to pilot market instruments, such as a carbon credit trading scheme for the waste, steel and power sectors, in 2020, and Indonesia is considering a market-based carbon pricing policy for the power and industry sectors.[146] Other countries in the region have not yet introduced carbon pricing or emission trading strategies.[147]

Island countries of **The Pacific** are among the most vulnerable to damages from climate change, as they are prone to natural disasters and to increased extreme weather patterns and coastal erosion.[148] They also rely heavily on imported fuels that are susceptible to fluctuating oil prices, posing a burden on most sectors of the economy and on the national budget. Awareness of the implications of climate change for island development resulted in the formulation of a regional Framework for Resilient Development in the Pacific to encourage integrated and cost-effective approaches to climate change adaptation and disaster risk reduction.[149]

This Pacific island framework complements national strategies and plans. Tonga's Joint National Action Plan for Disaster Risk Management and Climate Change Adaptation, as well as the country's Energy Road Map (2010-2020), lay out the least-cost approach and implementation plan to reduce the country's vulnerability to oil price shocks and to boost access to modern energy services in an economical and environmentally sustainable manner.[150]

In general, the climate goals and commitments to international climate agreements in most Asia Pacific countries are ambitious, given the existing energy mix that relies on fossil fuels.[151] The regulatory changes required at the national level to fulfil these obligations are currently inadequate, and these countries will likely fail to reach their targets.

CITY AND LOCAL GOVERNMENT POLICIES

Sub-national and municipal policies to promote sustainable energy through localised innovations are being developed across the Asia Pacific region. For example, the Cities Development Initiative for Asia is a regional platform that aims to promote sustainable and equitable urban development that would lead to improved environmental and living conditions for residents of medium-sized cities.[152] Other initiatives to "green" the region's cities include the ASEAN Smart City Network as well as efforts to promote low-carbon buildings and transport systems in specific cities (→ see Sidebar 12).[153]

Tokyo became the first city in Japan with an **urban rail network** powered entirely by renewable energy.

Overall, the policy landscape in Asia and the Pacific is dynamic and continues to develop at a variety of jurisdictional levels, reflecting growing support for renewable energy and energy efficiency as well as diverse efforts to directly address carbon footprints in the region. Rapid urbanisation coupled with population growth has led to rising energy demand and CO_2 concentration in many cities.

Several cities have initiated actions to reduce their environmental footprint and improve the living standards for their residents, by eliminating sources of air pollution, increasing the share of EVs powered by renewables and introducing energy efficiency measures in highly energy-intensive sectors. While still in the inception phases, these initiatives will be important in ensuring sustainable urban growth and supporting the transition to renewable energy supply in cities.

With the goal of mapping out the current trends and developments in renewable energy in cities, REN21 is releasing the first edition of its new report series – the *Renewables in Cities Global Status Report* – in late 2019.[154] The report series spotlights the key role that cities play in the energy transition and will be a powerful tool for accelerating renewable energy deployment, supporting city-level commitments and inspiring innovations in policy, financing and technology.

SIDEBAR 12. Renewable Energy Initiatives in Cities

ASEAN Smart City Network – This regional initiative by ASEAN member states aims to synergise efforts for smart and sustainable urban development. The network of 26 pilot cities will work to improve the lives of ASEAN citizens by sharing best practices, facilitating bankable projects with the private sector, and securing funding and support from ASEAN's external partners, such as the World Bank, ADB and the Asian Infrastructure Investment Bank (AIIB).

Tokyo's renewable urban rail network – Tokyo, Japan recently became the first city in the country with an urban rail network powered entirely by renewable energy. The five-kilometre train service, connecting Tokyo's Sangenjaya and Shimotakaido stations, transports 57,000 passengers a day and is powered by geothermal power and hydropower supplied to the railway company, Tokyu Corporation, by Tohoku Electric Power Co. The rail service used 2,200 MWh of electricity in 2018, and the switch to renewable power is projected to reduce CO_2 emissions by an estimated 1,263 metric tonnes per year. For Tokyu Corporation, the shift to renewables is in line with its goal of promoting sustainable urban development.

Ulaanbaatar's commitment to "greening" – Ulaanbaatar, Mongolia has committed to becoming a "green" city with inclusive economic growth, active public participation, and a safe and healthy environment for its citizens. Through a consultative process involving residents and experts, the municipality identified key challenges to green development in the city and prepared its Green Development Strategic Action Plan for 2020. The use of renewable energy and energy efficiency in buildings is a key imperative for achieving the city's clean air goal. Additionally, the city is undertaking efforts to transform urban ger areas – the traditional tent dwellings where a third of Mongolia's population live – into affordable, low-carbon and climate-resilient eco-districts. The project – which plans to build 10,000 homes in 20 eco-districts by 2027 and improve sanitation, waste management and water supply – is supported by a USD 53 million grant from the GCF and the High-Level Technology Fund as well as by ADB and GCF loans of USD 80 million and USD 95 million, respectively.

India's 100% renewable city – Diu, located at the eastern end of Diu Island in Gujarat state, is one of the participating cities in Prime Minister Narendra Modi's Smart Cities initiative. Diu imported most of its energy from the state until 2017 but has since become the first city in India to run on 100% renewable energy during the daytime. The city has developed a 9 MW solar park and installed solar panels on the roofs of government buildings. It also provides subsidies to its residents to install small-scale rooftop solar PV, which has resulted in a 10-15% reduction in residential electricity tariffs.

A smart and clean capital for Indonesia – The Indonesian government plans to build a new "smart and clean" capital city that relies on renewable energy for its electricity needs. In August 2019, the government announced a plan to relocate the country's capital from Jakarta to the province of East Kalimantan on the island of Borneo as a way to resolve the constraints of rapid urbanisation and overpopulation of the current capital. An environmental assessment to ensure that the new city does not entail the destruction of rainforests is expected to be completed in late 2019. Building renewable energy infrastructure as envisioned in the plan presents opportunities for investments in renewables. However, Kalimantan currently relies on fossil fuels including diesel and coal: the country's coal and oil hubs are located in east Kalimantan, and Kutai Kartanegara, the site for the new capital, is Indonesia's biggest coal producer.

Source: See endnote 153 for this chapter.

05 INVESTMENT FLOWS

Worldwide, annual investment in renewable power capacity is now **3X** the amount invested in fossil fuel generating capacity.

05

05 INVESTMENT FLOWS

OVERVIEW

Renewable energy investment has continued its long-term upward trajectory, with an estimated USD 288.9 billion invested in renewables worldwide in 2018.[1] This was 2% lower than in 2016 and below the record level of USD 326.3 billion in 2017, but it represents the ninth year in a row that global investment in renewables exceeded USD 230 billion. Notably, annual investment in renewable power capacity is now three times the amount invested in fossil fuel generating capacity.[2]

To some extent, this figure underestimates the level of investment and interest in the renewable energy and energy efficiency sectors. Many other types of investments that could be classified instead as forms of infrastructure also comprise elements of renewable and efficiency investments. For example, investments in smart cities, which regularly involve digital technologies for electricity control and metering, may not be included in the renewable energy investment figure. However, they enable greater efficiencies as well as higher penetration of renewables in existing energy markets.

Similarly, numerous investments in buildings and transport, while not explicitly seen as energy investments, may have a significant enabling role for renewable energy. For example, investments in e-mobility and increasing electrification of vehicle fleets is more amenable to the increased use of renewables for electricity. Investments in public transport such as bus rapid transit systems improve overall systems efficiency, and many programmes aimed at future-proofing and improving the performance of buildings and urban spaces include a combination of energy, climate adaptation and amenity components.

The downturn in the value of renewable energy investment in 2018 also reflects the rapid decline in the costs of most renewable energy technologies, as the capital cost and investment requirement per installed MW of generation has decreased drastically. The average capital cost for solar PV projects starting construction in 2016 was 13% lower than in 2015, while for onshore wind power the drop was 11.5% and for offshore wind power it was 10%.[3] The expansion in renewable energy capacity is therefore greater than the investment figures might suggest at first glance.[4]

In 2018, an estimated USD **150.2 billion** was invested in renewables in the Asia Pacific region.

