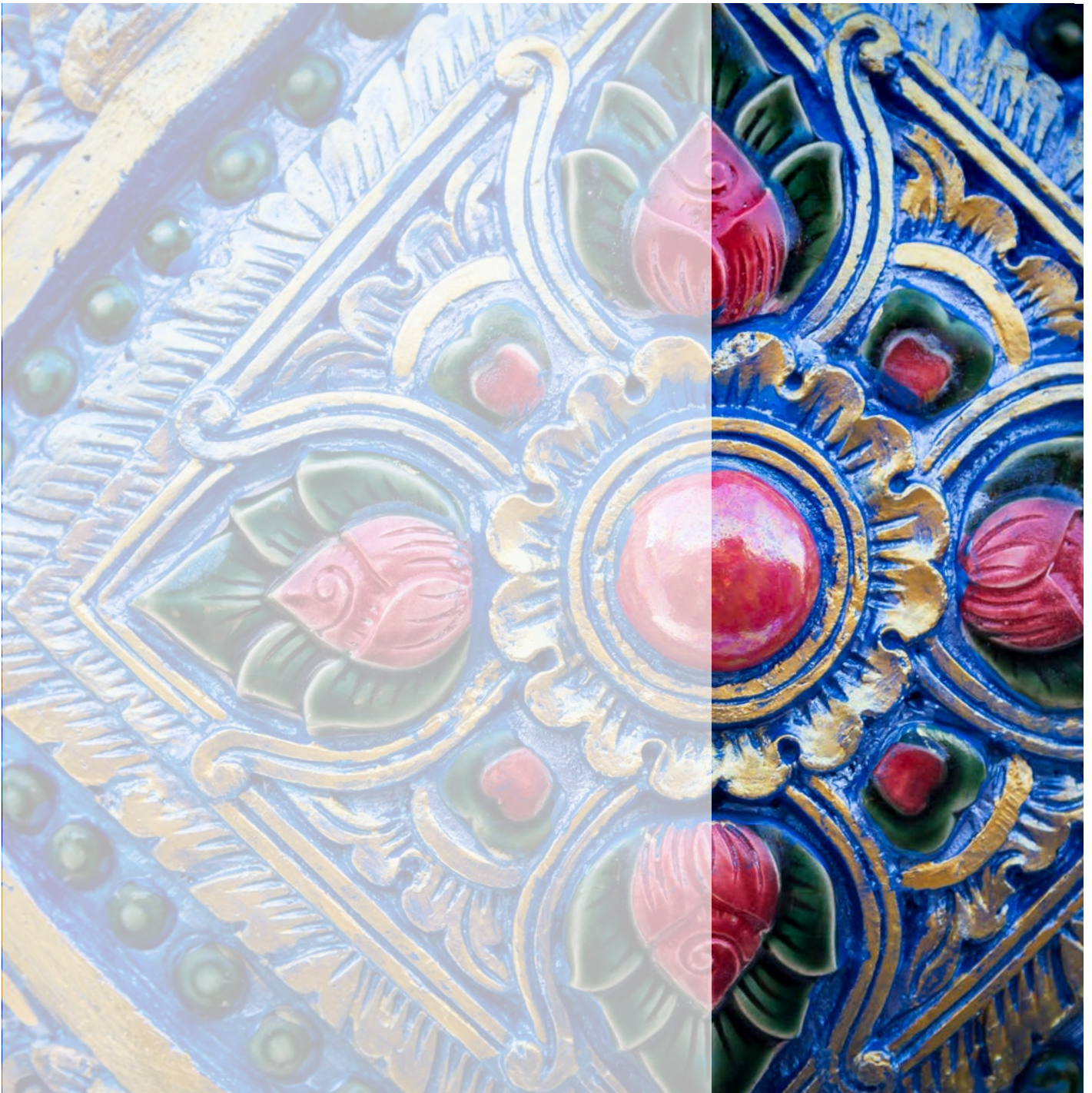


RENEWABLE ENERGY MARKET ANALYSIS

SOUTHEAST ASIA



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ABOUT IRENA

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that supports countries in their transition to a sustainable energy future, and serves as the principal platform for international co-operation, a centre of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy. IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy, in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity.

www.irena.org

AUTHORS

The report was directed by Rabia Ferroukhi (IRENA), authored by Divyam Nagpal and Diala Hawila (IRENA).

Chapter-specific contributing authors include: Michael Renner, Bishal Parajuli, Barbara Franceschini, Sandra Lozo, Joanne Jungmin Lee, Costanza Strinati, Tobias Rinke, Michael Taylor, Andrei Ilas, Jacinto Estima, Abdulmalik Oricha Ali (IRENA); Arslan Khalid, Julia Curtis and Tero Raassina (Independent consultants) and Allotrope Partners.

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Southeast Asia has emerged as one of the world's fastest-growing economic regions, a global hub for international trade, manufacturing and financial services, and an outstanding example of regional co-operation. Countries in the region, despite their diversity, are well-positioned to accelerate their growth and pursue broader socio-economic objectives.

Affordable, secure and environmentally sustainable energy will be crucial to underpin Southeast Asia's development over the coming decades. Energy consumption is expected to more than double by 2040. Meeting this growing demand through fossil fuels alone comes at the expense of energy security, environment and sustainable development. The diversification of Southeast Asia's energy supply through investments in renewables offers a viable option to support expansion and also achieve wider socio-economic and environmental benefits.

Encouragingly, all countries in the region have taken steps to tap into this immense opportunity. The adoption of national and regional renewable energy targets, combined with active efforts to reduce carbon emissions under the 2015 Paris Agreement, signal the region's firm commitment to transforming the energy sector. To translate targets into deployment, several countries have adopted policy and investment frameworks that are driving the growth of nearly all forms of renewables, ranging from hydropower, geothermal and bioenergy to increasingly cost-competitive solar PV and wind installations.

The analysis presented in *Renewable Energy Market Analysis: Southeast Asia* comes at a crucial juncture. While the seeds of the region's energy transformation have been sown, they require sustained policy support. To reach the aspirational target of 23% renewables in the region's primary energy mix by 2025, Southeast Asian countries will have to substantially scale-up their deployment of renewables in the power sector, as well as in heating, cooling and transport.

The report brings to the fore the critical considerations for effective policy-making to accelerate the energy transition. It analyses trends in energy supply and consumption at the regional and national level, drivers for renewable energy, resource potential, costs, benefits, policies and investment. The report considers utility-scale, roof-top as well as off-grid applications for expanding energy access.

Earlier editions in the *Renewable Energy Market Analysis* series – covering the GCC and Latin America – have provided a valuable reference point for a range of stakeholders both within those regions and beyond. I am confident that this study will provide comparable insights on Southeast Asia's energy future. It forms an integral part of our regional engagement which has included national-level Renewables Readiness Assessments and REmap country roadmaps. IRENA also continues to co-operate closely with the Secretariat of the Association of Southeast Asian Nations (ASEAN) and the ASEAN Centre for Energy (ACE) to support the region's energy transition.



Adnan Z. Amin
Director General, IRENA



RENEWABLE ENERGY MARKET ANALYSIS

SOUTHEAST ASIA

RENEWABLE ENERGY MARKET ANALYSIS

SOUTHEAST ASIA



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ACRONYMS

ACE	ASEAN Centre for Energy
ADB	Asian Development Bank
APG	ASEAN Power Grid
ASEAN	Association of Southeast Asian Nations
BNEF	Bloomberg New Energy Finance
CLMV	Cambodia, Lao PDR, Myanmar and Viet Nam
DFI	Development finance institution
FiT	Feed-in tariff
GDP	Gross domestic product
GHG	Greenhouse gas
GW	Gigawatt
IDR	Indonesian rupiah
IEA	International Energy Agency
IMPT	Indonesia, Malaysia, Philippines and Thailand
IPP	Independent power producer
IRENA	International Renewable Energy Agency
kW	Kilowatt
kWh	Kilowatt-hours
Lao PDR	Lao People's Democratic Republic
LCOE	Levelised cost of electricity
Mtoe	Million tonnes of oil equivalent
MW	Megawatt
MWh	Megawatt-hours
MYR	Malaysian ringgit
NGO	Non-government organisation
PHP	Philippine pesos
PPA	Power purchase agreement
PPP	Public-private partnership
PV	Photovoltaic
SDG	Sustainable Development Goal
TFEC	Total final energy consumption
THB	Thai baht
TPES	Total primary energy supply
TWh	Terrawatt-hours
USD	U.S. dollar
VND	Vietnamese dong

ABOUT THE REPORT

IRENA's *Renewable Energy Market Analysis* series captures the wealth of knowledge and experience embedded in different regions. It identifies emerging trends and themes at the intersection of public policy and market development. The first two editions covered the Gulf Cooperation Council (GCC) countries (2015) and Latin America (2016).

This edition focuses on Southeast Asia, a region characterised by strong economic growth, rising energy demand, growing environmental challenges and concerns about energy security. The countries analysed are the Member States of the Association of Southeast Asian Nations (ASEAN): Brunei Darussalam, Cambodia, Indonesia, the Lao People's Democratic Republic (Lao PDR), Malaysia, Myanmar, the Philippines, Singapore, Thailand and Viet Nam.

With economic growth exceeding 4% annually, Southeast Asia's energy consumption has doubled since 1995; demand is expected to continue growing at 4.7% per year through 2035. **Chapter 1** describes macroeconomic and social trends in the region, examining the relationship between economic growth and energy demand.

Southeast Asia's rising energy demand encompasses both fossil fuels and some forms of renewable energy, with domestic availability of such resources shaping the energy mix of each country. The region's main fossil fuel sources are coal and natural gas for electricity generation and oil for transportation, while the renewable sources are large hydropower, geothermal and bioenergy for power generation. Yet some 65 million people in the region still lack electricity access, while more than 250 million rely on traditional biomass for cooking. **Chapter 2** analyses the region's energy sector landscape, focusing on trends in supply and consumption. Countries lacking domestic energy resources face questions of security of supply and high cost exposure for energy purchases, while fossil fuel exporters worry about the stability of their revenues. Both groups strive to diversify their energy sources and weigh the role of renewable energy in that context.

Southeast Asia is rich in renewable energy resources, although their potential remains largely untapped. **Chapter 3** explores the region's renewable energy options, analysing the latest trends in costs and deployment as well as the benefits offered by a renewables-driven energy transition in terms of GDP growth and jobs. Scaling up deployment and realising the full spectrum of benefits from the energy transition

requires an enabling environment in terms of policy and investment conditions – the focus of Chapters 4 and 5, respectively.

Collectively, the Member States of the ASEAN have set a regional target of securing 23% of their primary energy from modern, sustainable, renewable sources by 2025. Individually, all ASEAN countries have adopted medium- and long-term targets for renewable energy. **Chapter 4** discusses these targets and examines the policy frameworks and institutional setting in place to support the deployment of renewables across the power sector (both on- and off-grid) and end-use sectors, as well as the development of local industries.

The introduction of deployment policies by several ASEAN countries has unlocked growing investments in renewable energy over the past decade. Between 2006 and 2016, cumulative investment in renewable power in Southeast Asia amounted to over USD 27 billion. As the sector has grown, the pool of available capital has expanded. Meanwhile, the role of traditional financiers, such as development banks, is increasingly changing from providing the bulk of finance to making projects attractive for private investments. **Chapter 5** analyses the latest investment trends, the evolution of the capital mix, and remaining finance barriers.

Sustained public and private action to develop renewable energy is closely tied to several of the United Nations' Sustainable Development Goals. Southeast Asia offers compelling examples of the synergies between renewable energy and socio-economic development, whether in rural, urban or island settings. **Chapter 6** discusses the economic, social, health and environmental benefits of decentralised renewable energy solutions.

Renewable Energy Market Analysis: Southeast Asia aims to provide insights for regional and international stakeholders active in the renewable energy sector. The study is part of a wider IRENA initiative in the region, which includes country-level engagement (e.g., REmap analyses and Renewables Readiness Assessments for Indonesia, the Philippines and Thailand) and regional-level initiatives (e.g., with the ASEAN Centre for Energy). The report advances the joint efforts of IRENA and the governments of the ASEAN to accelerate the region's transition to low-carbon, sustainable energy.

EXECUTIVE SUMMARY



Makati City, Manila, Philippines



Southeast Asia is seeing rapid economic growth and development, combined with increasing populations and urbanisation, as well as improving access to basic services¹. Regional gross domestic product (GDP) reached USD 2.5 trillion in 2016 – triple what it was in 2005. However, this impressive growth trajectory creates staggering energy challenges and raises acute concerns about environmental sustainability.

The regional economy is growing at more than 4% per year, among the highest rates in the world, with considerable variation between countries. Countries are also undergoing structural transformations, moving from agriculture to extractive industries, manufacturing and services in different ways and at varying speeds. Backed by a strong influx of foreign direct investment, some countries have emerged as hubs for a wide variety of industries and services.

The region has also made strides over the past decade on several socio-economic indicators. Based on the USD 1.25 purchasing power parity (PPP) per day threshold, the poverty rate has fallen considerably, from 47% in 1990 to 14% in 2015. Cambodia, the Lao People's Democratic Republic (Lao PDR), Myanmar and Viet Nam have achieved the fastest reductions. Significant progress has also

been made in lowering malnutrition, increasing life expectancy and improving access to education, clean water and sanitation.

Growing populations, rising incomes and rapid rate of urbanisation have combined to boost consumption levels for energy and other resources across the region. By 2050, the region's population is expected to grow by another 25%, putting pressure on national and local governments to keep pace with rising needs for housing, transportation, water and sanitation, and other infrastructure. Governments also need to ensure the creation of jobs and provision of social services.



¹ / This report covers the Member States of the Association of Southeast Asian Nations (ASEAN): Brunei Darussalam, Cambodia, Indonesia, the Lao People's Democratic Republic (Lao PDR), Malaysia, Myanmar, the Philippines, Singapore, Thailand and Viet Nam. The terms 'ASEAN' and 'Southeast Asia' are used interchangeably to refer to this set of countries unless otherwise mentioned.

All these factors have depended upon, and have in turn accelerated the demand for, access to affordable and reliable energy.

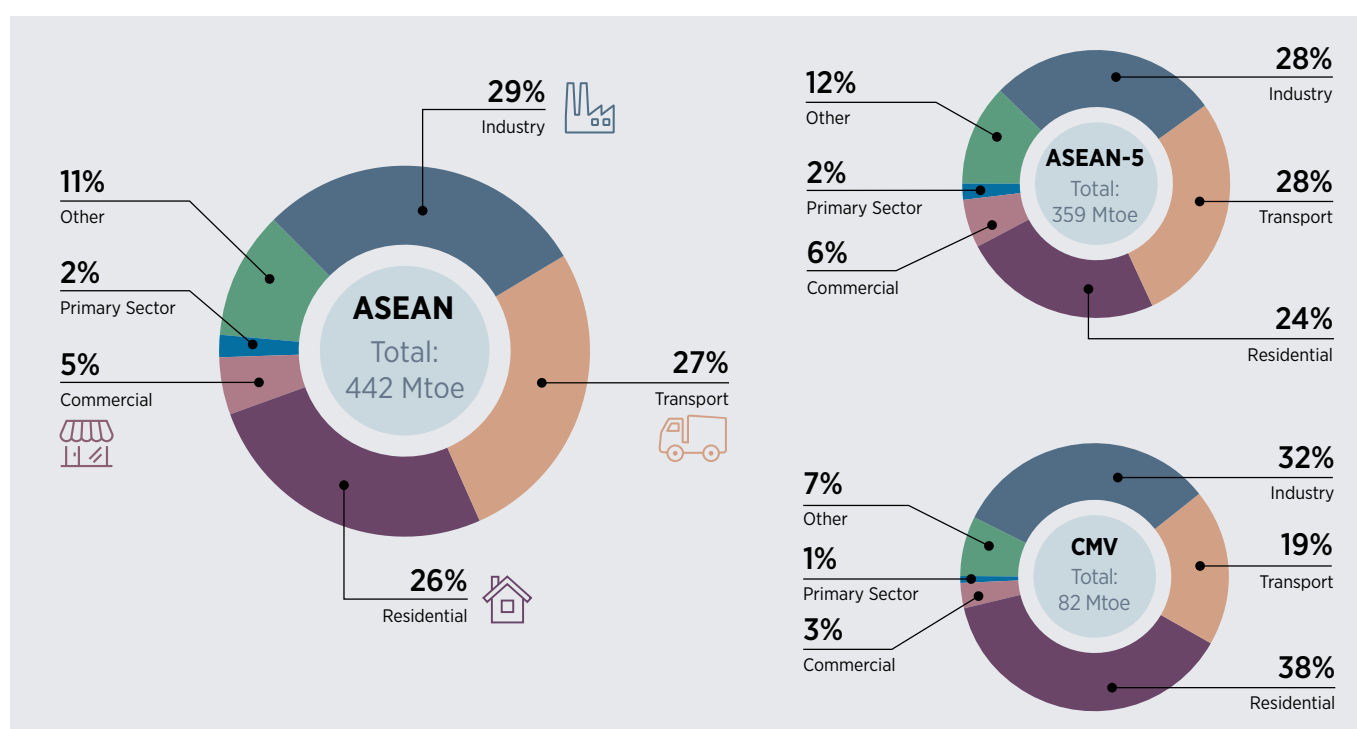
RISING DEMAND FOR ENERGY WITH SOCIO-ECONOMIC DEVELOPMENT AND URBANISATION

Energy consumption in Southeast Asia nearly doubled between 1995 and 2015, growing at an average pace of 3.4% annually. This has fuelled economic growth and permitted higher living standards. Over the past decade, the most rapid growth came from Brunei Darussalam, Cambodia and Viet Nam. In 2015, Indonesia, Malaysia, Thailand, and Viet Nam accounted for most of the region's total final energy consumption (TFEC). That year, the industry, transport and residential sectors accounted for roughly similar shares of region-wide energy consumption, although differences emerge at the sub-regional level (Figure ES.1). Industry was the largest consumer, with shares of the total

consumption ranging from around 12% in Myanmar to nearly 40% in Viet Nam.