Renewable energy investment trends in the Asia Pacific region are mixed, reflecting the changing economic circumstances and fluctuating policy conditions in the 18 countries being analysed. At the macro level, Asia accounted for 52% of new investment in the renewables sector worldwide in 2018, with China, Japan and India among the top 10 destinations of renewable energy investment globally and Viet Nam and the Republic of Korea also ranking in the top 20.[5] Renewable energy investment is driven by a range of circumstances, including a country's economic strength, the existing energy infrastructure, the policy and regulatory environment, political support and the favourability of investment conditions.

China, the global renewable energy leader, saw renewables investment in 2017 of USD 145.9 billion – its highest level ever – accounting for 45% of the global total. Investment in China subsequently dropped to USD 91.5 billion in 2018 (32% of the global total), which is attributed to a mid-year change in the country's feed-in tariff policy, to the rapidly declining capital costs of solar PV as well as to timing differences in investment decisions. Investment in solar power in China fell by half, from USD 89 billion in 2017 to USD 40.2 billion in 2018, while investment in wind power declined 6% to USD 50.1 billion.

At an aggregate level, the importance of the Asia Pacific region to global renewable energy investment is highlighted in Figure 10, which illustrates the size of renewables markets in China, India, Asia and Oceania relative to other markets.[6]

Renewable energy investment in India fell 16% to USD 15.4 billion in 2018, although this was the country's second highest annual total to date. The investment decline reflected uncertainty and changes in tax regimes, import tariffs and exchange rates. Investment in wind power in India was similar to the country's 2016 record, at USD 7.2 billion, but investment in solar power declined 27% to USD 8.2 billion. India remained the world's fifth largest clean energy investment market in 2018.

Outside of China and India, the rest of the Asia region experienced mixed fortunes, although overall investment increased 6% to USD 44.2 billion in 2018 (also including Oceania), the highest level in three years. Notably, investment in Viet Nam reached USD 4.1 billion, up seven-fold from 2017 with the emergence of a multibillion-dollar market for solar PV. In Japan, renewable energy investment was down 19% to USD 18.3 billion, hampered by uncertainties related to grid connection and to a shift in policy from a generous FIT to a tendering regime for projects larger than 2 MW.

Downturns in other investment destinations included Thailand (down 65% to USD 535 million) and the Philippines (down 77% to USD 300 million), although these results reflect short-term policy uncertainty and starting from a small base, rather than being symptomatic of any concerted trend.[7] Meanwhile, both Indonesia and Pakistan registered large investment increases in 2017, up 67% to USD 1.0 billion and up 42% to USD 700 million, respectively.

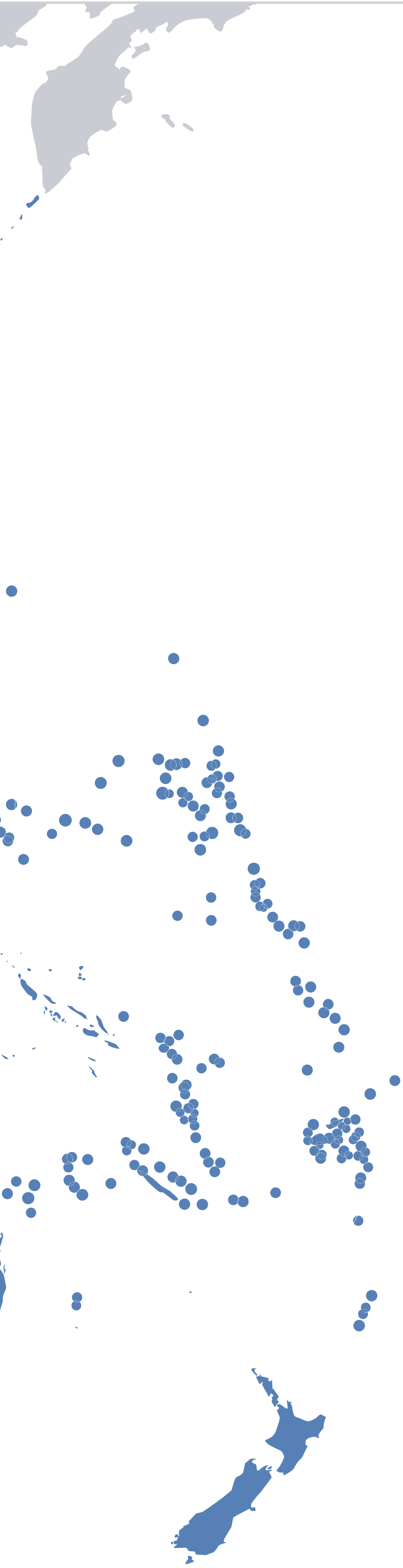
BloombergNEF's Climatescope[i] tool provides valuable insight into the fundamentals of renewable energy investment markets in the Asia Pacific region and globally, as well as into the opportunities for future investment. *Figure 11* provides a snapshot of the relative attractiveness of investment locations around the region.[8] According to the survey, the best investment opportunities can be found in Myanmar, Kazakhstan, China and India. In all cases, a country's attractiveness as an overall investment location is tempered by the scale of investment need, by the perceived sovereign risk of the country (which can be influenced by a range of factors) and increasingly by the emergence of favourable policies that encourage inward investment.

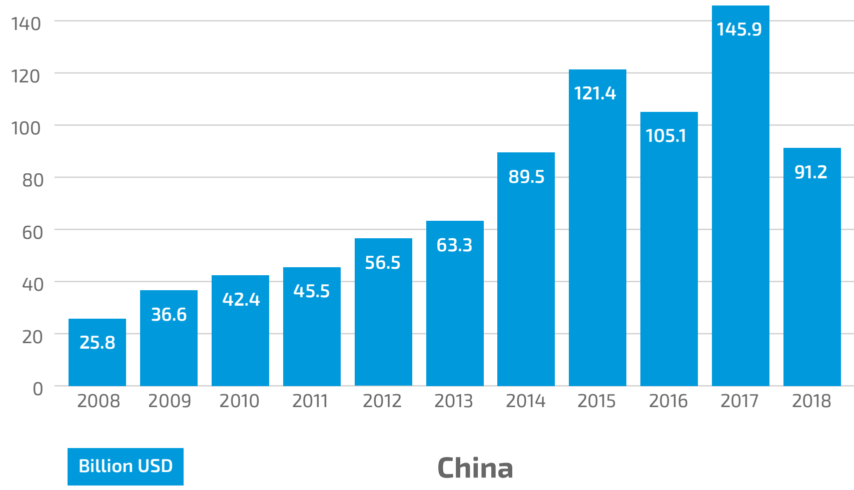
i Climatescope is a unique country-by-country assessment, interactive report and index that evaluates the investment conditions for clean energy in emerging markets. It profiles 103 markets worldwide and evaluates their ability to attract capital for low-carbon energy sources while building a greener economy.

Renewable energy investment in Viet Nam increased **seven-fold** in 2018.

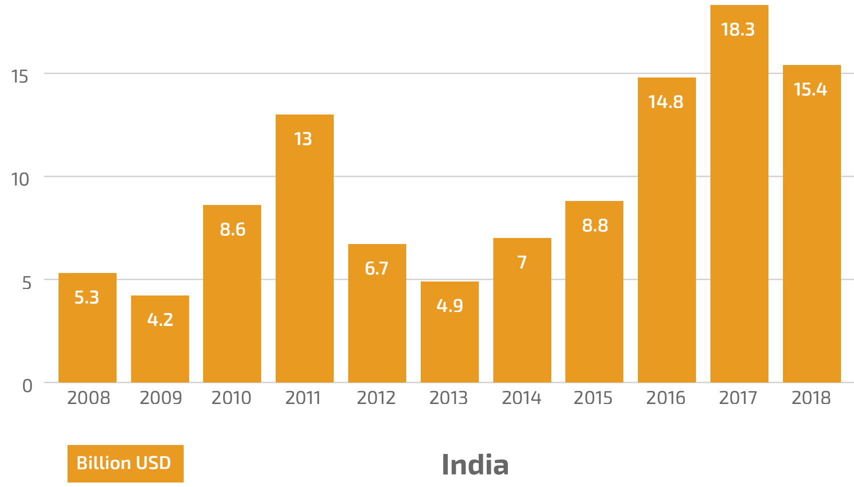
FIGURE 10. Regional Trends in Renewable Energy Investment

Note: Data are in 2018 USD and include government and corporate research and development. Figure for Asia and Oceania includes USD 9.5 billion of investment in Australia in 2018, as well as amounts from other countries in Asia and the Oceania region, which are outside the scope of this report. This figure has been reproduced from REN21's *Renewables 2019 Global Status Report*; based on data from BloombergNEF. Source: See endnote 6 for this chapter.