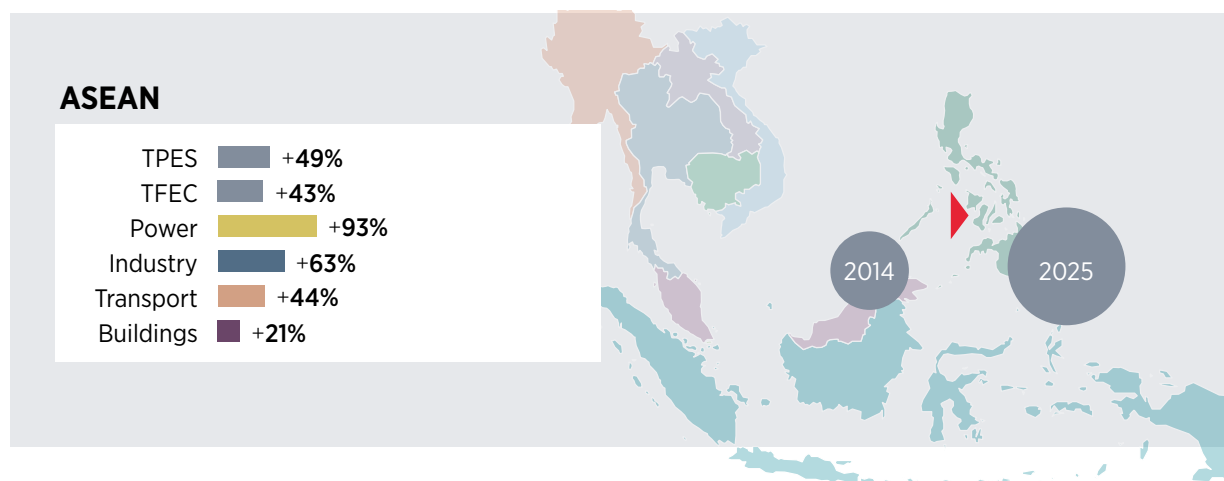
Fossil fuels, led by oil and natural gas, account for more than half of the region's energy supply. Crude oil and its derivatives are predominantly used in the transport sector, where fuel demand has grown rapidly. While the share of natural gas in the total primary energy supply (TPES) has risen considerably over the past two decades, the fastest growth has been registered by coal, especially with the commissioning of numerous coal-fired power plants since 2000. Natural gas contributed the largest share (41%) to the power generation mix in 2015, followed by coal (33%) and hydropower (16%). In line with the region's continued rapid economic expansion, energy demand is expected to grow by an average of 4.7% per year in the period to 2035. Growth in energy demand will be highest in the power sector, followed by industry, transport and buildings (Figure ES.2).

Figure ES.1 Total final energy consumption by sector in Southeast Asia, 2015



Source: Based on IEA, 2017c.

Note: The ASEAN figure does not include Lao PDR due to non-availability of data; CMV = Cambodia, Myanmar and Viet Nam. ASEAN-5 comprises Indonesia, Thailand, the Philippines, Singapore and Malaysia.

Figure ES.2 Increase in energy demand by 2025 over 2014 levels

Source: IRENA and ACE, 2016.

Note: ASEAN = Association of Southeast Asian Nations; TFEC = total final energy consumption; TPES = total primary energy supply.

STRENGTHENING THE CASE FOR ENERGY DIVERSIFICATION THROUGH RENEWABLES

Over the long-term, meeting growing consumption through fossil fuels alone will come at the expense of energy security, with related economic costs for both exporters and importers, in addition to damaging the environment. Energy security concerns are rising as indigenous fossil fuels are depleted or are unable to meet growing demand. With some net exporting countries already turning into net importers, ensuring the security of fuel supply for long-term energy infrastructure is a high priority for all of Southeast Asia. Meanwhile, the concerns about the environmental impact of fossil fuels, from the local to the global level, combined with the lack of modern energy services for a large proportion of the population in several countries, have contributed to the pursuit of a diversified energy mix.

The diversification of energy supply through investments in renewable energy, coupled with improvements in energy efficiency, offers a viable option to expand the energy system and simultaneously realise substantial socio-economic and environmental benefits. The costs of generating

electricity from hydropower, geothermal and bioenergy are already within the estimated range of fossil-fuel costs in Southeast Asia. Indeed, solar photovoltaic (PV) and onshore wind power have seen the most significant cost reductions – a 45% decline in installed costs for PV and an 11% decline for onshore wind between 2012 and 2016. Renewable power technologies offer substantial opportunities for future cost reductions as domestic markets mature. The potential for cost-effective renewable energy deployment in the heating/cooling and transport sectors is also immense, especially in industry.

Analysis by the International Renewable Energy Agency (IRENA) has shown that pursuing a renewable-driven energy transition reinforces the regional economic growth agenda. Renewable energy deployment would have a small, but positive, impact on the region's GDP. The renewable energy sector is already creating jobs across Southeast Asia, estimated at 611 000 jobs in 2016. Most of these jobs were in liquid biofuels, followed by large hydropower and solar PV (Figure ES.3). Analysis in this report shows that employment in Southeast Asia's renewable energy sector could reach 1.7



million by 2030 based on current plans and policies (the REmap Reference Case), rising to 2.2 million with accelerated deployment (REmap Options).

Countries in Southeast Asia have already taken important steps in diversifying their energy mix and have begun to reap wide-ranging socio-economic benefits as a result. All countries in the region have set national renewable energy targets. The ten Member States of the ASEAN, furthermore, have agreed to aim for the aspirational target of 23% renewables in their total primary energy supply (including large-scale hydropower but excluding traditional biomass) by 2025.

GROWING DEPLOYMENT OF RENEWABLE ENERGY TECHNOLOGIES

Renewable energy sources accounted for 17% of the region's total electricity generation in 2015. Large hydropower comprised over three quarters of the renewable generation mix, although its share in total installed capacity decreased from 80% in 2000 to 75% in 2016. Bioenergy and geothermal energy are the other major contributors (Figure ES.4), with geothermal facilities being concentrated in Indonesia and the Philippines.

Non-hydropower renewables have grown rapidly as a power source, with their installed capacity more than doubling in a decade, from 6 GW in 2006 to 15 GW in 2016. Despite rapid capacity additions, solar and wind power still account for a small share of the generation mix. Electricity trade, mainly of hydropower, is increasing as interconnection infrastructure is developed for the ASEAN Power Grid initiative. Lao PDR more than quadrupled electricity exports from 2.8 terawatt-hours (TWh) in 2000 to 11.5 TWh in 2015, with Thailand as the main destination.

Figure ES.3 Renewable energy jobs in Southeast Asia in 2016, by technology

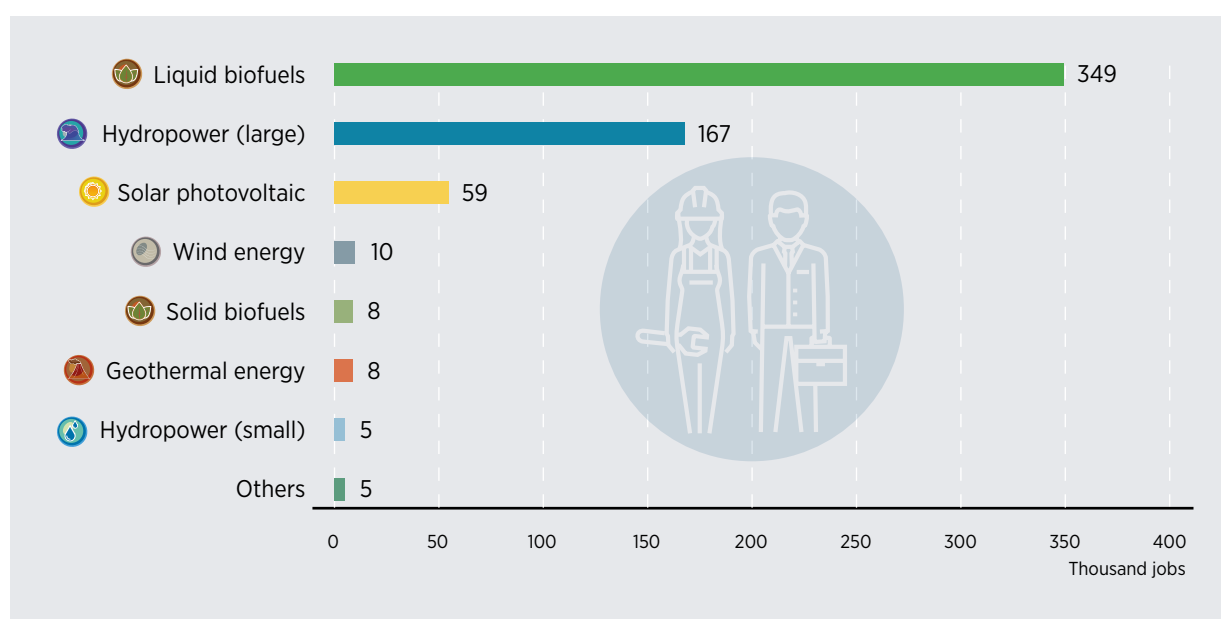
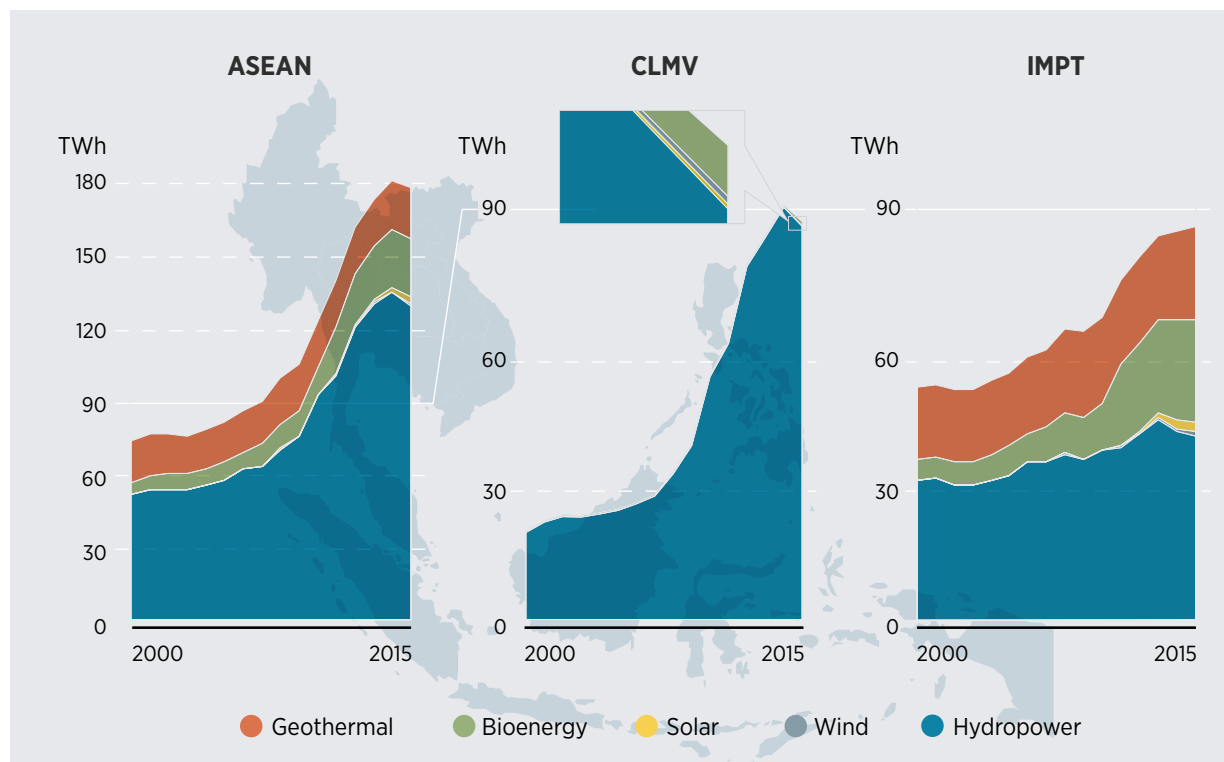


Figure ES.4 Renewable electricity generation in Southeast Asia, 2000–2015 (TWh)

Source: Based on IRENA, 2017f.

Note: CLMV comprises Cambodia, Lao PDR, Myanmar and Viet Nam. IMPT comprises Indonesia, Malaysia, the Philippines and Thailand.

For industry, bioenergy is the most common renewable energy application. Other sources of direct renewable heat suitable for industrial uses are solar and geothermal. In the residential sector, bioenergy represents 69% of TFEC, although the share is decreasing as modern fuels (e.g., liquefied petroleum gas) become more available. The use of traditional bioenergy still represents a significant share of residential energy consumption, notably in Cambodia, Indonesia, Lao PDR, Myanmar and Viet Nam. The share of renewables in transport fuels is small (equivalent to 3%) and primarily comprises liquid biofuels. Indonesia, Malaysia, the Philippines and Thailand are the major markets where biofuel use has grown, mainly driven by blending mandates.

Based on current plans and policies, the share of renewables in TPES would increase to just under 17% by 2025 (compared to less than 10% in 2014). Therefore, the region must overcome a six-percentage-point gap to reach its goal of 23%. This requires further efforts to develop enabling policy and investment frameworks for renewable energy.



ENABLING POLICY AND INVESTMENT FRAMEWORKS FOR ACCELERATED DEPLOYMENT

Most countries in Southeast Asia have set renewable energy targets and have adopted some form of national renewable energy policy to meet them. Indonesia, Malaysia, the Philippines, Thailand and Viet Nam are comparatively more advanced in the region in terms of policy maturity and comprehensiveness.

In the power sector, policies that have catalysed deployment have focused on dedicated financing schemes to support projects; permitting and licensing mechanisms and technical standards to facilitate grid interconnection; and guaranteed purchase of renewable power at attractive tariffs. Most countries have introduced technology-specific feed-in tariffs, often combined with other deployment policies such as net metering, like Malaysia did for roof-top solar power generation.

With the falling cost of technologies, especially for solar PV and onshore wind, and increasing maturity of the sector as a whole, policies that support the deployment and integration of renewables are evolving. New mechanisms, such as the auctions now seen in Indonesia, Malaysia and the Philippines,

are being introduced to supplement the traditional instruments that have driven the region's renewable energy growth. Recent experience has shown that adaptations in the policy and regulatory landscape need to be well-communicated and managed, particularly to minimise the investment uncertainty and risk perceptions.