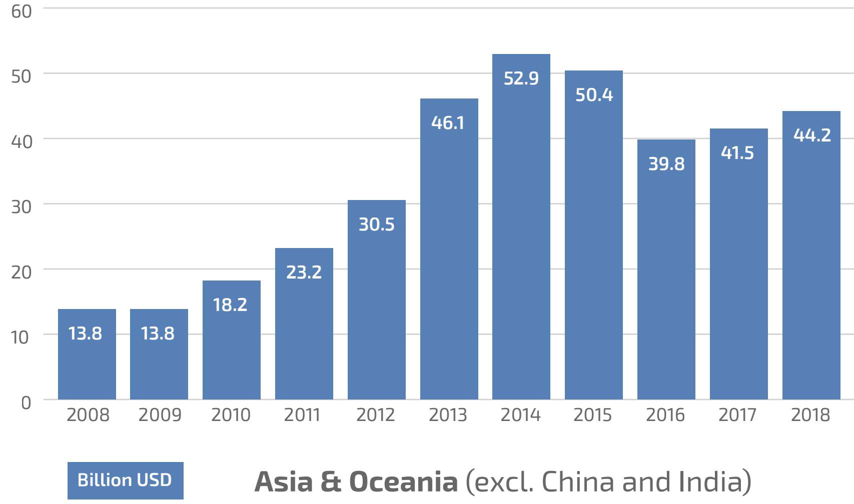




China

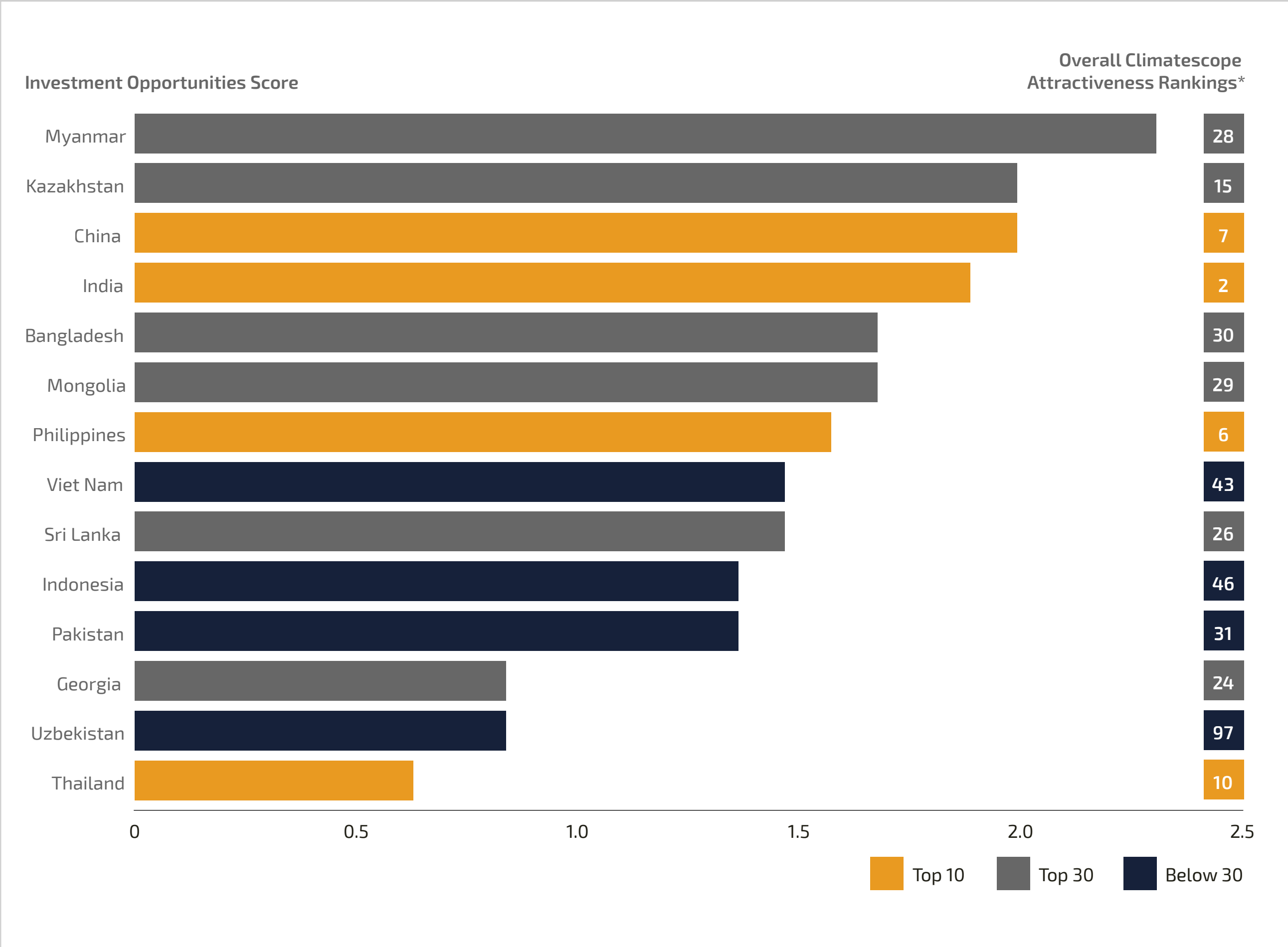


India



Asia & Oceania (excl. China and India)

FIGURE 11. Renewable Energy Attractiveness and Investment Opportunities in Selected Asia Pacific Countries, 2018



Note: Climatescope's data presented here cover two concepts: one is a multi-criteria assessment of investment opportunities, the other is an overall ranking of a country's investment "attractiveness" weighted between fundamentals 50%, opportunities 25% and experience 25%. This provides two different perspectives on each investment location. A lower ranking indicates greater attractiveness and vice versa. Climatescope calculates the future investment opportunities score by taking into account multiple indicators including a country's current and future electricity demand, energy consumption, CO_2 emissions from the power sector, overall price attractiveness, existing electrification rates, etc., to achieve an overall market opportunities assessment.

* Japan, Republic of Korea, Fiji and Tonga were not included in Climatescope's 2018 ranking.

Source: See endnote 8 for this chapter.

Although sub-regional trends are difficult to generalise, the following observations can be made:

Northeast Asia: China dominates the investment landscape in East Asia and globally, with a long-term trend of increasing solar deployment. Most investment in the Chinese renewables sector comes from domestic commercial banks and from government concessional/development lenders. In the Republic of Korea, which plans to boost its renewable generation share to 35% by 2040, there is increased interest from institutional investors due to a guaranteed revenue stream based on 20-year long-term off-take contracts with the obligors of the Renewable Portfolio Standard scheme; many of these are the generation subsidiary companies of the monopoly utility, Korea Electric Power Corporation.[9]

Energy sector investment in Japan is still heavily influenced by the move away from nuclear power following the Fukushima disaster in 2011. Japan's annual new investment in renewable energy capacity, which was already picking up before Fukushima, rose from USD 7.3 billion in 2010 to a peak of USD 37.3 billion in 2014. Since then, investment has slowed somewhat but still totalled USD 18.3 billion in 2018, behind only China and the United States. The renewables sector in Mongolia, although starting from a low base, is expanding rapidly, with the vast majority of investment coming from international development banks such as the EBRD.

Central Asia: Many of the countries of Central Asia have limited investment in renewables. This is due to a combination of cheap and/or subsidised fossil fuel supplies, poor indigenous renewable energy resources and unfavourable investment environments for international financiers. Exceptions exist, however: in Uzbekistan, the private company SkyPower Global is developing a 1 GW solar PV plant at a cost of around USD 1.3 billion, and the government is allocating further funds in an attempt to "crowd in" private sector clean energy investment.[10] Additionally, Kazakhstan introduced FITs in 2009 and has seen steady growth in wind and solar investment, although local financing costs remain an issue.