Beyond power generation, many countries still lack comprehensive frameworks for the end-use sectors, meaning energy for heating/cooling and transport. The region has enormous potential to scale up modern bioenergy for sustainable, efficient cooking, for industrial heat generation and in co-generation of power and heat. Solar thermal offers great potential for low-temperature industrial processes. Some countries have introduced dedicated policies to support deployment, including specific heating targets in Lao PDR and a feed-in tariff for co-generation in Viet Nam.

The transport sector currently has the lowest share of renewables in the region. However, it offers high potential for deployment, through a combination of liquid biofuels, electric vehicles and urban mass transit systems. More than half the countries in the region have adopted liquid biofuel blending mandates, which are being steadily increased. Indeed, a programme to maximise bioenergy use in transport and industry needs to safeguard environmental, social and economic sustainability. Fuel standards and incentives for electric mobility adoption and manufacturing are also increasingly common in the region.

Deployment policies represent part of a broader mix of policies that also address education and training, research and development, industrial policy and the broader national investment climate. These are important considerations for countries looking to attract foreign capital and technology, while maximising the socio-economic benefits of renewable energy, including the development of a local industry. In supporting local products and services, some countries, such as Indonesia and Malaysia, have adapted deployment policy design



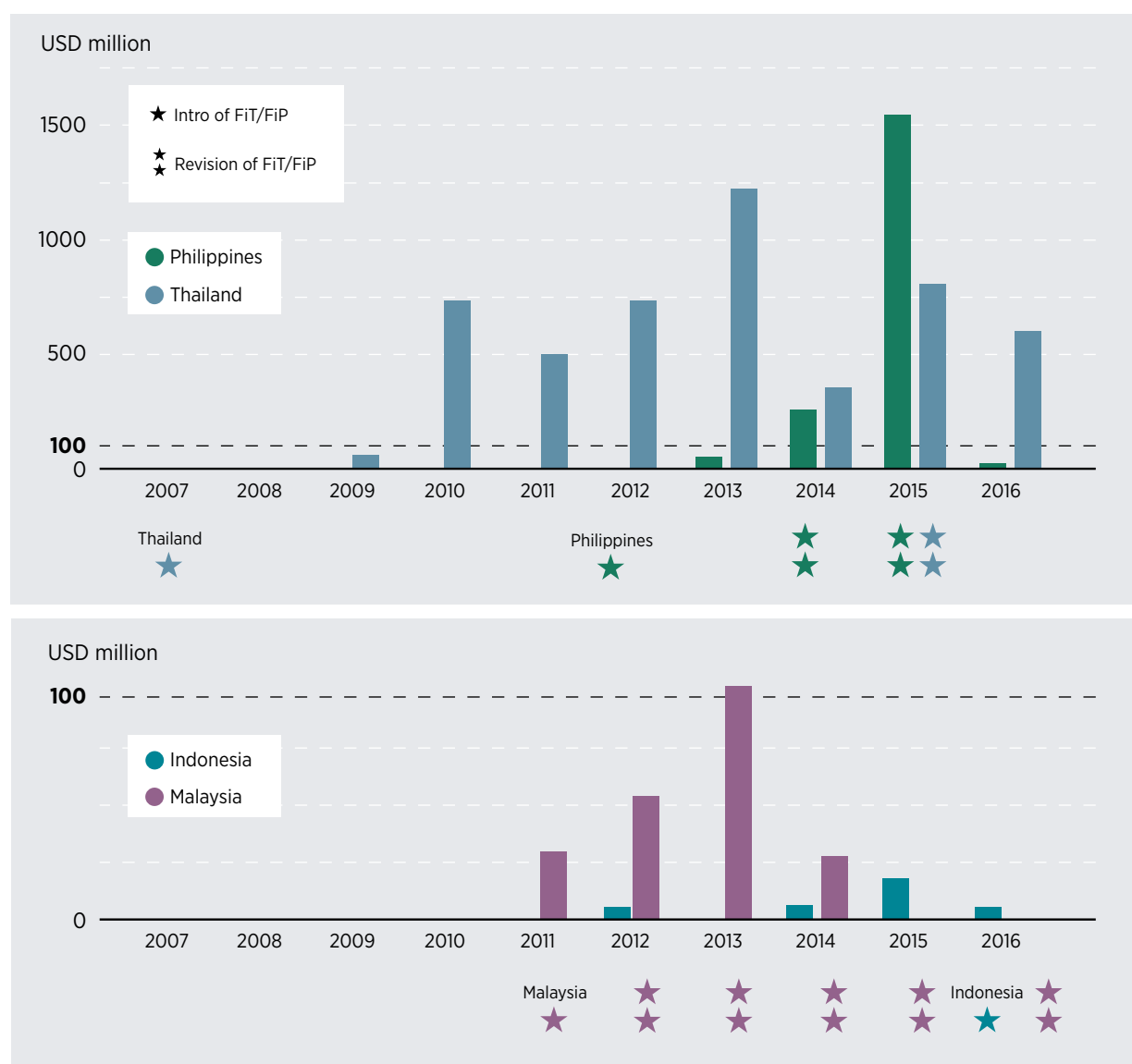
by offering a premium tariff for projects meeting a specified minimum local content or capping foreign participation in auctions.

While strong policies are essential, a robust regulatory and institutional framework provides the basis for overcoming some of the most prevalent deployment barriers. The strong correlation between

policy and investment flows in solar PV (Figure ES.5) illustrates the importance of maintaining a stable, yet adaptable, policy environment that underpins long-term investments in the sector.

Between 2006 and 2016, USD 27 billion was invested in the renewable power sector in the six major Southeast Asian markets of Indonesia, Malaysia,

Figure ES.5 Investments in solar PV in selected countries driven by feed-in tariff policy, 2007-2017



Source: Investment data from BNEF, 2017.

Note: FiT = feed-in tariff; FiP = feed-in premium.

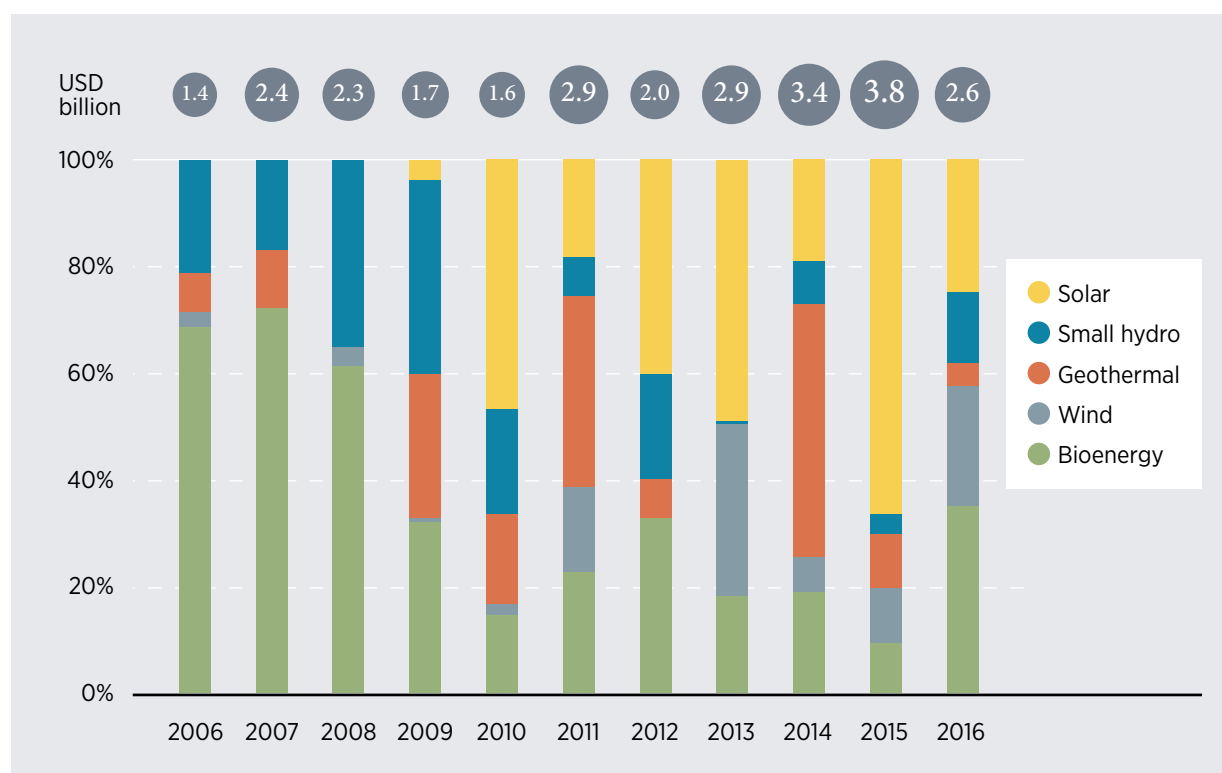
the Philippines, Singapore, Thailand and Viet Nam. Thailand attracted the largest share of that financing, with over USD 10 billion invested, followed by Indonesia and the Philippines. Bioenergy received most of the investment in the region (32%), followed by solar PV and geothermal energy (Figure ES.6).

As the renewable energy sector has grown, the capital mix and the range of financing institutions engaged has also evolved. Development finance has been crucial in backing large hydropower, geothermal and bioenergy projects, followed by rising private sector investments, supported through public-private partnership models and carbon markets. Financial actors in the sector have become more diverse in recent years, providing equity and

debt financing and setting the stage to unlock more capital through new avenues, such as green bonds and climate funds.

Public finance will continue to have an important role, especially in countries with less mature financial markets and renewable energy sectors. Around USD 6 billion has been invested cumulatively by development banks in renewable energy between 2009 and 2016. To reach the region's aspirational renewable energy target, annual investment would need to be significantly scaled up to an estimated USD 27 billion. This calls for serious efforts to catalyse private investment, requiring a focus on project readiness and attractiveness, improving access to capital at the local level, and mitigating investment risks.

Figure ES.6 Investment in renewable power by technology, 2006–16 (USD billion)



Source: Based on BNEF, 2017.

Note: Based on power sector asset finance data for Indonesia, Malaysia, the Philippines, Singapore, Thailand and Viet Nam.

HARNESSING RENEWABLE ENERGY TO MEET MULTIPLE SUSTAINABLE DEVELOPMENT GOALS

The value of renewable energy goes well beyond providing energy services. The deployment of renewables to meet the Sustainable Development Goals (SDGs) set by the United Nations would transform the global energy system. However, fulfilling SDG 7 (on energy) would also help countries meet other key goals, including the SDGs on poverty alleviation, health, water, nutrition, cities and climate. This holds true both in terms of expanding energy access and in other contexts.

As several projects and programmes in the region have demonstrated, decentralised renewable energy solutions, such as micro-hydro and biogas plants based on local entrepreneurship and strong community participation, can greatly improve access to modern energy services. Such solutions in turn bring about substantial economic, social, health and environmental benefits, which contribute to several of the SDGs. In the non-access context, the role of renewable energy in supporting climate mitigation and adaptation, sustainable cities and communities, decent work and economic growth, among other SDGs, cannot be overstated.

Maximising the benefits of renewable energy technologies requires a holistic view. This means considering the impact of renewables both within and beyond the energy sector.





BACKGROUND AND MACROECONOMIC OVERVIEW



Hanoi, Viet Nam



1.1 BACKGROUND

The countries of Southeast Asia are enjoying rapid economic growth, yet also face a range of demographic, social and energy challenges. The majority of the countries in the region are members of the Association of Southeast Asian Nations (ASEAN): Brunei Darussalam, Cambodia, Indonesia, the Lao People's Democratic Republic (Lao PDR), Malaysia, Myanmar, the Philippines, Singapore, Thailand and Viet Nam.¹ The region's population of 644 million people (as of mid-2017) accounts for 8.5% of the global total. It is projected to grow to 722 million by 2030 and 789 million by 2050 (PRB, 2017). Regional gross domestic product (GDP) reached USD 2.5 trillion in 2016 and is currently growing at more than 4% per year (World Bank, 2017). In addition to being one of the fastest-growing consumer markets in the world, the Southeast Asia region has become a major manufacturing and trading hub.

Energy demand, though low by global standards, is increasing fast, driven by increasing industrial activities, growing populations and rising incomes. The region's heavy reliance on fossil fuels for power

generation and other needs is contributing to rapidly rising greenhouse gas (GHG) emissions, a trend that presents a major policy challenge in the context of global climate targets. The region's economic development needs to be balanced against other considerations, related to sustainability, well-being and equity. Around 10% of the region's population has no access to electricity and larger numbers lack access to modern cooking fuels. Ensuring an affordable supply of energy for businesses and for all citizens is a key objective for the region's governments.

This chapter explores Southeast Asia's main economic and social trends, and the role of energy in supporting the region's economy. The first section describes macroeconomic trends across the region and looks at the sectoral composition of regional GDP. It also outlines the region's progress toward key societal goals, particularly poverty reduction. The second section highlights the close relationship between economic growth and energy use, and the important role of the energy sector in underpinning future socio-economic development in the region.

¹ / Two other countries, Papua New Guinea and Timor-Leste, have ASEAN observer status but are not members. This report focuses on ASEAN Member States and the term 'ASEAN' and 'Southeast Asia' are used interchangeably to refer to these set of countries unless otherwise mentioned.

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1.2 MACROECONOMIC OVERVIEW

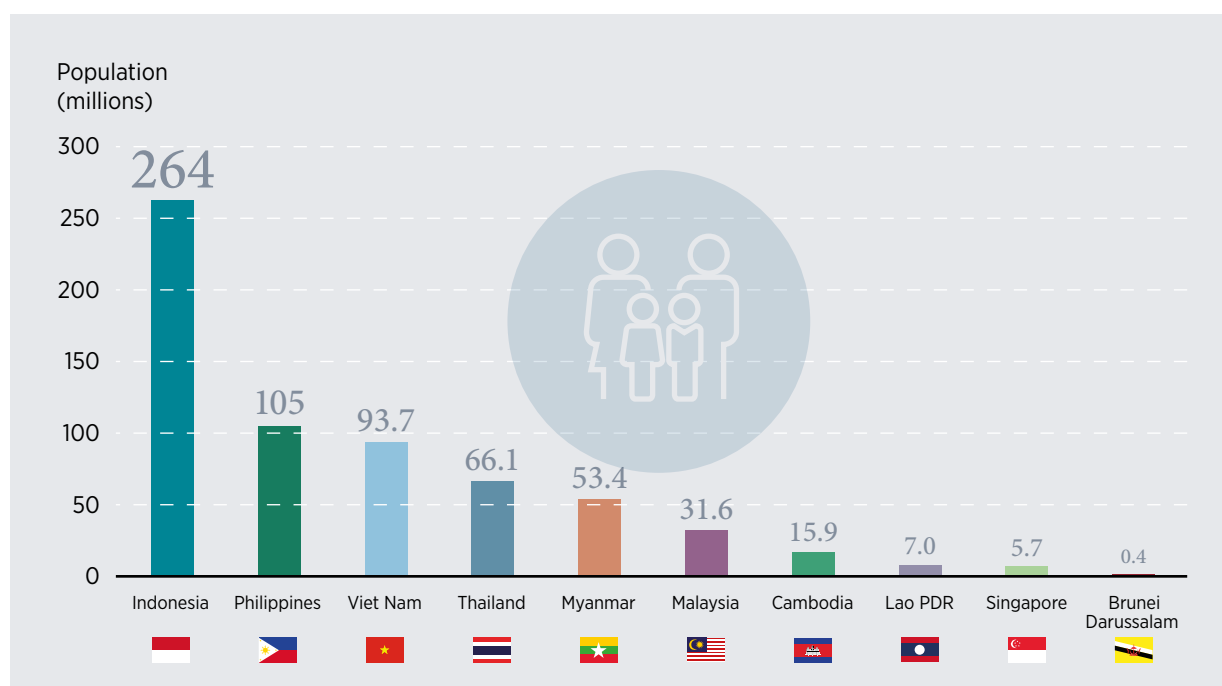
The Southeast Asia region is demographically and economically diverse. Energy and natural resource endowments vary considerably by country, as does the economic structure and the degree of integration into global supply chains.