> Renewables investment in **Japan** slowed in 2018 but still totalled **USD 18.3 billion**, behind only China and the US

South Asia: In South Asia, the investment trend leans heavily towards smaller-scale mini-grid and rooftop solar projects, as a means to avoid frequent power shutdowns and to reduce overall electricity infrastructure costs (→ see Box 2).[11] Multilateral development banks are active in pushing energy access as well as in promoting initiatives such as smart metering. In the area of energy efficiency, the Indian government-backed Energy Efficiency Services Limited (EESL) has provided a leading model based on the mass procurement and deployment of efficient lighting and other appliances, which has seen very rapid uptake of the specific energy efficiency technologies supported.[12]

While India dominates the sub-region in renewables deployment, Pakistan's total installed capacity of solar, wind and biomass crossed 2,000 MW by the end of 2018.[13] Bangladesh is active in developing off-grid solar, with IDCOL being the largest facilitator of renewable energy financing.[14] Most projects in South Asia still rely on some form of concessional financing, and many projects are funded by domestic lenders that in turn have access to credit lines from development banks and other donors.

Southeast Asia: Renewable energy investment trends are uneven across the sub-region, reflecting the different resource endowments, demographic circumstances and economic priority given to renewables. In countries with abundant hydroelectric resources, such as Cambodia and the Lao PDR[i], international investment funds have been channelled into hydropower development. In Indonesia, on the other hand, investment in geothermal accounted for around 90% of the USD 800 million raised in 2017, far surpassing investments in solar and wind power. Malaysia[i], Thailand and Viet Nam have large and active renewables investment markets, driven by long-standing policies and financing schemes to promote inward investment. Among the technology sectors, solar PV and solar thermal are taking a growing share of investment interest.

i Cambodia, the Lao PDR and Malaysia are not covered by this report.

BOX 2. Government Financing for Rooftop and Farmland Solar in India

India's installed capacity of 1.5 GW of solar rooftops in 2018 is falling short of the country's ambitious target to develop 40 GW of rooftop solar PV by 2022. However, the Indian government has approved around USD 6.5 billion in financial support to promote the use of rooftop solar among farmers, group housing societies and resident welfare associations. The residential solar scheme will subsidise 40% of the cost of rooftop systems up to 3 kW, and 20% for larger systems up to 10 kW. MNRE also provides central financial assistance to private developers under the Grid-Connected Rooftop and Small Solar Power Projects Program. A subsidy of up to 30% is helping the Ministry achieve its target of 3,500 MW of rooftop solar in Tamil Nadu by 2022.

Source: See endnote 11 for this chapter.

Access to finance for large-scale renewable energy investments remains a key issue in Southeast Asian markets. Challenges range from permitting requirements and ownership restrictions in the Philippines, to inadequate infrastructure for grid stability in Myanmar, to a lack of robust financial institutions in the lower-income countries of the sub-region. At present, only a limited number of domestic banks and other financial institutions in Southeast Asia, such as national, regional and global development financial institutions, have the ability to support renewable energy projects, and further capacity building is required. Although local commercial banks generally are interested in participating in the renewables market, their involvement has been limited both because of their own capacity and because of the lack of investment-grade utility-scale projects that can meet their hurdle rate requirements.

The Pacific: As in other sub-regions, the Pacific is seeing an upswing in investor interest in small off-grid and micro/mini-grid solar applications, which are well suited to the remote communities that they serve in the Pacific Island countries. These systems are increasingly cost competitive as replacements for diesel generation and can help to improve indigenous energy security. ADB is a major funder of renewable projects in the region, including through the Pacific Renewable Energy Program, a financing structure that provides up to USD 100 million in support for the power payment obligations of power utilities, where governments are unable to guarantee a utility's offtake obligations under PPAs due to fiscal constraints.[15] ADB also has supported the long-standing Promoting Energy Efficiency in the Pacific initiative, which has catalysed energy efficiency investments in many Pacific countries.[16]

REGIONAL AND INTERNATIONAL FINANCING SOURCES

A wide range of funding sources exist for renewable energy investment, including public funds allocated through domestic energy sector budgeting, bilateral and multilateral official development assistance, and a range of specialist multilateral and private sector clean energy-related funds. In many cases investors have used a "blended" approach to financing, as a way of sharing renewable energy investment risk with other investors. Such blended investments may include direct equity investments, loans (debt), mezzanine financing (for example, through preferred shares or debt convertible to shares), catalytic funding (grants or loans intended to stimulate further investment) and concessional loans. The role of banks, including both private and development banks, has been to package a combination of loans and equity financing, plus concessional financing if necessary, to ensure that the risk profile of the deal is acceptable.

The World Bank and **ADB** are the top international financial institutions for renewable energy investments in Asia.

A range of global investment assistance programmes with specific renewable energy and energy efficiency objectives are active across Asia. They include the GCF, the GEF, the Global Climate Partnership Fund and the Global Green Growth Initiative, which has a model of embedded country-level assistance.[17] These funds and assistance programmes are well established to support project development and investment.

As a general observation, many of these funds target larger projects and appear to struggle with pipeline development and the transaction costs associated with smaller, disaggregated projects that may be present in the renewables and energy efficiency sectors. This can be a significant barrier for countries across the region that have smaller and less mature investment markets, including in the Pacific and some countries of Central Asia. There is a strong need for investment facilitation services that allow profitable and beneficial projects to be able to qualify for these funds and thereby to accelerate the uptake of available funding.

Development finance institutions were the most active investors in the early phase of renewable energy deployment across the region. More recently, the emergence of bankable utility-scale solar and wind projects has meant increasing uptake of private sector funding since 2010 as renewables transition to a mainstream infrastructure investment. Development finance institutions continue to play a critical role in capacity and awareness building, technology transfer programmes, feasibility studies and technical co-operation with other donor-funded public agencies.

The World Bank and ADB are the largest international financial institutions for renewable energy investments in the region, particularly for large-scale hydropower investments in South Asia (→ see Table 11).[18] In Southeast Asia, development banks cumulatively invested around USD 6 billion between 2009 and 2016, with the World Bank, ADB and Japan Bank for International Cooperation (JBIC) contributing the largest amounts (more than USD 1 billion each), mainly in the form of loans (73%), concessional loans (10%) and equity investments (3%).[19] Other major development financiers in the region include the EBRD in western Asia, the Islamic Development Bank and the recently established Asian Infrastructure Investment Bank (AIIB), which so far has focused its renewable energy investments mostly on large-scale hydropower projects.

TABLE 11. Selected Ongoing Renewable Energy Projects Financed by the World Bank, ADB and Other Development Institutions

Region/ Country	World Bank	ADB	Other funding
Northeast Asia			
China	6 active projects, total commitment USD 321 million	25 active projects	GEF[i]: Distributed Renewable Energy Scale-Up Project, USD 7.3 million; Developing Market-based Energy Efficiency Program in China, USD 17.8 million
Mongolia	Second Energy Sector Project, USD 42 million	Upscaling Renewable Energy Sector Project, USD 61 million	
Central Asia			
Georgia	No active projects	Promoting Low-Carbon Development in Central Asia Regional Economic Cooperation Program Cities, USD 4 million	
Kazakhstan	Kazakhstan Energy Efficiency Project, USD 22 million	4 active projects	
Uzbekistan	No active projects	8 active projects	
South Asia			
Bangladesh	6 active projects, total commitment of around USD 459 million	Improving Institutional Capacity on Preparing Energy Efficiency Investments, USD 2 million Promoting and Scaling Up Solar Photovoltaic Power Through Knowledge Management and Pilot Testing, USD 2 million Capacity Development for Renewable Energy Investment Programming and Implementation, USD 2 million Deploying Solar Systems at Scale, USD 2 million	GEF: Sustainable Renewable Energy Power Generation project (SREPGen), USD 4 million
India	6 active projects, total commitment of around USD 1,398 million	39 active projects	
Pakistan	7 active projects, total commitment of around USD 2,452 million	6 active projects including the USD 67 million Foundation Wind Energy I and II Projects and the USD 37 million Zorlu Enerji Power Project	
Sri Lanka	No active projects	Improving Institutional Capacity on Preparing Energy Efficiency Investments, USD 2 million	
Southeast Asia			
Indonesia	Geothermal Upstream Industry Development, USD 55 million	14 active projects	
Myanmar	Off-grid component of the National Electrification Plan, USD 80 million	USD 2 million (completed)	GEF: USD 5 million, implemented by UNDP Rockefeller Foundation: USD 5 million
Philippines	Access to Sustainable Energy Project, USD 23 million	Market Transformation Through Introduction of Energy-Efficient Electric Vehicles Project, USD 405 million	
Thailand	No active projects	Provincial Solar Power Project, USD 795 million	
Viet Nam	4 active projects, total commitment of around USD 355 million	Municipal Waste-to-Energy Project, USD 100 million	
The Pacific			
Fiji	No active projects	Pacific Renewable Energy Program (regional)	
Tonga	Tonga Energy Roadmap, USD 12 million	Pacific Renewable Energy Program (regional) Outer Island Renewable Energy Project, USD 26 million Renewable Energy Project, USD 44.6 million	

i GEF: Global Environment Facility

Source: See endnote 18 for this chapter.