Indonesia is the world's fourth-most populous country, with 264 million inhabitants; it accounts for 41% of Southeast Asia's population and for a similar share of the region's economic output. The Philippines and Viet Nam each have about 100 million inhabitants, and Thailand and Myanmar follow with 66 million and 53 million, respectively. The relatively small states of Brunei Darussalam (0.4 million people) and Singapore (5.7 million) (Figure 1.1) enjoy high per capita gross national incomes (GNIs) due to oil and gas resources and an advanced service economy, respectively. Expressed in purchasing power parity (PPP) terms, their per capita GNI is almost eight times higher than Indonesia's and about 24 times higher than Cambodia's (PRB, 2017). Indeed, per capita

incomes in Cambodia, Lao PDR, Myanmar and Viet Nam are just one-fifth the regional average or less. Domestic material consumption per capita is three to four times higher in Singapore (39 tonnes) than in most other countries and almost ten times higher than in Myanmar and the Philippines (ADB, 2017a).

Demographic characteristics diverge widely across the region, with implications for economic dynamics, energy demand and job creation needs. Birth rates in Cambodia, Lao PDR and the Philippines are double those in Singapore and Thailand (PRB, 2017), resulting in more youthful populations and greater pressure on labour markets. Just under half of the region's population lives in cities, roughly in line with the developing world's average, and up from 38% at the turn of the century. However, the share of the urban population ranges from 100% in the city state of Singapore and 75% in Malaysia to as low as 21% in Cambodia, 33% in Viet Nam and 35% in Myanmar (PRB, 2017). These differences help explain disparities in economic activity and energy use among the countries of the region.

Figure 1.1 Populations of Southeast Asian countries, 2017



Source: Based on PRB, 2017.

GDP GROWTH

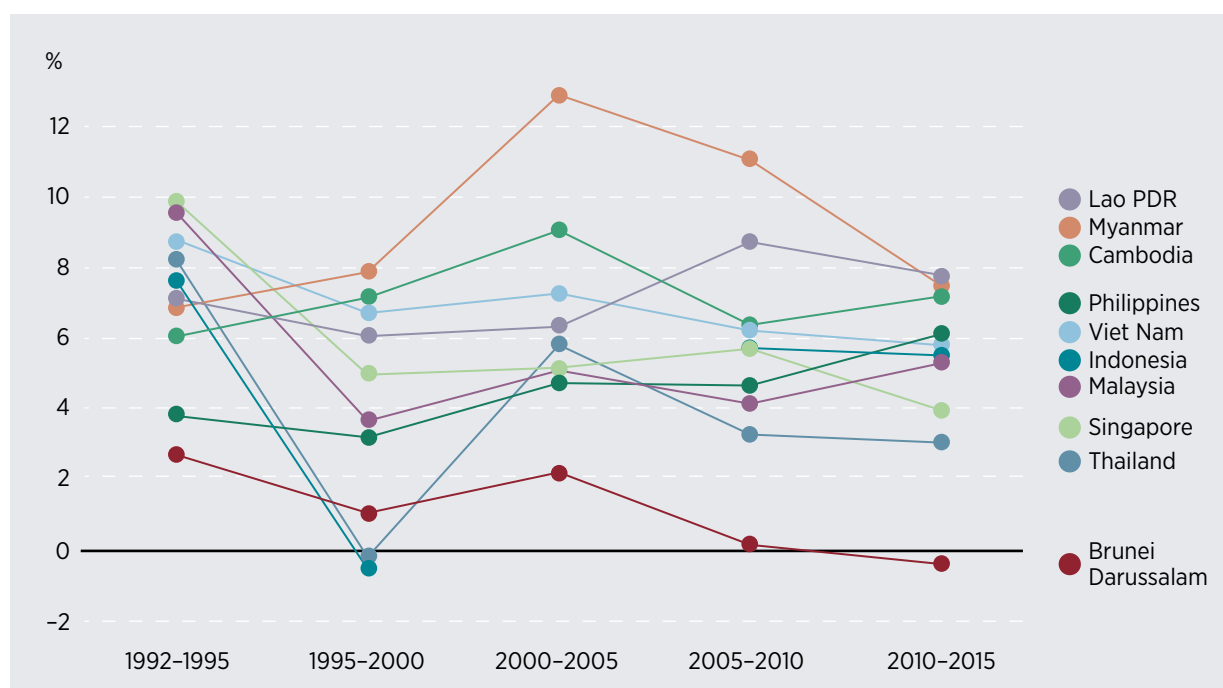
During the past quarter century, the Southeast Asia region experienced strong economic growth at rates that surpassed the global average most years. Interrupted by the 1997 Asian financial crisis, this expansion resumed during the 2000s, driven by the demand for commodities led by China (especially important for Indonesia and Malaysia) and by a deepening of regional production networks and hubs (of critical importance for Thailand and Singapore) (ERIA, 2014).

The Southeast Asian regional economy has expanded by more than 125% since 2000. Regional GDP was about USD 2.5 trillion in 2016 representing about 4% of the global total (World Bank, 2017). GDP is projected to reach USD 3.5 trillion in 2020 and USD 5.4 trillion in 2030 (in constant 2010 dollars). The implied annual average GDP growth of 4.6% is among the highest in the world, though less than the 5.3% projected for China (USDA, 2016a).

Economic growth rates across the region slowed somewhat in recent years, reaching 4.8% in both 2015 and 2016, and rising to 5.1% in 2017 (IMF, 2017). The Asian Development Bank (ADB) estimates that growth in 2018 will remain at 5.1%. This is a result of improvements in the global electronics market, stronger inflows of foreign direct investment (FDI), and higher agricultural production, slightly offset by weaknesses in the mining sector (ADB, 2017b; ADB, n.d.-a).

The regional averages hide substantial differences across individual countries. Cambodia, Lao PDR and Myanmar have experienced far faster growth than Malaysia, Singapore and Thailand (while Brunei Darussalam has seen an extended slowdown in growth) (Figure 1.2). Expanding from a considerably smaller economic base, these countries are focusing their development efforts on resource extraction and light manufacturing and assembly operations.

Figure 1.2 Average GDP growth rate, by country



Source: Based on UNCTAD, n.d.

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ECONOMIC TRANSITIONS

As they expanded during recent decades, the economies of the region underwent significant structural transformations, moving from a once heavy reliance on agriculture toward extractive industries and manufacturing as well as services, though in different ways and at varying speeds. Backed by a strong influx of FDI, parts of Southeast Asia have emerged as important hubs for manufacturing and a wide variety of services (Box 1.1).

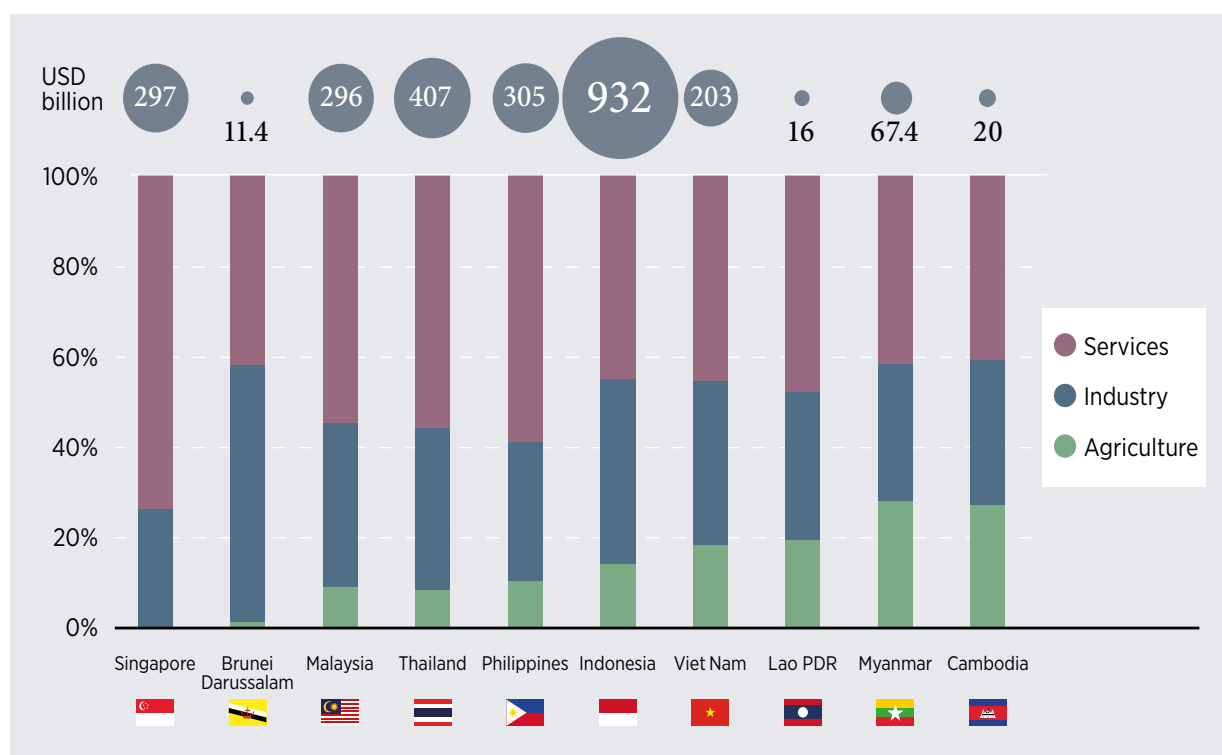
Countries in the region can be grouped into two categories in terms of their economic development. The ASEAN-5 (Indonesia, Malaysia, the Philippines, Singapore and Thailand) were the region's early movers towards industrial development and still account for the lion's share of regional GDP (CEIC Data, 2016). The ASEAN-5 countries' economies continue to mature and diversify. Since

2000, their service sectors have grown to represent slightly more than half of GDP, while industry's share has declined to about one-third.

The CLMV countries (Cambodia, Lao PDR, Myanmar and Viet Nam) are recent bloomers of the region and the fastest growing. In the CLMV countries, the industrial share of GDP rose from 28% to 34% in 2000-2016, as agriculture's contribution fell to 21%; the share of the service sector remained stable at around 40%. The drop in agriculture's share was particularly pronounced in Myanmar, falling from 60% to 28%.

Except for Cambodia, Lao PDR, Myanmar and Viet Nam, agriculture now accounts for a relatively small share of GDP in Southeast Asian countries (Figure 1.3), even as production of main agricultural products doubled after 1995 (ASEAN, 2017b). Extractive and manufacturing industries represent roughly a third of GDP in most countries. The

Figure 1.3 GDP (billion USD) and sectoral composition, by country, 2016



Source: Based on World Bank, 2017.

Box 1.1 Foreign direct investment in Southeast Asia

More than 1 600 economic development zones in the ASEAN region have been set up to attract FDI in a range of industries and service sector activities and thus to support the region's overall drive toward economic development. Objectives include employment generation, foreign exchange earnings, increased involvement in global supply chains and spill-over effects in the domestic economy.

Annual FDI flows into the region hovered in the range of USD 20-40 billion during the 1990s. They then rose rapidly, interrupted only by the 1997 Asian financial crisis, to more than USD 100 billion. Most recently, FDI flows declined from USD 121.6 billion in 2015 to USD 96.7 billion in 2016 (reflecting a broader global downturn in FDI, rather than region-specific reasons). But intra-ASEAN flows continued their upward trend, beginning at the turn of the century. They now represent a quarter of total FDI flows in the region. In 2015 and 2016, most investments went into the financial and insurance sector (Table 1.1).

Table 1.1 FDI by selected sector, 2015-16 (USD millions)

Sector	2015	2016
Financial and insurance activities	36 364	33 941
Wholesale and retail trade	7 569	18 428
Manufacturing	29 148	8 013
Real estate	8 463	7 776
Transportation and storage	3 645	4 796
Mining and quarrying	7 867	3 885
Electricity, gas, steam, air-conditioning supply	1 959	3 080
Agriculture, forestry and fishing	5 389	1 797
Others	21 217	15 007
Total	121 621	96 723

The European Union represents the largest group of foreign investors in Southeast Asian countries, with 31% of the total. Other leading investors come from Japan, the United States, China and the Republic of Korea. More than half of all FDI into the region went to Singapore alone, with Indonesia, Malaysia and Viet Nam following at a considerable distance. Flows into the CLMV countries (Cambodia, Lao PDR, Myanmar and Viet Nam) continued to increase, reaching about USD 19 billion in 2016, or 13% of the region's total.

Source: ASEAN, 2017a.

exceptions are Singapore (where services play an exceptionally large role) on one end, and Brunei Darussalam on the other (where the oil and gas industry is key).

Strongly oriented toward export markets, resource extraction remains important to several of the region's economies. However, economies relying strongly on commodity exports are vulnerable to world market price fluctuations and disruptions.

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The manufacturing and service sectors offer opportunities for diversification and higher added value. Malaysia and Singapore are leading exporters of electrical and electronic products, while Thailand is strong in the automotive sector. Cambodia and Viet Nam saw rapid growth particularly in labour-intensive manufacturing for export (ERIA, 2014). But Viet Nam is now moving from an initial focus on lower-value manufacturing towards higher-value outputs. By mid-2017, surging exports of computers, electronic products and components surpassed sales of textiles and are now the second largest export category after telephones and accessories (Customs News, 2017).

Energy use in the industrial sector rose by 70% between 2000 and 2016 to about 160 million tonnes of oil equivalent (Mtoe), edging past the buildings sector to become the largest energy consumer. Industrial development has been based in part on some of the most energy-intensive industries, including steel, petrochemicals, paper, cement and aluminium (IEA, 2017a).

Vehicle manufacturing is a major and fast-growing segment of the region's economy. Thailand has multiplied its output five-fold since 2000. Now one of the world's top dozen vehicle manufacturers, the country produces about half of the region's output, destined mostly for export (OICA, n.d.; ASEAN Automotive Federation, n.d.). Regional production of motor vehicles more than doubled to over 4 million vehicles in the decade 2006-16.

The service sector is prominent in all Southeast Asian countries. But the specific profile of services rendered varies considerably by country. In the Philippines and Singapore, trade facilitation, finance and insurance contribute the most value. Almost 80% of new jobs in the Philippines in the past six years were created in services, particularly business process outsourcing (which employs 1.2 million people), but also tourism and retail trade. The tourism sector employed 5 million workers in 2015, or close to 13% of national employment (ADB, 2016a). Thailand was host to the world's

second-largest number of tourists in 2016 (32.6 million), more than the combined number for Cambodia, Lao PDR, Myanmar, the Philippines and Viet Nam (ASEAN, 2017c).

TRADE AND ECONOMIC INTEGRATION

Exports are one of the key drivers of ASEAN economies. China is the top trading partner, with flows of USD 368 billion in 2016, while Japan, the European Union and the United States each accounted for more than USD 200 billion worth of trade in goods (ASEAN, 2017d). Market integration with China and other countries in East Asia is deepening as production and distribution networks increase in complexity and investments from China and Japan rise. However, ASEAN's export orientation could present a challenge in the context of slower global economic growth, and may necessitate developing domestic markets more strongly (OECD, 2017; Broadman, 2016).

Regional integration efforts, particularly the launch of the ASEAN Economic Community (AEC) at the end of 2015, are aimed at stimulating intra-regional trade by creating, within a decade, a single market with a free flow of goods, investment and skilled labour. Trade within the region amounted to USD 516 billion in 2016 or over 23% of total trade flows (ASEAN, 2017c). The share is up from 20% five years earlier (ASEAN, 2016a). The AEC's launch has since prompted the adoption of a number of "Blueprint 2025" sectoral plans (OECD, 2017). If the AEC plans are successfully implemented, the Asian Development Bank Institute expects that ASEAN will transform into a "truly borderless economic community" by 2030 (ADB, 2014).

Meanwhile, wages that are low relative to those prevalent in China have created fresh incentives for multinational companies to shift manufacturing investments to some Southeast Asian countries (Broadman, 2016). Malaysia, Thailand, Indonesia and Viet Nam are now thought to have an advantage over China in manufacturing labour-intensive

products like apparel, textiles, toys and basic consumer electronics (Lloyd, 2017).