Funding from development finance institutions is supported with different types of technical assistance funds, including those for project preparation as well as special purpose technical assistance to improve the enabling conditions in countries to ensure that the investments succeed. Development banks also have private sector operations alongside their sovereign lending operations, which aim to crowd in private finance and retain an imperative to design and work on projects that are in line with national development objectives.

The vast majority of investment in renewable energy and energy efficiency is spent in the same country in which it is sourced: during 2015-2016, 81% of finance was raised in the same country in which it was spent.[20] Potential local sources of finance for renewable energy and energy efficiency across the Asia Pacific region are discussed below.

- **Private sector banks and other private financiers** (for example, pension funds): These are large possible sources of finance, and many invest directly in businesses in developing countries. Many potential sources exist for this kind of funding, which channels both private sector and blended funds towards private investments in target countries. Renewable energy and energy efficiency investments can present an increasingly attractive investment proposition to create returns for shareholders while reducing environmental impacts and promoting sustainable development.

- **Bond market initiatives:** Bonds are a significant source of private sector capital as well. The global "green bond" market has grown rapidly as more renewable energy companies in the United States, Europe and China issue instruments to finance plant development. For the rest of Asia, however, green bonds are still in a nascent stage.[21]

- **Private equity and capital markets:** As the costs of key renewable energy technologies (especially wind and solar power) decline, equity investors have shown increasing interest in the renewables sector. Private equity funds and venture capitalists have become more active in recent years as the technologies reach grid parity with conventional energy sources.[22] Since its inception, the Private Financing Advisory Network Asia (PFAN-Asia) – a network of more than 200 investors and financiers that secures renewable energy and energy efficiency investments for both the private sector and governments – has assisted 112 clean energy projects globally by securing more than USD 1.46 billion from private investors.[23] In 2018, PFAN leveraged more than USD 200 million in finance in Asia, including for four projects in Southeast Asia and six in South Asia.[24] Globally, private sources accounted for around 87% of total renewable energy finance between 2013 and 2016, averaging USD 223 billion annually during 2013-2014 and USD 270 billion annually during 2015-2016, peaking at nearly USD 300 billion in 2015.[25]

- **Power utilities:** Seeking to maximise returns, utilities are increasingly looking to energy efficiency investments as a cheaper way to acquire new system capacity than by upgrading supply infrastructure. At the same time, self-financed utility investments in clean generation are gaining pace as a cost-effective way for utilities to reduce their own emissions and exposure to carbon constraints.

In some cases, innovative business models and financing are being used to accelerate renewable energy deployment. For example, crowdfunding is becoming an increasingly popular means for closing the financing gap experienced by businesses and non-profits that provide renewable energy products and services to off-grid communities. However, the ticket sizes in the Asia Pacific region are smaller compared to the African market. Kiva (the dominant crowdfunding platform globally) and Lendahand have raised funding for projects in India and the Philippines, with a total of USD 250,000 in energy access financing.[26]

Large off-grid populations across the Asia Pacific region, as well as the increase in off-grid solutions, also provide opportunities to integrate energy access technologies with mobile money, including through the use of innovative pay-as-you-go approaches (→ see Distributed Renewables chapter).

CLIMATE FINANCE PATHWAYS AND FUTURE POTENTIAL

Globally, climate finance flows reached a record high of USD 472 billion in 2015, driven primarily by rising private investment in renewables.[27] This was followed by a drop in 2016 to USD 455 billion, attributed to declining renewable energy technology costs and to fewer renewable capacity additions in some countries.[28]

Climate finance funds have continued to provide opportunities for financing renewable energy and energy efficiency projects in the Asia Pacific region. Table 12 provides data on the recipient countries of climate finance from major multilateral climate change funds as of February 2019.[29] The largest funds by overall investment volume are the Clean Technology Fund , the GCF and the GEF. The GEF administers by far the largest number of projects, with 168 projects active as of February 2019, while other funds, including the Scaling Up Renewable Energy Program (SREP), aim for impact via larger infrastructure investments.[30] Just three countries – India, Indonesia and China – received 53% of climate funds invested in all countries in Asia and the Pacific during 2003-2017, reflecting the relative size and dominance of their economies and energy markets.[31]

Notably, extracting renewable energy investment figures from climate data is difficult, as many climate-financed interventions have multiple objectives and may include some clean energy objectives although the principal project focus is elsewhere. Table 12 therefore likely underestimates the scale of climate finance for renewable energy and energy efficiency, as it captures only projects with a specific and articulated clean energy focus, rather than those with multiple objectives.[32]

TABLE 12. Country Recipients of Climate Funds for Sustainable Energy Projects in the Selected Asia Pacific Countries

Country	Amount approved (USD)	Number of projects approved	Largest funder[i]
Northeast Asia			
China	222 million	24	GEF
Mongolia	73 million	9	GCF
Central Asia			
Georgia	14 million	2	GEF
Kazakhstan	281 million	12	GCF, CTF
Uzbekistan	9 million	2	GEF
South Asia			
Bangladesh	79 million	5	SREP
India	1,077 million	34	CTF
Pakistan	10 million	6	GEF
Sri Lanka	6 million	2	GEF
Southeast Asia			
Indonesia	538 million	22	CTF
Myanmar	14 million	4	GEF
Philippines	104 million	8	CTF
Thailand	125 million	9	CTF
Viet Nam	136 million	12	GCF
The Pacific			
Fiji	1 million	1	GEF
Tonga	33 million	2	GCF
Regional Projects			
	1,212 million	45	
Other Asia Pacific Countries[ii]			
	415 million	60	
	4,349 million	259	

Note: The Republic of Korea and Japan are excluded from being recipients of climate funds for development.

i GEF = Global Environment Facility, GCF = Green Climate Fund, CTF = Clean Technology Fund, SREP = Scaling Up Renewable Energy Program in Low Income Countries

ii Includes all remaining countries from the region, not covered in this report.

Source: See endnote 29 for this chapter.

LIST OF ABBREVIATIONS

ADB	Asian Development Bank
APEC	Asia- Pacific Economic Cooperation
ASEAN	Association of Southeast Asian Nations
CAREC	Central Asia Regional Economic Cooperation
CHP	Combined heat and power
CO_2	Carbon dioxide
CSP	Concentrating solar thermal power
CTF	Clean Technology Fund
DREA	Distributed renewables for energy access
ERC	Energy Regulatory Commission
ERBD	European Bank for Reconstruction and Development
EV	Electric vehicle
FAME	Fatty acid methyl ester
FIT	Feed-in tariff
GCF	Green Climate Fund
GDP	Gross domestic product
GEF	Global Environment Facility
GW/GWh	Gigawatt/gigawatt-hour
GW_{th}	Gigawatt-thermal
IDCOL	Infrastructure Development Company Limited
IEA	International Energy Agency
IFC	International Finance Corporation
IPP	Independent power producer
IREDA	Indian Renewable Energy Development Agency
IRENA	International Renewable Energy Agency
JICA	Japan International Cooperation Agency
ktoe	Kilotonnes of oil equivalent
kW/kWh	Kilowatt/kilowatt-hour
LPG	Liquefied petroleum gas
m^2	Square metre
MJ	Megajoule
MNRE	Ministry of New and Renewable Energy
MW/MWh	Megawatt/megawatt-hour
MW_{th}	Megawatt-thermal
NDC	Nationally Determined Contribution
NGO	Non-governmental organisation
PAYG	Pay-as-you-go
PCREEE	Pacific Centre for Renewable Energy and Energy Efficiency
PPA	Power purchase agreement
PPP	Purchasing power parity
PV	Photovoltaic/photovoltaics
RBF	Results-based financing
REC	Renewable electricity certificate
REN21	Renewable Energy Policy Network for the 21st Century
RPS	Renewable portfolio standard
SDG	Sustainable Development Goal
SPP	Small power producer
TFEC	Total final energy consumption
TPES	Total primary energy supply
TW/TWh	Terawatt/terawatt-hour
UN	United Nations
UN ESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States dollar
W/Wh	Watt/watt-hour

GLOSSARY

Auction. See Tendering.