URBANISATION, POVERTY REDUCTION AND A GROWING MIDDLE CLASS

Growing populations, rising incomes and urbanisation are combining to raise overall consumption levels in the region. By 2050, the total population of Southeast Asia is expected to grow by around 25% (PRB, 2017), putting pressure on national and local governments to keep pace with growing needs for housing, transportation, water and sanitation, and other infrastructure, in addition to employment generation and provision of a variety of social services. Southeast Asia's urbanisation rate will likely increase from 48% today to 64% in 2050, according to United Nations (UN) projections (UNDESA, 2014). Already, Jakarta and Manila are mega-cities of more than 10 million inhabitants. Five other cities (Bangkok, Ho Chi Minh City, Kuala Lumpur, Singapore and Yangon) have populations ranging between 5 and 10 million, and three dozen other cities in the region have more than 1 million residents each (ASEAN, 2017a).

The metropolis is responsible for the lion's share of national economic activity. In Viet Nam, for instance, at least 70% of GDP is generated in cities (ADB, 2016a). Generally, urban populations tend to use more energy than their rural counterparts. Incomes and consumption levels are higher, and the use of air-conditioning and energy-intensive appliances is more prevalent. Urban households typically have fewer members than rural ones and therefore there are fewer shared goods and services, raising energy and materials consumption. Therefore, urban settlements entail a greater amount of embedded energy – in the steel, cement, and other materials needed for the built environment – than do rural areas.

As populations grow and economies continue to expand, so does the middle class. In Southeast Asia, the middle class grew from 59 million people in 1990 to 197 million in 2010, although incomes remain low by the standards of the high-income countries. The climb up the economic ladder has also enabled better health and education, resulting in a better quality of life for growing numbers of people (ERIA, 2014). Life expectancy has risen considerably, access to safe drinking water and sanitation has improved, and the share of undernourished people and the under-five mortality rate has plummeted (ASEAN, 2017b).







But it is important to remember that migration to cities does not automatically lift people out of poverty. There are still substantial numbers of urban poor, with limited access to modern energy, sanitation and health services, and exposed to dangerous levels of indoor and outdoor air pollution. According to the ADB (2017a), the share of the urban population living in urban slums as of 2014 is highest in Cambodia (55%), Myanmar (41%) and the Philippines (38%), although comparable data are not available for all countries in the region.

Extreme poverty, meanwhile, has been slashed (using the old international poverty line² of USD 1.25 PPP per day), from close to 60% in 1980 to about 14% in 2015 (ERIA, 2014; ASEAN, 2017b). Outside of extreme poverty, there are substantial numbers of people living on relatively low incomes. The World Bank offers data for two somewhat higher poverty lines, USD 3.20 PPP per day (“lower middle class poverty”) and USD 5.50 PPP per day (“upper middle class poverty”) (Table 1.2). Equitable and inclusive economic development can improve this situation. To date, however, among Southeast Asian countries only Cambodia and Thailand have been able to improve their income distribution (as measured by the Gini coefficient). Malaysia and the Philippines have the region's highest income inequality levels (Indexmundi, n.d.).

² / Estimates depend on the specific definition of poverty and the poverty line used. National poverty lines vary, naturally, and may be set at a higher or lower level than the international threshold. The international poverty line itself was revised upward to USD 1.90 per day in 2015, principally to reflect changes in the cost of living. The real value of USD 1.90 is the same as USD 1.25 was in earlier years.

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Table 1.2 Extreme and relative poverty in Southeast Asian countries (most recent available years)

Country	International poverty line (USD 1.90 PPP per day)		Lower middle class poverty line (USD 3.20 PPP per day)		Upper middle class poverty line (USD 5.50 PPP per day)	
	Share of pop. (%)	Millions of people	Share of pop. (%)	Millions of people	Share of pop. (%)	Millions of people
 Indonesia (2016)	6.8	17.8	31.4	82.1	62.8	163.9
 Philippines (2015)	8.3	8.5	33.7	34.3	64.2	65.3
 Myanmar (2015)	6.5	3.4	30.2	15.8	67.9	35.6
 Viet Nam (2014)	2.8	2.5	11.6	10.5	36.3	32.9
 Thailand (2013)	0	0	1.1	0.7	11.6	7.9
 Lao PDR (2012)	22.7	1.5	58.5	3.8	85	5.5
 Malaysia (2009)	0.3	0.1	3.1	0.9	13.6	3.8
Total	n.a.	33.8	n.a.	148.1	n.a.	314.9

Source: Based on World Bank, n.d-a.

Note: No data available for Brunei Darussalam, Cambodia and Singapore.

1.3 ROLE OF ENERGY IN FOSTERING GROWTH AND SOCIO-ECONOMIC DEVELOPMENT

The role of energy in underpinning economic growth and socio-economic development is widely recognised. As population increases and economies expand, energy use also grows. This relationship is stronger for developing countries. As seen in this chapter, countries in the region are at different stages of development – majority of them experiencing strong economic growth over the past several years. Rising incomes and economic transformation, coupled with urbanisation, poverty reduction and improvements in access to modern energy, are all expected to strongly influence future energy demand in the region.

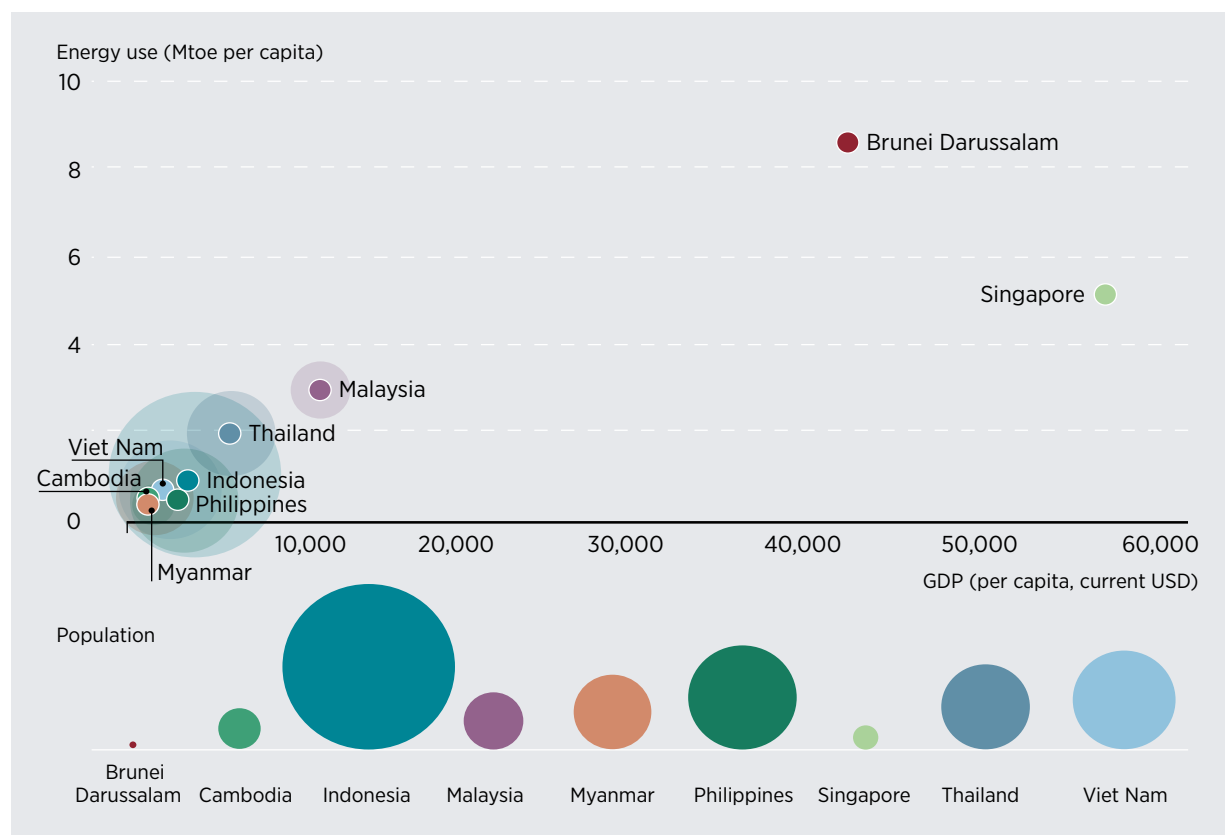
Figure 1.4 illustrates the relationship between GDP and energy use per capita for the different ASEAN Member States. Brunei Darussalam and Singapore are outliers for various reasons – small populations, developed economies and, in the specific case of Brunei, a heavy reliance on oil and gas export revenues. The other countries in the region, comprising the majority share of the population in the region, are closely clustered. Their energy use per capita is well-below the OECD average and for several countries, such as Cambodia, Indonesia, Myanmar, the Philippines and Viet Nam, it is even under the world average.

Energy consumption in the region is estimated to increase by up to 140% by 2040 (ACE, 2017). A key challenge is to meet the growing energy demand in a timely manner while pursuing a number of other critical socio-economic and environmental objectives. These include enhancing energy security, reducing the environmental and health impacts of energy supply and achieving universal access to modern energy services. This has prompted a number of countries in the region to evaluate the structures of their energy sector, including power market design, and identify opportunities for augmenting public investments with private participation. At the same time, there has been a strong regional and national push towards the diversification of the energy mix as demonstrated through the setting of renewable



energy targets (discussed in detail Chapter 4). The next chapter details the energy sector landscape in Southeast Asia analysing key energy supply and consumption trends from the past decade, the diversity of structures in the energy markets, as well as the key drivers for the energy transition.

Figure 1.4 Per capita energy use and GDP for Southeast Asian countries



Source: Based on World Bank, n.d.-b. Note: Based on 2014 data for all countries except Viet Nam for which 2013 has been used. The size of the bubble represents the population of the country.



ENERGY SECTOR LANDSCAPE

Supertree Grove, Singapore



Rapid economic growth in Southeast Asia has driven up energy use over the past few decades. Energy consumption in the region has doubled since 1995 and the demand for energy is expected to continue to grow by an average of 4.7% per year till 2035 (ASEAN, 2015a). Energy demand for the production of electricity will rise at the fastest pace; energy demand in the industry and transport sectors will also increase rapidly (IRENA and ACE, 2016). The challenge is to supply the growing demand for energy to underpin economic growth while at the same time enhancing energy security and environmental sustainability.

The energy sector landscape of the region comprises heterogeneous national contexts that have been evolving quite rapidly over the past decade or so. The rapid growth in energy demand has fuelled the use of fossil fuels (especially coal and natural gas for electricity generation and oil for transportation uses) as well as of renewable energy options (including large hydropower and geothermal) for power generation. The availability of these resources domestically has had a key influence on the energy mix, particularly on the use of coal in Indonesia, coal and natural gas in Viet Nam and hydro resources in the lower-Mekong countries such as Cambodia, Lao PDR and Viet Nam. At the same time, the region's energy sector landscape is shaped by uneven access: over 65 million people

are without electricity access and 250 million rely on traditional biomass for cooking. Bringing modern energy services to these segments of the population requires expanding the catalogue of solutions to include decentralised options, especially those involving cost-effective renewable energy. Faced with the dynamics associated with rising domestic energy demand, environmental impacts, energy access challenges, as well as a rapidly changing energy landscape globally, both net exporters and importers of fossil fuels are being compelled to reconsider their energy choices.

Decision-making structures, institutions and planning processes in the energy sector vary throughout the region. A shift towards liberalisation is underway in some power markets to attract private sector investments in infrastructure development. Furthermore, targets for renewable energy and energy efficiency are encouraging a rethinking of the way energy is generated, distributed and consumed in the region. This chapter analyses the region's current energy sector landscape, focusing on the trends in primary energy supply and final energy consumption from the perspective of energy sources as well as end-use sectors. The chapter further analyses the key factors contributing to the diversification of energy sources and the role of renewable energy in that context.

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2.1 ENERGY SECTOR STATUS AND TRENDS

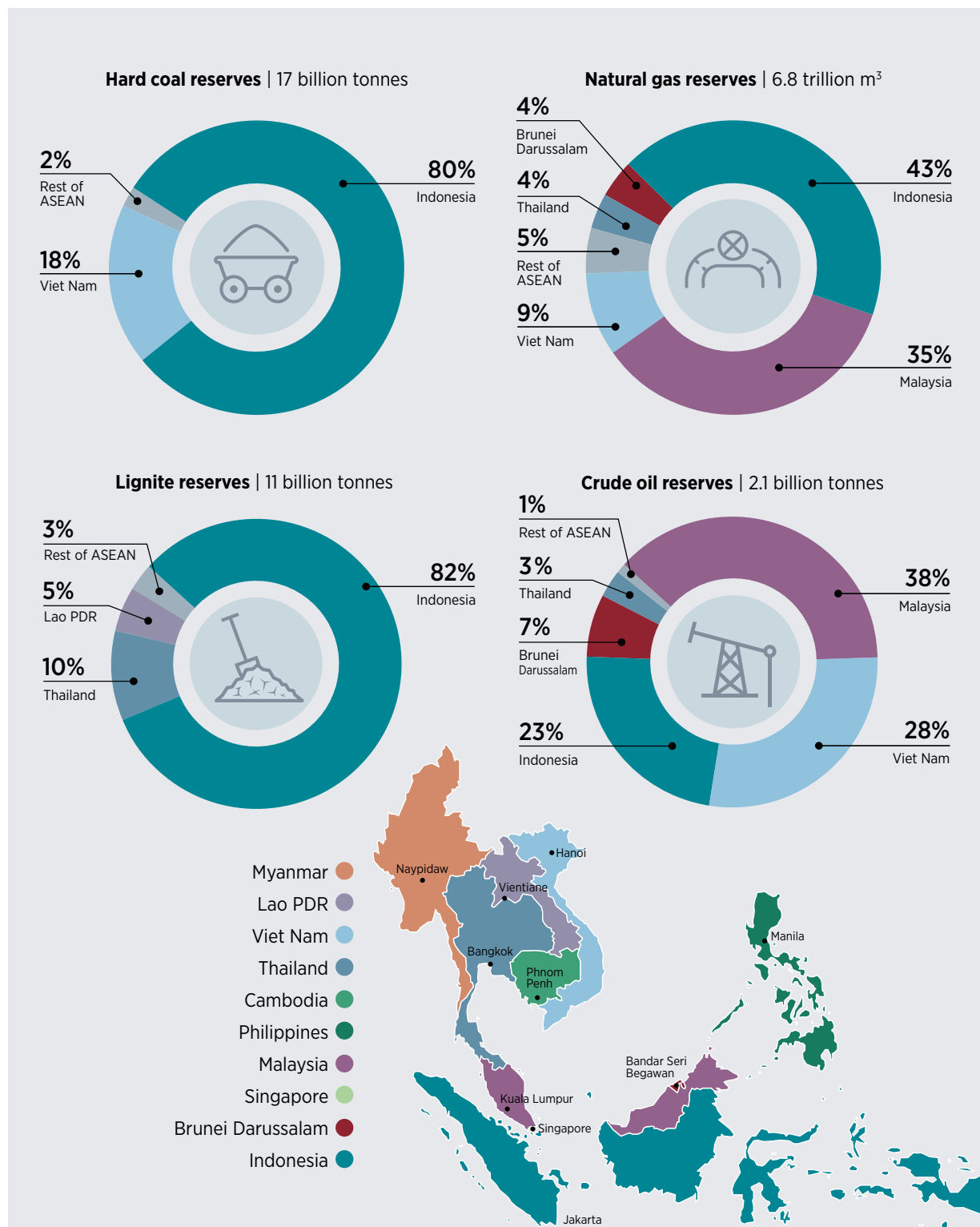
PRIMARY ENERGY SUPPLY

Southeast Asia is rich in natural resources, with reserves of hard coal, lignite, natural gas and oil (Figure 2.1) while distribution is uneven, as well as of renewables (ACE, 2015; ACE, 2017). The region accounts for 4.1% of the world's proven recoverable coal reserves, 3.4% of the world's proven recoverable natural gas reserves and 0.8% of the world's oil reserves. Indonesia is the world's fifth-largest producer and the second-largest exporter of coal (IEA, 2017b). The unexploited potential for hydropower in Southeast Asia is substantial, especially in the Lao PDR, which alone has an estimated hydropower potential of 26 gigawatts (GW) (OECD, 2017). The region also has substantial bioenergy resources from farm and forest residues, industrial and municipal waste, and traditional energy crops (IRENA and ACE, 2016). It is rich in solar resources with potential across all countries (see section on resources in chapter 3). Good wind

resources are limited to areas in Indonesia, the Philippines, Thailand and Viet Nam. Because of geographical constraints, the technical potential for renewable energy is more limited in Singapore and Brunei Darussalam, although Singapore is targeting the rapid development of rooftop solar photovoltaic (PV) (OECD, 2017) while Brunei Darussalam is trying to promote solar PV and landfill biogas. Indonesia and the Philippines also have geothermal resources which have been developed partially.