Biodiesel. A fuel produced from oilseed crops such as soy, rapeseed (canola) and palm oil, and from other oil sources such as waste cooking oil and animal fats. Biodiesel is used in diesel engines installed in cars, trucks, buses and other vehicles, as well as in stationary heat and power applications. Most biodiesel is made by chemically treating vegetable oils and fats (such as palm, soy and canola oils, and some animal fats) to produce fatty acid methyl esters (FAME).

Bioenergy. Energy derived from any form of biomass (solid, liquid or gaseous) for heat, power and transport. (Also see Biofuel.)

Biofuel. A liquid or gaseous fuel derived from biomass, primarily ethanol, biodiesel and biogas. Biofuels can be combusted in vehicle engines as transport fuels and in stationary engines for heat and electricity generation. They also can be used for domestic heating and cooking (for example, as ethanol gels). Conventional biofuels are principally ethanol produced by fermentation of sugar or starch crops (such as wheat and corn), and FAME biodiesel produced from oil crops such as palm oil and canola and from waste oils and fats. Advanced biofuels are made from feedstocks derived from the lignocellulosic fractions of biomass sources or from algae. They are made using biochemical and thermochemical conversion processes, some of which are still under development.

Biogas/Biomethane. Biogas is a gaseous mixture consisting mainly of methane and carbon dioxide produced by the anaerobic digestion of organic matter (broken down by microorganisms in the absence of oxygen). Organic material and/or waste is converted into biogas in a digester. Suitable feedstocks include agricultural residues, animal wastes, food industry wastes, sewage sludge, purpose-grown green crops and the organic components of municipal solid wastes. Raw biogas can be combusted to produce heat and/or power; it alsocan be transformed into biomethane through a process known as scrubbing that removes impurities including carbon dioxide, siloxanes and hydrogen sulphides, followed by compression. Biomethane can be injected directly into natural gas networks and used as a substitute for natural gas in internal combustion engines without risk of corrosion.

Biomass. Any material of biological origin, excluding fossil fuels or peat, that contains a chemical store of energy (originally received from the sun) and that is available for conversion to a wide range of convenient energy carriers.

Biomass, traditional (use of). Solid biomass (including fuel wood, charcoal, agricultural and forest residues, and animal dung), that is used in rural areas of developing countries with traditional technologies such as open fires and ovens for cooking and residential heating. Often the traditional use of biomass leads to high pollution levels, forest degradation and deforestation.

Biomass energy, modern. Energy derived from combustion of solid, liquid and gaseous biomass fuels in high-efficiency conversion systems, which range from small domestic appliances to large-scale industrial conversion plants. Modern applications include heat and electricity generation, combined heat and power (CHP) and transport.

Capacity. The rated power of a heat or electricity generating plant, which refers to the potential instantaneous heat or electricity output, or the aggregate potential output of a collection of such units (such as a wind farm or a set of solar panels). Installed capacity describes equipment that has been constructed, although it may or may not be operational (e.g., delivering electricity to the grid, providing useful heat or producing biofuels).

Capital subsidy. A subsidy that covers a share of the upfront capital cost of an asset (such as a solar water heater). These include, for example, consumer grants, rebates or one-time payments by a utility, government agency or government-owned bank.

Combined heat and power (CHP). CHP facilities produce both heat and power from the combustion of fossil and/or biomass fuels, as well as from geothermal and solar thermal resources. The term also is applied to plants that recover "waste heat" from thermal power generation processes.

Community energy. An approach to renewable energy development that involves a community initiating, developing, operating, owning, investing and/or benefiting from a project. Communities vary in size and shape (e g., schools, neighbourhoods, partnering city governments, etc.); similarly, projects vary in technology, size, structure, governance, funding and motivation.

Competitive bidding. See Tendering.

Concentrating solar thermal power (CSP) (also called solar thermal electricity, STE). Technology that uses mirrors to focus sunlight into an intense solar beam that heats a working fluid in a solar receiver, which then drives a turbine or heat engine/generator to produce electricity. The mirrors can be arranged in a variety of ways, but they all deliver the solar beam to the receiver. There are four types of commercial CSP systems: parabolic troughs, linear Fresnel, power towers and dish/engines. The first two technologies are line-focus systems, capable of concentrating the sun's energy to produce temperatures of 400°C, while the latter two are point- focus systems that can produce temperatures of 800°C or higher.

Curtailment. A reduction in the output of a generator, typically on an involuntary basis, from what it could produce otherwise given the resources available. Curtailment of electricity generation has long been a normal occurrence in the electric power industry and can occur for a variety of reasons, including a lack of transmission access or transmission congestion.

Demand-side management. The application of economic incentives and technology in the pursuit of cost-effective energy efficiency measures and load-shifting on the customer side, to achieve least-cost overall energy system optimisation.

Demand response. The use of market signals such as time-of-use pricing, incentive payments or penalties to influence end-user electricity consumption behaviours. Demand response is usually used to balance electrical supply and demand within a power system.

Distributed generation. Generation of electricity from dispersed, generally small-scale systems that are close to the point of consumption.

Distributed renewable energy. Energy systems are considered to be distributed if 1) the systems are connected to the distribution network rather than the transmission network, which implies that they are relatively small and dispersed (such as small-scale solar PV on rooftops) rather than relatively large and centralised; or 2) generation and distribution occur independently from a centralised network. Specifically for the purpose of the chapter on Distributed Renewables for Energy Access, "distributed renewable energy" meets both conditions. It includes energy services for electrification, cooking, heating and cooling that are generated and distributed independent of any centralised system, in urban and rural areas of the developing world.

Distribution grid. The portion of the electrical network that takes power off the high-voltage transmission network via substations (at varying stepped-down voltages) and distributes electricity to customers.

Electric vehicle (EV). A vehicle that uses one or more electric motors for propulsion. A battery electric vehicle is a type of EV that uses chemical energy stored in rechargeable battery packs. A plug-in hybrid EV can be recharged by an external source of electric power. Fuel cell vehicles are EVs that use pure hydrogen (or gaseous hydrocarbons before reformation) as the energy storage medium.

Energy. The ability to do work, which comes in a number of forms including thermal, radiant, kinetic, chemical, potential and electrical. Primary energy is the energy embodied in (energy potential of) natural resources, such as coal, natural gas and renewable sources. Final energy is the energy delivered for end-use (such as electricity at an electrical outlet). Conversion losses occur whenever primary energy needs to be transformed for final energy use, such as combustion of fossil fuels for electricity generation.

Energy conservation. Any change in behaviour of an energy consuming entity for the specific purpose of affecting an energy demand reduction. Energy conservation is distinct from energy efficiency in that it is predicated on the assumption that an otherwise preferred behaviour of greater energy intensity is abandoned. See Energy efficiency and Energy intensity.

Energy efficiency. The measure that accounts for delivering more services for the same energy input, or the same amount of services for less energy input. Conceptually, this is the reduction of losses from the conversion of primary source fuels through final energy use, as well as other active or passive measures to reduce energy demand without diminishing the quality of energy services delivered. Energy efficiency is technology-specific and distinct from energy conservation, which pertains to behavioural change. Both energy efficiency and energy conservation can contribute to energy demand reduction.

Energy intensity. Primary energy consumption per unit of economic output. Energy intensity is a broader concept than energy efficiency in that it is also determined by non-efficiency variables, such as the composition of economic activity. Energy intensity typically is used as a proxy for energy efficiency in macro-level analyses due to the lack of an internationally agreed upon high-level indicator for measuring energy efficiency.

Energy subsidy. A government measure that artificially reduces the price that consumers pay for energy or that reduces the energy production cost.

Ethanol (fuel). A liquid fuel made from biomass (typically corn, sugar cane or small cereals/grains) that can replace petrol in modest percentages for use in ordinary spark-ignition engines (stationary or in vehicles), or that can be used at higher blend levels (usually up to 85% ethanol, or 100% in Brazil) in slightly modified engines, such as those provided in "flex-fuel" vehicles. Ethanol also is used in the chemical and beverage industries. Fatty acid methyl esters (FAME). See Biodiesel.

Fatty acid methyl esters (FAME). See Biodiesel.

Feed-in policy (feed-in tariff or feed-in premium). A policy that typically guarantees renewable generators specified payments per unit (e.g., USD per kWh) over a fixed period. Feed-in tariff (FIT) policies also may establish regulations by which generators can interconnect and sell power to the grid. Numerous options exist for defining the level of incentive, such as whether the payment is structured as a guaranteed minimum price (e.g., a FIT), or whether the payment floats on top of the wholesale electricity price (e.g., a feed-in premium).

Final energy. The part of primary energy, after deduction of losses from conversion, transmission and distribution, that reaches the consumer and is available to provide heating, hot water, lighting and other services. Final energy forms include, among others, electricity, district heating, mechanical energy, liquid hydrocarbons such as kerosene or fuel oil, and various gaseous fuels such as natural gas, biogas and hydrogen.

(Total) Final energy consumption (TFEC). Energy that is supplied to the consumer for all final energy services such as transport, cooling and lighting, building or industrial heating or mechanical work. TFEC differs from total final consumption (TFC), which includes all energy use in end-use sectors (TFEC) as well as energy use for non-energy applications, mainly various industrial uses, such as feedstocks for petrochemical manufacturing.

Fiscal incentive. An incentive that provides individuals, households or companies with a reduction in their contribution to the public treasury via income or other taxes.

Generation. The process of converting energy into electricity and/or useful heat from a primary energy source such as wind, solar radiation, natural gas, biomass, etc.

Geothermal energy. Heat energy emitted from within the Earth's crust, usually in the form of hot water and steam. It can be used to generate electricity in a thermal power plant or to provide heat directly at various temperatures.

Green bond. A bond issued by a bank or company, the proceeds of which will go entirely into renewable energy and other environmentally friendly projects. The issuer will normally label it as a green bond. There is no internationally recognised standard for what constitutes a green bond.

Heat pump. A device that transfers heat from a heat source to a heat sink using a refrigeration cycle that is driven by external electric or thermal energy. It can use the ground (geothermal/ ground-source), the surrounding air (aerothermal/air-source) or a body of water (hydrothermal/water-source) as a heat source in heating mode, and as a heat sink in cooling mode. A heat pump's final energy output can be several multiples of the energy input, depending on its inherent efficiency and operating condition. The output of a heat pump is at least partially renewable on a final energy basis. However, the renewable component can be much lower on a primary energy basis, depending on the composition and derivation of the input energy; in the case of electricity, this includes the efficiency of the power generation process. The output of a heat pump can be fully renewable energy if the input energy is also fully renewable.

Hydropower. Electricity derived from the potential energy of water captured when moving from higher to lower elevations. Categories of hydropower projects include run-of-river, reservoir based capacity and low-head in-stream technology (the least developed). Hydropower covers a continuum in project scale from large (usually defined as more than 10 MW of installed capacity, but the definition varies by country) to small, mini, micro and pico.

Investment. Purchase of an item of value with an expectation of favourable future returns. In this report, new investment in renewable energy refers to investment in: technology research and development, commercialisation, construction of manufacturing facilities and project development (including the construction of wind farms and the purchase and installation of solar PV systems). Total investment refers to new investment plus merger and acquisition (M&A) activity (the refinancing and sale of companies and projects).

Investment tax credit. A fiscal incentive that allows investments in renewable energy to be fully or partially credited against the tax obligations or income of a project developer, industry, building owner, etc.

Joule. A joule (J) is a unit of work or energy equal to the work done by a force equal to one newton acting over a distance of one metre. One joule is equal to one watt-second (the power of one watt exerted over the period of one second). The potential chemical energy stored in one barrel of oil and released when combusted is approximately 6 gigajoules (GJ); a tonne of oven-dry wood contains around 20 GJ of energy.

Levelised cost of energy/electricity (LCOE). The cost per unit of energy from an energy generating asset that is based on the present value of its total construction and lifetime operating costs, divided by total energy output expected from that asset over its lifetime.

Long-term strategic plan. Strategy to achieve energy savings over a specified period of time (i.e., several years), including specific goals and actions to improve energy efficiency, typically spanning all major sectors.

Mandate/Obligation. A measure that requires designated parties (consumers, suppliers, generators) to meet a minimum – and often gradually increasing – standard for renewable energy (or energy efficiency), such as a percentage of total supply, a stated amount of capacity, or the required use of a specified renewable technology. Costs generally are borne by consumers. Mandates can include renewable portfolio standards (RPS); building codes or obligations that require the installation of renewable heat or power technologies (often in combination with energy efficiency investments); renewable heat purchase requirements; and requirements for blending specified shares of biofuels (biodiesel or ethanol) into transport fuel.

Mini-grid/Micro-grid. For distributed renewable energy systems for energy access, a mini-grid/micro-grid typically refers to an independent grid network operating on a scale of less than 10 MW (with most at very small scale) that distributes electricity to a limited number of customers. Mini-/micro-grids also can refer to much larger networks (e.g., for corporate or university campuses) that can operate independently of, or in conjunction with, the main power grid. However, there is no universal definition differentiating mini- and micro-grids.

Monitoring. Energy use is monitored to establish a basis for energy management and to provide information on deviations from established patterns.

Municipal solid waste. Waste materials generated by households and similar waste produced by commercial, industrial or institutional entities. The wastes are a mixture of renewable plant and fossil-based materials, with the proportions varying depending on local circumstances. A default value that assumes that at least 50% of the material is "renewable" is often applied.

Net metering/Net billing. A regulated arrangement in which utility customers with on-site electricity generators can receive credits for excess generation, which can be applied to offset consumption in other billing periods. Under net metering, customers typically receive credit at the level of the retail electricity price. Under net billing, customers typically receive credit for excess power at a rate that is lower than the retail electricity price. Different jurisdictions may apply these terms in different ways, however.

Ocean power. Refers to technologies used to generate electricity by harnessing from the ocean the energy potential of ocean waves, tidal range (rise and fall), tidal streams, ocean (permanent) currents, temperature gradients (ocean thermal energy conversion) and salinity gradients. The definition of ocean power used in this report does not include offshore wind power or marine biomass energy.

Off-take agreement. An agreement between a producer of energy and a buyer of energy to purchase/sell portions of the producer's future production. An off-take agreement normally is negotiated prior to the construction of a renewable energy project or installation of renewable energy equipment in order to secure a market for the future output (e.g., electricity, heat). Examples of this type of agreement include power purchase agreements and feed-in tariffs.

Off-taker. The purchaser of the energy from a renewable energy project or installation (e.g., a utility company) following an off-take agreement. (See Off-take agreement.)

Pay-as-you-go (PAYG). A business model that gives customers (mainly in areas without access to the electricity grid) the possibility to purchase small-scale energy-producing products, such as solar home systems, by paying in small instalments over time.

Pico solar devices/pico solar systems. Small solar systems such as solar lanterns that are designed to provide only a limited amount of electricity service, usually lighting and in some cases mobile phone charging. Such systems are deployed mainly in areas that have no or poor access to electricity. The systems usually have a power output of 1-10 watts and a voltage of up to 12 volts.

Power. The rate at which energy is converted into work, expressed in watts (joules/second).

Power purchase agreement (PPA). A contract between two parties, one that generates electricity (the seller) and one that is looking to purchase electricity (the buyer).

Primary energy. The theoretically available energy content of a naturally occurring energy source (such as coal, oil, natural gas, uranium ore, geothermal and biomass energy, etc.) before it undergoes conversion to useful final energy delivered to the end-user. Conversion of primary energy into other forms of useful final energy (such as electricity and fuels) entails losses. Some primary energy is consumed at the end-user level as final energy without any prior conversion.

Primary energy consumption. The direct use of energy at the source, or supplying users with unprocessed fuel.