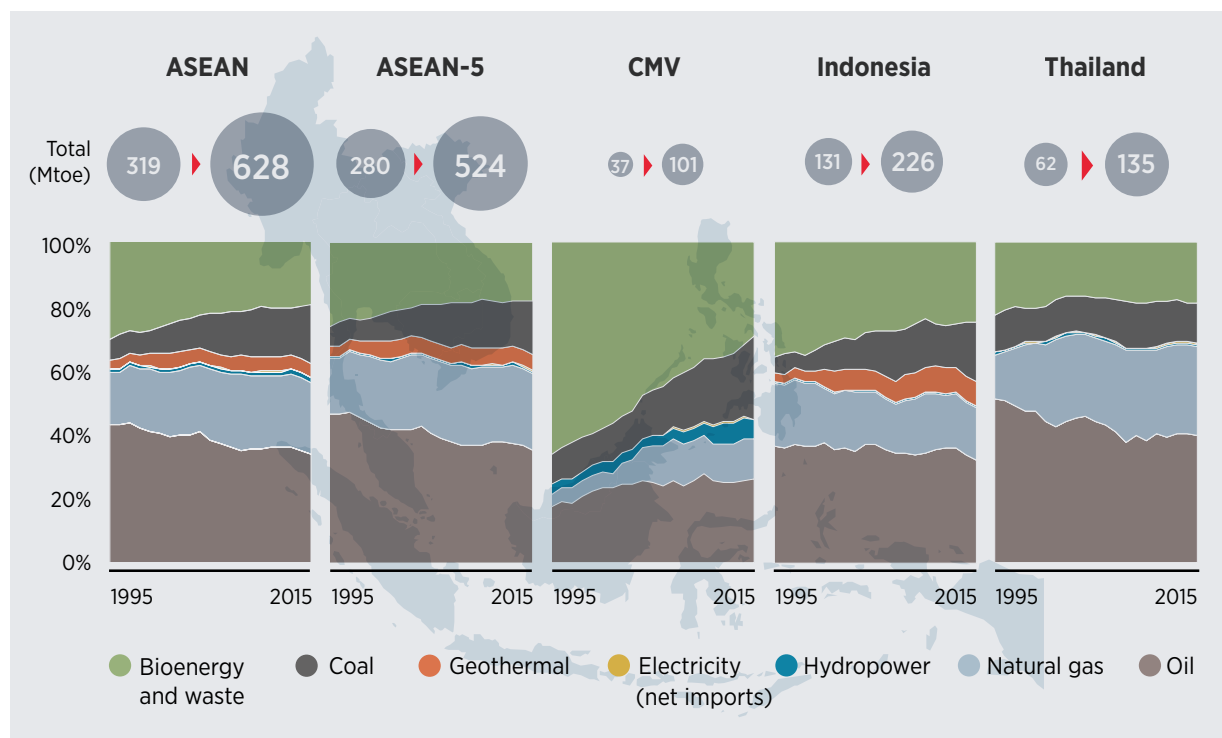
The total primary energy supply (TPES) in Southeast Asia nearly doubled over two decades, reaching 628 Mtoe in 2015 (Figure 2.2). Total per capita primary energy use in the region also grew, but remains nearly 50% below the global average (World Bank, 2017). Oil is the main source of TPES, accounting for 34%, followed by natural gas (22%), coal (18%) and bioenergy (20%). Crude oil and its derivatives are predominantly used in the transportation sector, where fuel demand has grown rapidly amid population growth, increasing urbanisation and greater economic activity.



Figure 2.1 Fossil-fuel reserves in Southeast Asia

Source: ACE, 2015.

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Figure 2.2 Total primary energy supply by energy source in Southeast Asia, 1995-2015

Source: Based on IEA, 2017c.

Note: The ASEAN figures do not include Lao PDR due to non-availability of data. ASEAN = Association of Southeast Asian Nations; CMV = Cambodia, Myanmar and Viet Nam. ASEAN-5 comprises Indonesia, Malaysia, the Philippines, Singapore and Thailand.

The share of natural gas in TPES has grown strongly since 1990 as several countries in the region (e.g., Indonesia, Malaysia and Thailand) have replaced their oil-fired power plants with gas-based infrastructure.

The fastest growth has been registered by coal, especially since 2000, when a large number of coal-fired power plants were put into operation (ACE, 2015). Domestic coal consumption in Indonesia has grown at a constant pace in recent years, increasing nearly 60% since 2011 (IEA, 2017b). The share of renewables, including hydro, geothermal, solar PV and wind continues to increase, even as the share of bioenergy decreases, reflecting its reduced use in the residential sector. The share of geothermal has

largely hovered around 3–5% of the region's TPES, with hydro reaching a maximum of 1.6% in 2014.

At a national level, key differences in the energy mix can be observed. Countries experiencing a high rate of energy growth have also seen the greatest transformations in their energy mix. The share of coal in Cambodia's energy mix grew markedly, from 0.3% in 2011 to over 8% in 2015. This rise was largely a result of new coal power plants coming online and the greater use of coal in industry (e.g., cement) (ERIA, 2016a). This has also translated into higher imports of coal into the country. Lao PDR and Viet Nam have also seen rapid increases in the share of coal in their TPES, given strong domestic production and power sector development plans

that emphasise coal-based power generation. Traditionally a coal exporter, Viet Nam turned into a net importer in 2005, and imports grew to reach 13.3 metric tonnes in 2016 (IEA, 2017b). In the lower-Mekong countries, the share of hydro in TPES is high, at around 6%, and so is bioenergy, given that a significant proportion of the population continues to rely on traditional biomass for cooking/heat.

On the back of growing gas production, Myanmar is seeing a greater role for natural gas in its primary energy supply, although a vast majority of production is for export. Oil and natural gas are the dominant contributors of TPES in Malaysia, Thailand and Singapore. Malaysia is a major liquefied natural gas (LNG) exporter, although a substantial share of natural gas is utilised domestically in industry (e.g., petrochemical processes) (Malaysian Gas Association, 2016). Brunei Darussalam and Indonesia are also exporters of LNG, mainly to Japan (IEA, 2017d). Oil, renewables (non-hydro, modern) and coal play an important role in the TPES of Indonesia and the Philippines. Indonesia is the world's second-largest exporter of coal as well as the largest energy consumer in the region. Rising domestic needs coupled with a slowdown in imports in the People's Republic of China and India have redirected energy production to domestic markets (IEA, 2015a). Brunei Darussalam, a net exporter of natural gas and oil, relies predominantly on these fuels to meet its domestic energy demand.

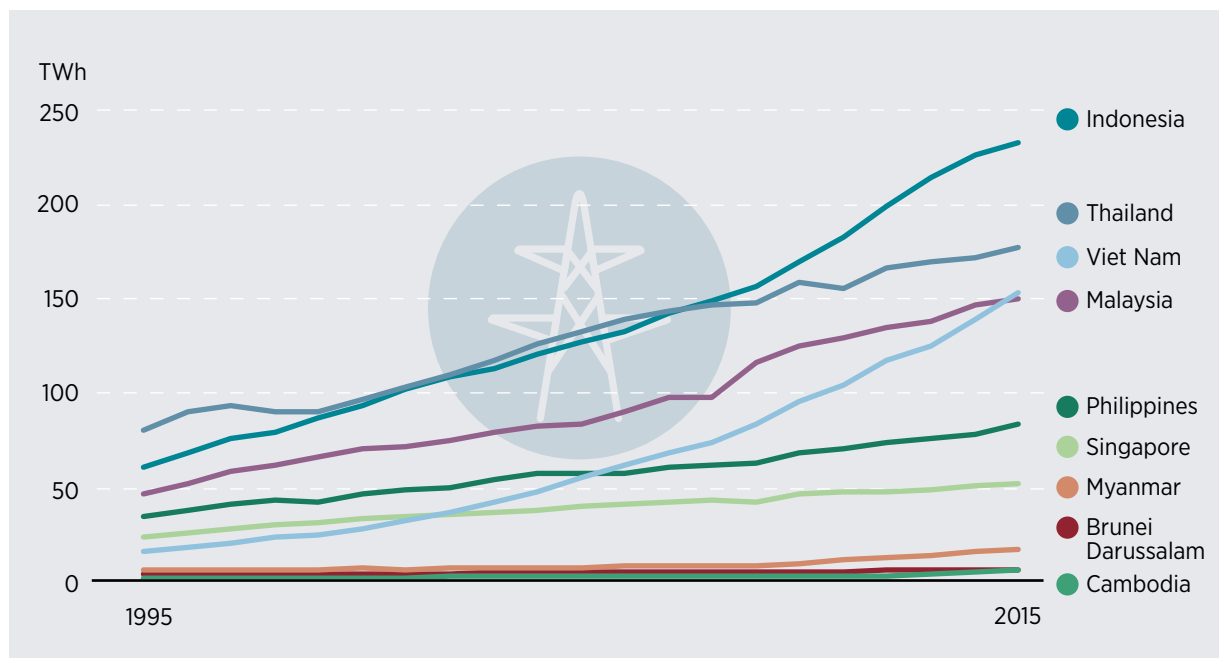
The availability of domestic energy resources as well as macroeconomic conditions reflect how the TPES evolves at the country level. Coal and natural gas production exceeds the region's consumption, though it is a net importer of oil to meet supply requirements. As the region anticipates rapid growth in energy demand, surplus coal production will reduce and it is expected to become a larger net importer of oil, and will probably also become a net natural gas importer in the medium-term.

GROWTH IN ELECTRICITY CONSUMPTION

Electricity generation in the region more than tripled between 1995 and 2015, reaching over 872 terawatt hours (TWh). During this period, electricity generation grew at an average rate of 7% per year, led by increases in Indonesia, Malaysia, the Philippines, Singapore, Thailand and Viet Nam (Figure 2.3). In the lower-Mekong countries, where economies are expanding at a rapid pace, electricity generation has expanded eight-fold since 1995 (although starting from a lower base compared with other major economies in the region). Between 2010 and 2015 alone, electricity generation increased by more than 68%, compared with 22% for the ASEAN-5 countries. The region's largest economy, Indonesia, saw electricity generation nearly triple since 1995, rising by over 3% every year. With strong economic growth, Viet Nam's power generation increased more than ten-fold in the same time period, growing by over 6% every year (IEA, 2017c).



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Figure 2.3 Electricity generation by country in Southeast Asia, 1995-2015

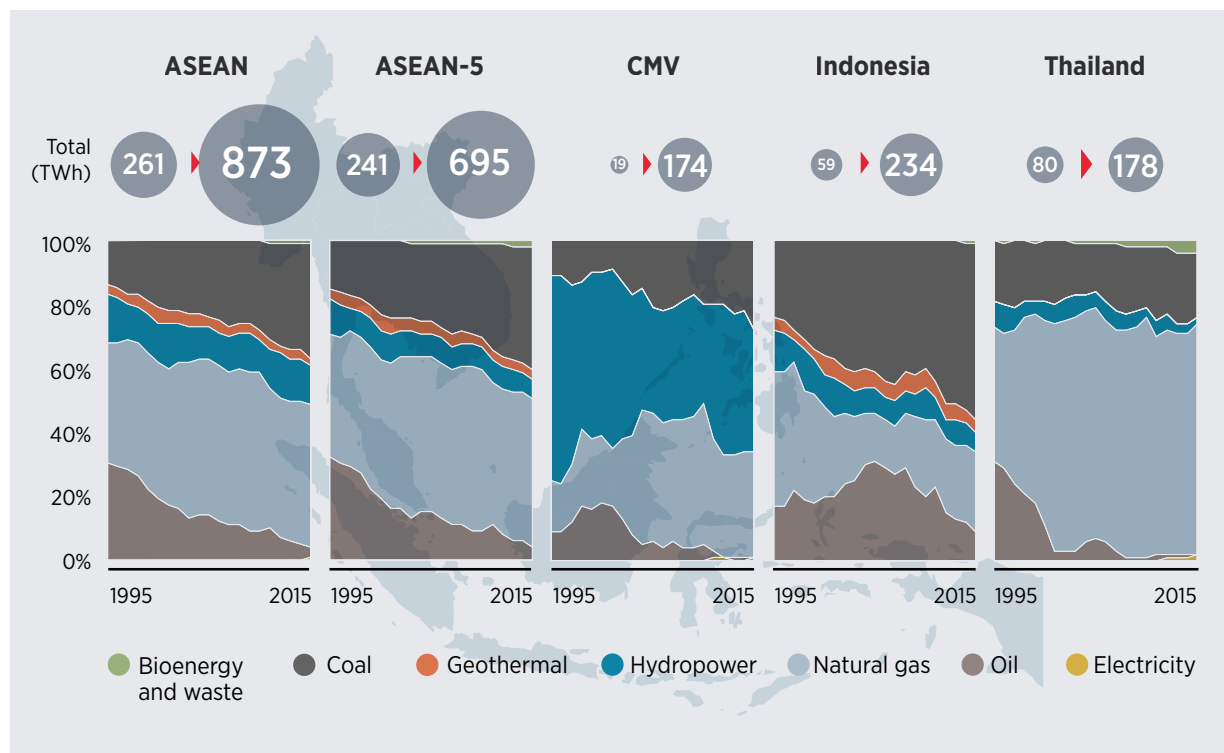
Source: Based on IEA, 2017c.

At a regional level, the electricity generation fuel mix has also changed considerably. In 1995, natural gas was the main fuel being used to produce electricity, followed by oil, hydropower and coal. Programmes to construct gas- and coal-fired power plants in various ASEAN Member States have reduced oil's share drastically¹. Coal-based generation, for instance, rose over 180% from 111 TWh in 2004 to 314 TWh in 2015. This growth is driven by the increasing use of coal-based power generation in Indonesia, Malaysia, the Philippines, Thailand, Viet Nam and, more recently, in Cambodia and Lao PDR. Electricity generation from natural gas nearly doubled between 2004 and 2015, driven primarily by increases in Indonesia, Thailand, Viet Nam, Singapore and Malaysia. Singapore and Brunei Darussalam rely almost entirely on natural gas to

meet their electricity needs. In 2015, natural gas contributed the largest share (41%) to the regional generation mix, followed by coal (33%) and hydro (16%) (ACE, 2017).

While renewable energy generation has grown significantly in recent decades, in reality, its share in the region's overall electricity mix has remained stagnant. Renewable energy options, mainly hydro and geothermal, contributed about 18% of all electricity generated in 1995 (Figure 2.4). In 2015, renewable energy share dropped to 17%. At a regional level, hydro's share in the electricity mix increased only marginally, from 10.5% to 12.4% between 2004 and 2015, despite a near doubling of generation, however, driven mostly by plant additions in Lao PDR, Indonesia, Cambodia,

¹ / Oil-based generation declined only marginally, from 65 TWh in 2004 to 52 TWh in 2014. Most of the decline was a result of reduced use in Cambodia, where coal and hydro shrunk oil usage, as well as in Singapore and Malaysia. Oil-based generation is still prevalent in Indonesia and Philippines, where an archipelago geography requires many islands to be powered by fuel-based options.

Figure 2.4 Electricity generation by energy source in Southeast Asia, 1995-2015

Source: Based on IEA, 2017c.

Note: The ASEAN figures do not include Lao PDR due to non-availability of data. CMV = Cambodia, Myanmar and Viet Nam. ASEAN-5 comprises Indonesia, Malaysia, the Philippines, Singapore and Thailand.

Malaysia, Myanmar and Viet Nam. Both Myanmar and Lao PDR derive a majority of their electricity generation from hydro. Geothermal-based electricity generation has grown steadily, especially in Indonesia and the Philippines, where resources are abundant. Other renewables, including bioenergy, solar PV and wind, are experiencing strong growth (albeit from a small base) thanks to the adoption of support policies in many countries.

Electricity demand is expected to increase significantly over the coming decades. It is estimated that energy demand for producing electricity will increase 95% by 2025 (IRENA and ACE, 2016). Most of this increase will be supplied by coal, followed by natural gas and large hydro. The remainder would come from a mix of renewable

sources, including geothermal, bioenergy, wind and solar PV. Under a business-as-usual scenario, coal is expected to replace natural gas as the dominant source of power generation in the region by 2040 (ACE, 2017).

Investments in power generation capacity, as well as transmission and distribution capacity, have to keep pace with demand. To support economic growth, eradicate poverty and respond to climate change, Southeast Asian countries would need to allocate up to 5.7% of their GDP for infrastructure through 2030, much of it dedicated to power sector development (ADB, 2017c). Some countries in the region are looking at the power sector as a source of export revenue through the cross-border sales of electricity. Lao PDR's exports of electricity

02 totalled over 11.5 TWh in 2015, compared to just 2.8 TWh in 2000; China, Thailand and Viet Nam were its largest electricity trade partners (IRENA, 2016a) (Figure 2.5).

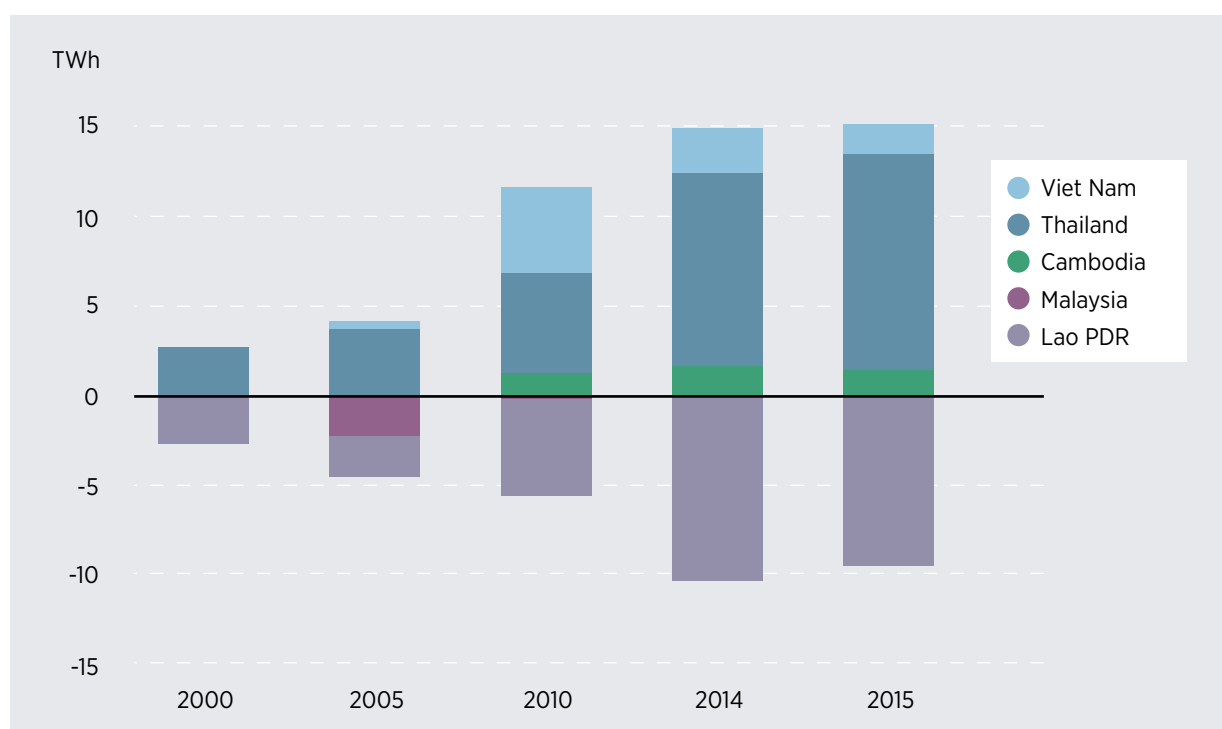
An increasing amount of electricity trade is seen in the region. Lao PDR and Myanmar, as well as China, are net exporters of electricity, mainly hydropower (IEA, 2017e). Cambodia imports electricity from

neighbouring countries, such as Lao PDR, Thailand and Viet Nam, since hydropower generation usually declines during the dry seasons. With an increase in generation from coal, imports fell from 2.3 TWh in 2013 to 1.5 TWh in 2015 (ERIA, 2016b).

Across the region, there are at least nine cross-border power grid projects totalling 5.2 GW in capacity. Six projects worth 3.3 GW are under development, and another 16 projects worth 23.2 GW are planned (APG, 2016). These projects form part of a wider strategy to enhance energy connectivity and market integration across the region to achieve energy security, accessibility, affordability and sustainability. Energy market integration and connectivity lie at the heart of the current ASEAN Plan of Action for Energy Cooperation (APAEC) and are seen to be essential for building the ASEAN Economic Community (Energy Studies Institute, 2016) (Box 2.1).



Figure 2.5 Net electricity imports in Southeast Asia, 2000–2015



Source: Based on IEA, 2015a and MEM, 2017.

Box 2.1 Advancing regional energy connectivity in Southeast Asia

Since the signing of the 1986 Agreement on ASEAN Energy Cooperation, the leaders of ASEAN have expressed their strong support of advancing regional energy connectivity, especially given the growing demand for energy in the region. Projects, such as the ASEAN Power Grid (APG) and the Trans-ASEAN Gas Pipeline (TAGP), are supported by recommending that Member States seriously consider harmonising regulatory frameworks and standards to facilitate regional energy connectivity.

The recently endorsed ASEAN Plan of Action for Energy Cooperation (APAEC) 2016–25 has been set as the guideline for energy co-operation in the region. The key initiatives under this plan include, among others, embarking on multilateral electricity trading to accelerate the realisation of the ASEAN Power Grid. To support the accelerated development of utility-scale, renewables-based electricity that can be integrated into the evolving APG, IRENA launched the Greening ASEAN Power Grid Initiative. Following approval for this initiative by the ASEAN Senior Officials Meeting on Energy in October 2015, IRENA initiated its engagement with governments and key ASEAN stakeholders to prepare for the implementation of the initiative. Two rounds of multi-stakeholder consultations organised in Malaysia (November 2015) and Thailand (June 2016), in partnership with ASEAN energy institutions, including the Head of ASEAN Power and Utilities Association and the ASEAN Centre for Energy, helped identify areas of priority action that would eventually constitute the main components of the initiative's implementation strategy.

Source: IEA, 2015b; IRENA and ACE, 2016.

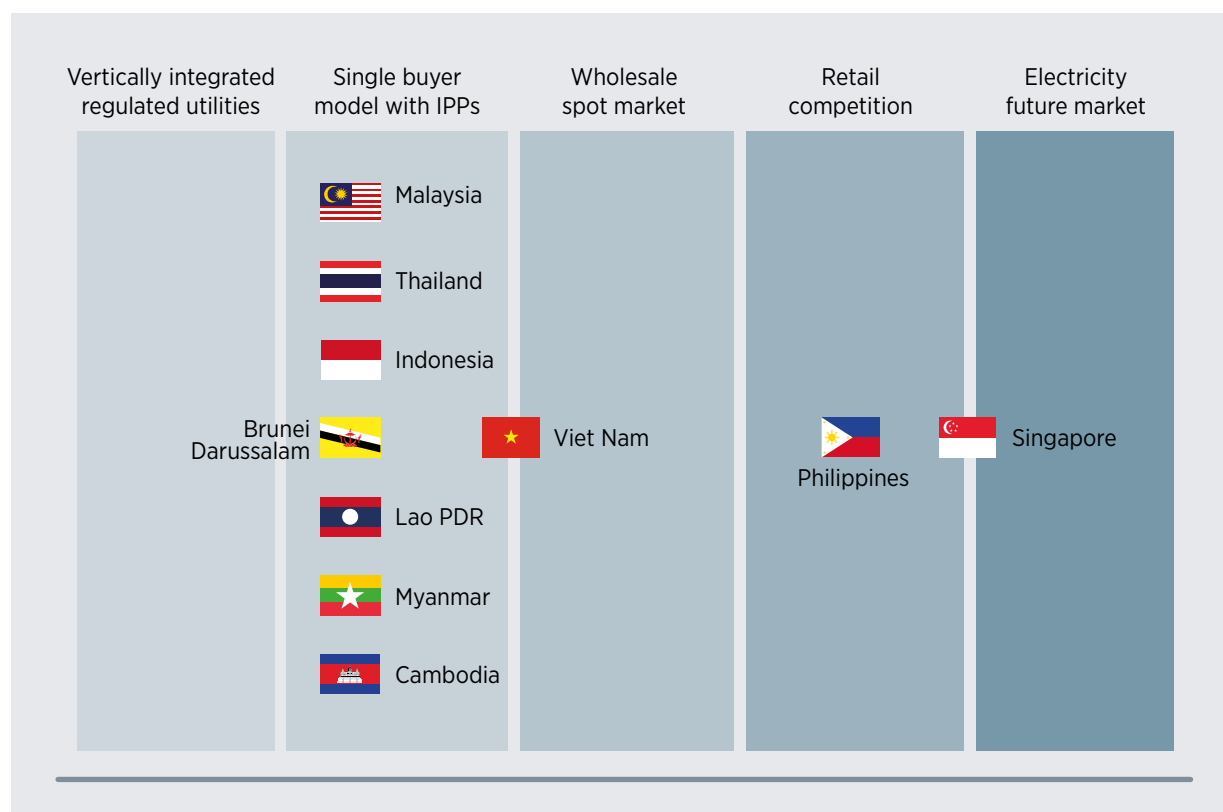


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Power sector structure and regulation is a key aspect influencing the regional integration of electricity markets and capacity additions in the domestic power sector. Generally, across the region, the single-buyer model with independent power producers (IPPs) is most prevalent (Figure 2.6). In several Southeast Asian countries, national and state utility companies monopolise their respective jurisdictions and act as sole offtakers for IPPs. Cambodia has a unique power sector structure in the region with a strong presence of mini-utilities that have been operating since the 1970s. Singapore and the Philippines operate liberalised retail electricity markets. Private participation has played a key role in the ASEAN-5's power sectors, where IPPs contribute more than half of

these countries' aggregate installed capacities. In 2006, the Vietnamese government approved a roadmap for the establishment of a competitive electricity market to improve the power industry's competitiveness and independence. As of end-2016, power generators were allowed to enter the market and sell electricity to the only buyer, Viet Nam Electricity (VCBS, 2016). Given the liberalised power sectors of the Philippines and Singapore, electricity tariffs in these countries are market driven and among the highest in the world. In other countries, tariffs are regulated and controlled by the government (RAM, 2016). Tariffs, in particular residential, in Brunei Darussalam, Lao PDR, Myanmar and Thailand are among the lowest in the region (Suryadi, 2014).

Figure 2.6 Structure of electricity markets in Southeast Asia



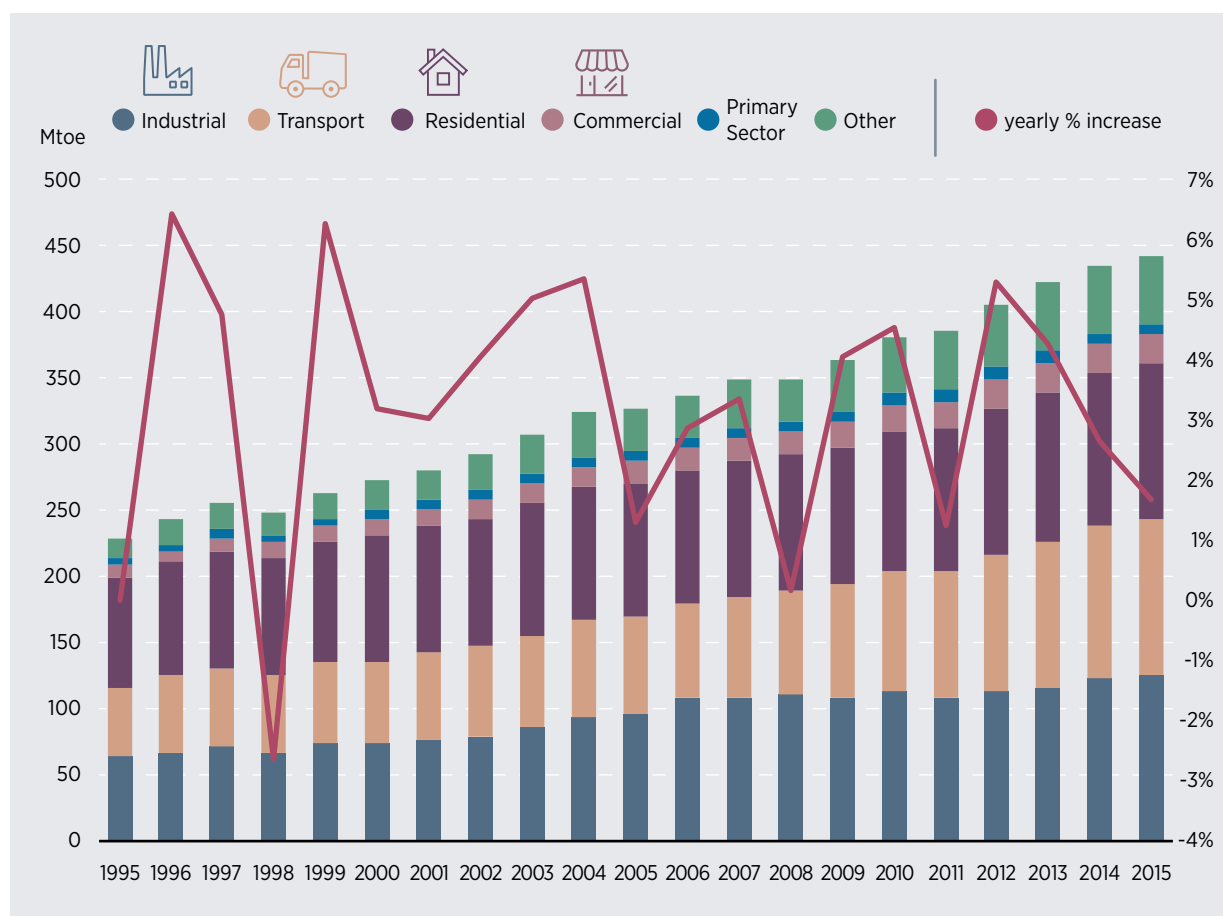
Source: Based on KPMG, 2015.

FINAL ENERGY CONSUMPTION

Energy consumption in Southeast Asia nearly doubled between 1995 and 2015, growing at an average pace of 3.4% annually, fuelling rapid economic growth and higher living standards (IEA, 2017c). Figure 2.7 provides an overview of how the region's TFEC evolved in those two decades. The overall increase in TFEC conceals significant fluctuations due to a series of events, including the regional financial crisis of 1997–98, the global crisis of 2008 as well as the floods of 2011 impacting Cambodia, Lao PDR, Myanmar, Thailand and Viet Nam.

In absolute terms, Indonesia, Malaysia, Thailand and Viet Nam constitute the majority of the region's TFEC, although the most rapid growth over the past decade came from Brunei Darussalam, Cambodia and Viet Nam. The industrial, transportation and residential sectors together account for 82% of TFEC in 2015, down from 88% in 1995. These trends were accompanied by an increase in energy consumption in the commercial and public services sector, as well as in the primary sectors, including agriculture, fishing and the use of fuels as direct feedstock in, for instance, the fertiliser industry.

Figure 2.7 Evolution of total final energy consumption by sector in Southeast Asia, 1995–2015



Source: Based on IEA, 2017c.

Note: Mtoe = million tons of oil equivalent.

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The share of the residential sector fell from 37% to 26%, compared with the other sectors, which show a steady increase in their respective shares of TFEC. At present, the share of energy consumption is roughly similar across the industry, transport and residential sectors, at around 27%. The share of energy consumed by industry and transport is lower than the averages for the world and for the Organisation for Economic Co-operation and Development (OECD) countries (IEA, 2017f). The residential sector's share is higher than the world average (23%) and the OECD countries (19%), owing to the fact that a large share of the population in the CLMV countries (Cambodia, Lao PDR, Myanmar and Viet Nam) rely on biomass for heating and cooling. In comparison, for ASEAN-5 countries, the residential sector's share of TFEC is 24%.