Product and sectoral standards. Rules specifying the minimum standards for certain products (e.g., appliances) or sectors (industry, transport, etc.) for increasing energy efficiency.

Production tax credit. A tax incentive that provides the investor or owner of a qualifying property or facility with a tax credit based on the amount of renewable energy (electricity, heat or biofuel) generated by that facility.

Public financing. A type of financial support mechanism whereby governments provide assistance, often in the form of grants or loans, to support the development or deployment of renewable energy technologies.

Pumped storage. Plants that pump water from a lower reservoir to a higher storage basin using surplus electricity, and that reverse the flow to generate electricity when needed. They are not energy sources but means of energy storage and can have overall system efficiencies of around 80-90%.

Regulatory policy. A rule to guide or control the conduct of those to whom it applies. In the renewable energy context, examples include mandates or quotas such as renewable portfolio standards, feed-in tariffs and technology/fuel specific obligations.

Renewable energy certificate (REC). A certificate awarded to certify the generation of one unit of renewable energy (typically 1 MWh of electricity but also less commonly of heat). In systems based on RECs, certificates can be accumulated to meet renewable energy obligations and also provide a tool for trading among consumers and/or producers. They also are a means of enabling purchases of voluntary green energy.

Renewable portfolio standard (RPS). An obligation placed by a government on a utility company, group of companies or consumers to provide or use a predetermined minimum targeted renewable share of installed capacity, or of electricity or heat generated or sold. A penalty may or may not exist for non-compliance. These policies also are known as "renewable electricity standards", "renewable obligations" and "mandated market shares", depending on the jurisdiction.

Reverse auction. See Tendering.

Smart grid technology. Advanced information and control technology that is required for improved systems integration and resource optimisation on the grid.

Solar collector. A device used for converting solar energy to thermal energy (heat), typically used for domestic water heating but also used for space heating, for industrial process heat or to drive thermal cooling machines. Evacuated tube and flat plate collectors that operate with water or a water/glycol mixture as the heat-transfer medium are the most common solar thermal collectors used worldwide. These are referred to as glazed water collectors because irradiation from the sun first hits a glazing (for thermal insulation) before the energy is converted to heat and transported away by the heat transfer medium. Unglazed water collectors, often referred to as swimming pool absorbers, are simple collectors made of plastics and used for lower temperature applications. Unglazed and glazed air collectors use air rather than water as the heat-transfer medium to heat indoor spaces or to pre-heat drying air or combustion air for agriculture and industry purposes.

Solar home system. A stand-alone system composed of a relatively low-power photovoltaic module, a battery and sometimes a charge controller that can provide modest amounts of electricity for home lighting, communications and appliances, usually in rural or remote regions that are not connected to the electricity grid. The term solar home system kit is also used to define systems that usually are branded and have components that are easy for users to install and use.

Solar photovoltaics (PV). A technology used for converting light directly into electricity. Solar PV cells are constructed from semiconducting materials that use sunlight to separate electrons from atoms to create an electric current. Modules are formed by interconnecting individual cells.

Target. An official commitment, plan or goal set by a government (at the local, state, national or regional level) to achieve a certain amount of renewable energy or energy efficiency by a future date. Targets may be backed by specific compliance mechanisms or policy support measures. Some targets are legislated, while others are set by regulatory agencies, ministries or public officials.

Tender (also called auction / reverse auction or tender). A procurement mechanism by which renewable energy supply or capacity is competitively solicited from sellers, who offer bids at the lowest price that they would be willing to accept. Bids may be evaluated on both price and non-price factors.

Transmission grid. The portion of the electrical supply distribution network that carries bulk electricity from power plants to substations, where voltage is stepped down for further distribution. High-voltage transmission lines can carry electricity between regional grids in order to balance supply and demand.

Variable renewable energy. A renewable energy source that fluctuates within a relatively short time frame, such as wind and solar energy, which vary within daily, hourly and even sub-hourly time frames. By contrast, resources and technologies that are variable on an annual or seasonal basis due to environmental changes, such as hydropower (due to changes in rainfall) and thermal power plants (due to changes in temperature of ambient air and cooling water), do not fall into this category.

Vehicle fuel standard. Rule specifying the minimum fuel economy of automobiles.

METHODOLOGICAL NOTE

The *Asia and the Pacific Renewable Energy Status Report*, in keeping with the objectives of previous REN21 regional reports, provides an overview of the renewable energy status of each selected country. The 18 countries and five sub-regions analysed in this report cover a vast territory that is extremely rich in natural resources, including those suitable for almost any type of renewable energy technology. The report highlights the fronts on which progress is being made and attempts, through newly gathered data and information, to provide the knowledge that is needed to identify specific obstacles and to highlight possible opportunities to greatly increase renewable energy uptake in the region.

The report draws from thousands of published and unpublished references, including: official government sources; reports from international organisations and industry associations; input from the REN21 community via questionnaires submitted by country, sub-regional and technology contributors as well as feedback from several rounds of formal and informal reviews; additional personal communications with several international experts; and a variety of electronic newsletters, news media and other sources. Where necessary, information and data that are conflicting, partial or older are reconciled by using reasoned expert judgment. Endnotes provide additional details, including references, supporting information and assumptions where relevant.

Much of the data found in this regional report is built from the ground up by the authors with the aid of these resources. This often involves extrapolation of older data, based on recent changes in key countries within a sector or based on recent growth rates and global trends. Other data, often very specific and narrow in scope, come more-or-less prepared from third parties. The report attempts to synthesise these data points into a collective whole for the focus year.

For ease of reference, wherever possible the report is structured by the five sub-regions of Northeast Asia, Central Asia, South Asia, Southeast Asia and The Pacific. Sub-regional conclusions have been drawn wherever common threads can be found.

The report considers the uptake of renewable energy across the three main energy sectors:

- **Power generation:** Meeting electricity demand and substituting non-renewable sources of electricity is, in some ways, a traditional application of renewable energy. Rapid reductions in unit costs for renewable electricity generation, along with innovations in regulatory models and rules for both producing and procuring energy in many national electricity markets, mean that the landscape is constantly evolving towards more decentralised generation and increased uptake of such technologies to meet electricity demand.

- **Heating and cooling:** Rising demand for heating and cooling is driven by the increasing desire for individual thermal comfort and by increased prosperity, improved supply chains and expanding industrial processes. The application of renewables to meet this demand remains in its early stages, and more could be done to further the deployment of renewable sources of thermal energy, such as biomass, solar thermal and terrestrial (geothermal and ocean) sources.

- **Transport:** Transport has long been a significant sector for emission reduction activity and for the application of lower-emission fuels and vehicles, which also have the potential to reduce air pollution. New technologies, including those to accelerate vehicle electrification and reduce dependence on petroleum, create many new opportunities for increasing the penetration of renewable energy.

CURRENCY

All exchange rates in this report are as of July 2019 and are calculated using the OANDA currency converter (http://www.oanda.com/currency/converter/).

REN21 DATA AND REPORTING CULTURE

REN21 has developed a unique renewable energy reporting culture, allowing it to become recognised as a **neutral data and knowledge broker** that provides credible and widely accepted information. The REN21 data and reporting culture comprises the following elements:

- Developing data collection processes that build on an international community of experts, allowing access to dispersed data and information that frequently are not consolidated;
- Consolidating formal (official) and informal (unofficial/unconventional) data gathered from a wide range of sources in a collaborative and transparent way;
- Complementing and validating data and information in an open peer-review process;
- Using validated data and information to provide fact-based evidence and to develop a supportive narrative to shape the global debate on the energy transition.

Transparency is at the heart of the REN21 data and reporting culture. REN21 ensures the accuracy and reliability of its reports by conducting data validation and fact-checking as a continuous process. From the first submission of the country questionnaires, data are continually verified up through the design period and until the final report is published.

All data provided by contributors, whether written or verbal, are validated by primary sources, which are published online in the full report (www.ren21.net).

REN21 HAS DEVELOPED A UNIQUE RENEWABLE ENERGY REPORTING CULTURE

Our process is built on collaboration (drawing on the power of many) consolidation (of data) and transparency (open and rigorous validation).

All data and information are openly available to be used to advocate for a sustainable energy future.

ENDNOTES

01 / REGIONAL OVERVIEW

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05 / INVESTMENT FLOWS

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