Analysing the shares of TFEC at a sub-regional level provides valuable insights linked also to macroeconomic developments in the economies of the region. Among the ASEAN-5 countries, while energy consumption increased in absolute terms in the industry sector, its share as a proportion of TFEC decreased from a peak of 33% in 2006 to 28% in 2015 (Figure 2.8). The region's emergence as a global manufacturing hub has driven greater energy use in the industry sector. Viet Nam, for instance, a rising industrial hub, has seen energy use in the sector more than double since 2004. The dynamics of energy consumption in the industrial, transport and residential sectors are analysed in more detail in the following sections.

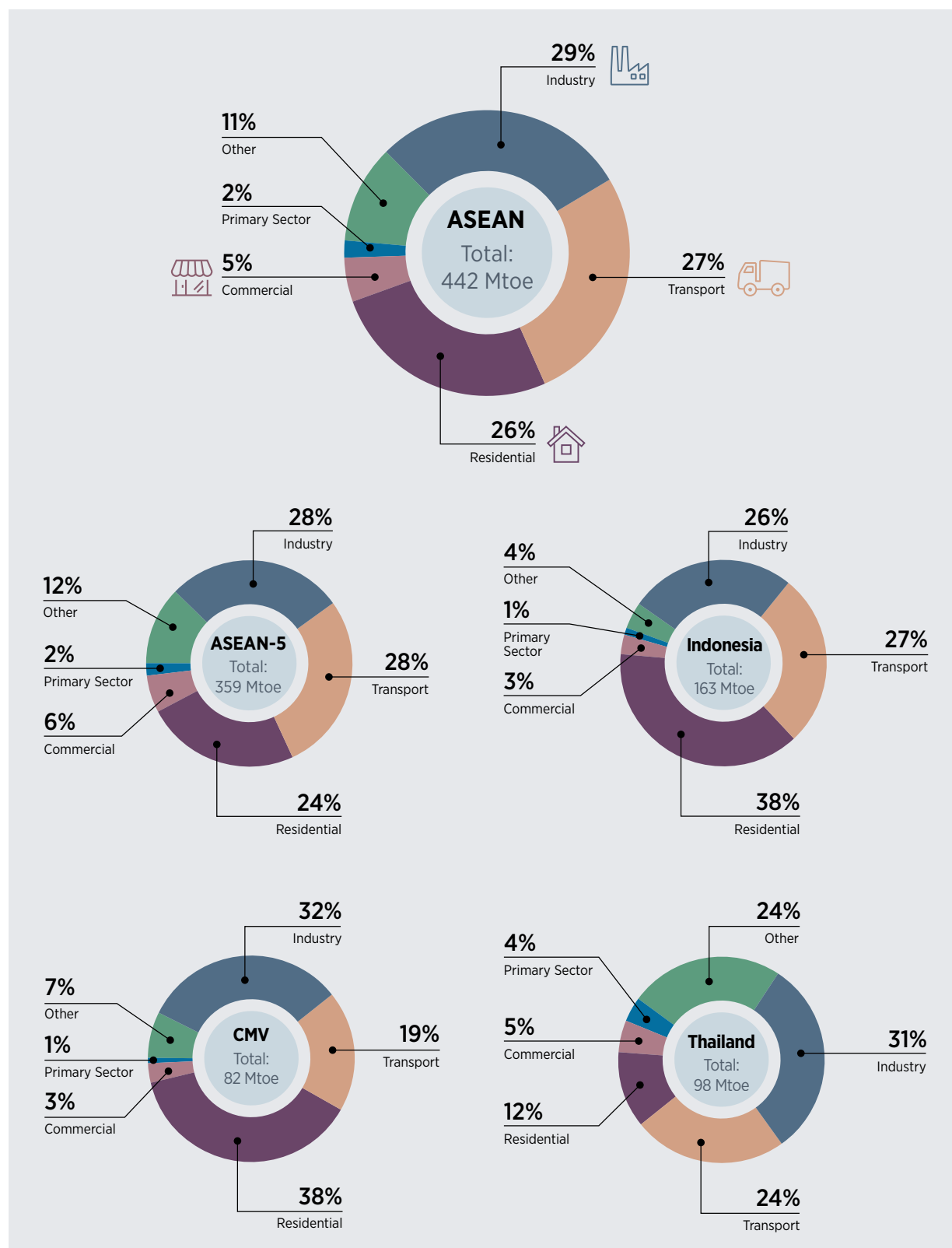


Industry

Industry is the largest energy consumer in Southeast Asia, accounting for over 29% of the TFEC, with shares ranging from around 12% in Myanmar to nearly 40% in Viet Nam (IEA, 2017c). The region's status as a major industrial hub began with the ASEAN-5 economies – including Indonesia, Malaysia and Thailand, which attracted investments in a wide range of local industries – followed by emerging markets such as Viet Nam. The sector comprises petrochemicals, food and beverages, pulp and paper, textiles, equipment, and steel and cement, among other industries.

Regional energy use in industry is nearly evenly split across coal, electricity, oil, natural gas and bioenergy and waste (Figure 2.9). Differences emerge at a sub-regional level, for instance, in the CMV countries (Cambodia, Myanmar and Viet Nam), where coal comprises over 40% of the share, followed by electricity (25%) and bioenergy (16%). In Cambodia, coal is extensively used in the cement industry, and consumption has risen dramatically since 2015, with the commissioning of new plants (ERIA, 2016b). Petroleum products, mainly diesel oil, lubricants and fuel, are also widely used in industry although their use has been decreasing. A small quantity of solid biofuels (fuel wood) is still being consumed in some industries, such as for heating the boiler or burner (ERIA, 2016b). In Viet Nam, coal is primarily used in steel, cement, paper and fertiliser production (ADB, 2015). As the industrial base expands, energy use is also growing. Coal use in Vietnamese industries tripled between 2004 and 2015, and nearly doubled in Myanmar during the same period.

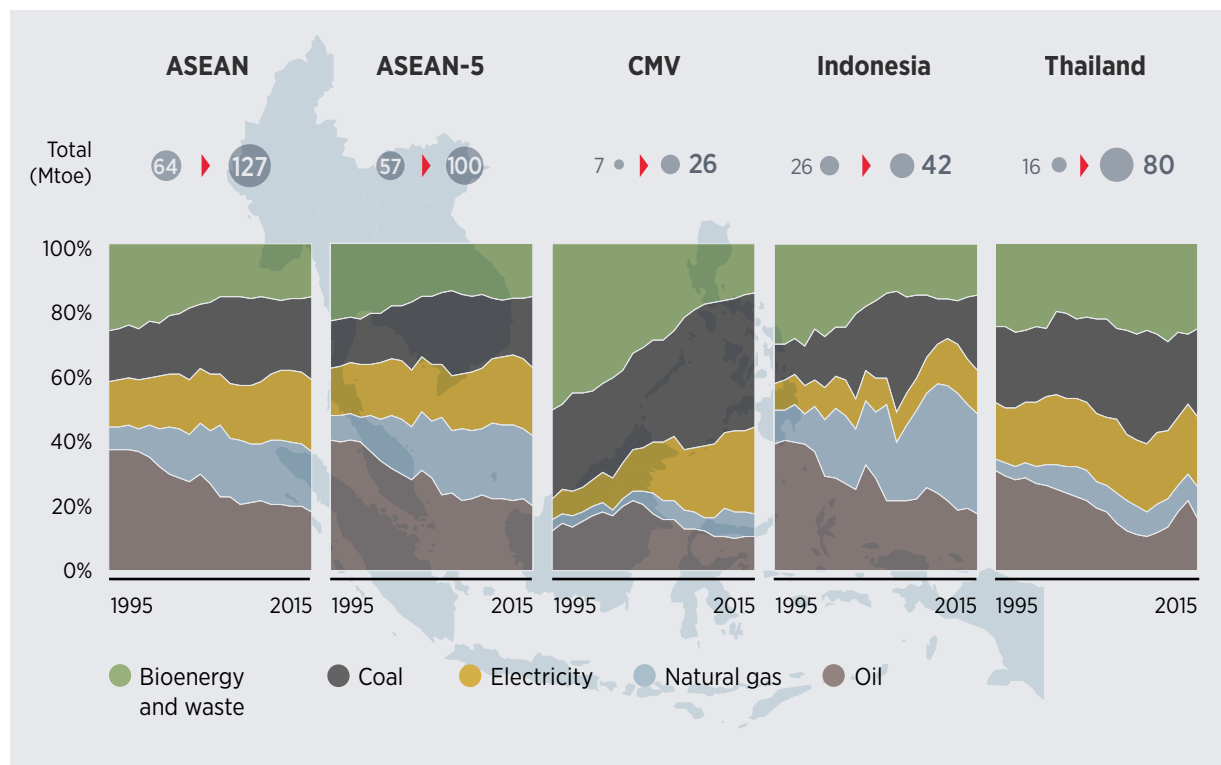
Compared with the CMV countries, natural gas plays a much more prominent role in the ASEAN-5; here the role of natural gas expanded dramatically, from just under 10% of the mix in 1995 to 18% in 2004 to 22% in 2015. This is the result of a greater emphasis on the utilisation of both domestic and imported natural gas for meeting energy needs in these countries. In the 1990s, as Malaysia's economy

Figure 2.8 Total final energy consumption by sector in Southeast Asia, 2015

Source: Based on IEA, 2017c.

Note: The ASEAN figure does not include Lao PDR due to non-availability of data; CMV = Cambodia, Myanmar and Viet Nam. ASEAN-5 comprises Indonesia, Thailand, the Philippines, Singapore and Malaysia.

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Figure 2.9 Final energy consumption in the industrial sector in Southeast Asia and its sub-regions, 1995-2015

Source: Based on IEA, 2017c.

Note: The ASEAN figure does not include Lao PDR due to non-availability of data; CMV = Cambodia, Myanmar and Viet Nam. ASEAN-5 comprises Indonesia, Malaysia, the Philippines, Singapore and Thailand.

shifted from an agricultural base to an industrial one, the government encouraged the establishment of integrated industrial and petrochemical complexes. The industrial sector is the second-largest consumer of natural gas after the power sector. Within the Malaysian manufacturing sector, the rubber products industry is the biggest user of gas followed by food, beverages and tobacco (Malaysian Gas Association, 2016). In Indonesia, some of the major industrial consumers of energy are the cement, iron and steel, pulp and paper, and textile sub-sectors (Vivadarinar, Purwanto and Saputra, 2016). Energy use in the non-metallic mineral sector (e.g., glass, cement, ceramic) has more than tripled since 1995 and accounts for over 10% of all energy consumed in the industry sector. Recently, energy use in the non-ferrous metal sub-sector increased dramatically and the trend is likely to continue as more processing

capacity (e.g., smelters) is handled domestically as a result of the banning of raw mineral exports in 2014. The share of natural gas in Indonesia's consumption mix increased dramatically from 20% in 2004 to 31% in 2015. The chemical, ceramics and textile industries are among the main users of natural gas in Indonesia (Enerdata, 2015).

The Philippines uses bioenergy in the food and tobacco industry and coal in non-metallic minerals, iron and steel. The fastest growth is expected to be in the demand for coal for non-power applications, which will increase at an annual average rate of 7.8%, with the bulk of end-use demand expected to come from the cement industry (Vivar, 2016). In Thailand, two industry sub-sectors represent around 60% of energy consumption: food (including beverages and tobacco) and non-metallic minerals (mainly

cement). Trend-wise, the share of energy use in the food industry (processed and frozen products) and in machinery (automobiles and electronics) is rising, while that in textiles and chemicals is falling (Enerdata, 2014; Wongsapai, Phuangyod and Damrongsak, 2016).

Among the major energy consumers in the region, Thailand has the highest share of bioenergy and waste in industry energy use. Bioenergy is used extensively in industries in the production process to produce heat, steam and power (Box 2.2). Coal is mainly used in industries such as cement, paper, food and textiles (EPPO, 2015a). Industry has historically been the largest electricity consumer, consuming 43% of the total power (ADB, 2016b). Four sub-sectors consume nearly half of electricity

in Thai industry: food (including beverages and tobacco, 14%), iron and steel (10%), machinery (automobiles and electronics, 16%) and textile (8%) (EPPO, 2015a).

The use of electricity in industry varies substantially across the Southeast Asian countries, ranging from 7.5% (as a percentage of TFEC in the industry) in Cambodia and Myanmar to over 25% in the Philippines, Singapore and Viet Nam, and 35% in Malaysia. The largest energy consumer in the region, Indonesia, sees a greater use of natural gas (31%) in industries such as fertilisers, petrochemicals, ceramics, steel, glass, cement and rubber gloves (Indonesia-Investments, 2016), compared with electricity in industry (13%).

Box 2.2 Use of bioenergy in industry in Thailand

Bioenergy is extensively used in Thai industries to generate heat, steam and power. For instance, more than 80% of the process heat in the sugar, pulp and paper, rice milling, timber and palm oil industries is provided by residues and wastes. Many small-scale plants focusing on agro-processing and food processing use solid biofuel for their process heat. Larger-scale plants producing sugarcane, cassava and palm oil use both solid biofuels as well as biogas in co-generation plants that produce heat and electricity for their operations. Some applications of bioenergy in industry include:

- **Sugar mills** use bagasse to produce thermal energy for the distillation process. Some mills use steam from the combustion of bagasse in steam turbines for electricity generation, while others use steam in the operation of rollers used to extract the cane juice.
- **Rice mills** commonly use rice husks as fuel for drying the paddy, further processing such as parboiling and production of rice noodles, as well as for power generation.
- **Oil palm** mills often use the fibre and shells from fruits as fuel to produce thermal energy for the sterilisation of fresh fruit. In addition, most oil palm mills have provision for electricity generation.
- It is common practice for **pulp and paper mills** to use wood waste and black liquor as fuel for the production of thermal energy and electricity. Sawdust, wood chips and other wood residues (called “hog fuel”) are also used on site.

Source: Papong et al., 2004; IEA, 2017g; IRENA, 2017a.

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Transport

The transport sector accounts for the second-largest share of TFEC in the region (27%). At the national level, these shares range from nearly 47% in Brunei Darussalam, 41% in Malaysia and 36% in the Philippines; to around 25% in Cambodia, Indonesia and Thailand; and under 20% in other countries. Oil accounts for the majority share and is used primarily for road transport, with much smaller shares of natural gas (e.g., in Myanmar and Thailand) and liquid biofuels (e.g., in Indonesia and Thailand). Electricity is also used for rail traction, particularly in Malaysia.

Vehicle ownership trends vary throughout the region. Car ownership is on the rise, but at an average of 43 cars per 1 000 persons in the region, it is still much lower than in high-income regions (434 in Europe and 606 in North America). The two countries with the highest ownership rates in the region are Malaysia and Singapore, at 325 and 117 per 1 000 persons, respectively (IRENA and ACE, 2016). Among the CLMV countries, car ownership averages 32 cars per 1 000 persons, compared with 75 in Indonesia and 184 in Thailand (PwC, 2015). In these countries, two-wheeler motorcycles are much more commonplace. More than 80% of households surveyed in Indonesia, Malaysia, Thailand and Viet Nam reported owning a motorcycle (PwC, 2015).

Spurred by economic growth, urbanisation and road infrastructure development, it is expected that vehicular growth will accelerate. This is true for passenger vehicles, in demand among a rising middle class in the region, as well as for commercial vehicles. In 2016, total reported sales of passenger and commercial vehicles reached 3.2 million (compared with 2.5 million in 2010), led by double-digit growth in the Philippines, Singapore and Viet Nam (ASEAN Automotive Federation, 2017). Future energy use in the sector is expected to be 45% higher in 2025 (IRENA and ACE, 2016).



Residential

Energy consumption in the residential sector has grown relatively modestly compared with other sectors, rising 39% between 1995 and 2015. Bioenergy accounts for the majority share of the consumption in the sector at over 65% (Figure 2.10). This primarily represents the use of traditional bioenergy for cooking in rural areas. Over 250 million people or 40% of the population use traditional biomass for cooking in the region, the majority of them living in Indonesia, Myanmar, the Philippines and Cambodia (IEA, 2017c). In Indonesia, bioenergy continues to dominate energy use in the residential sector, followed by oil products and electricity. In Malaysia and Singapore, electricity dominates energy use in the residential sector.

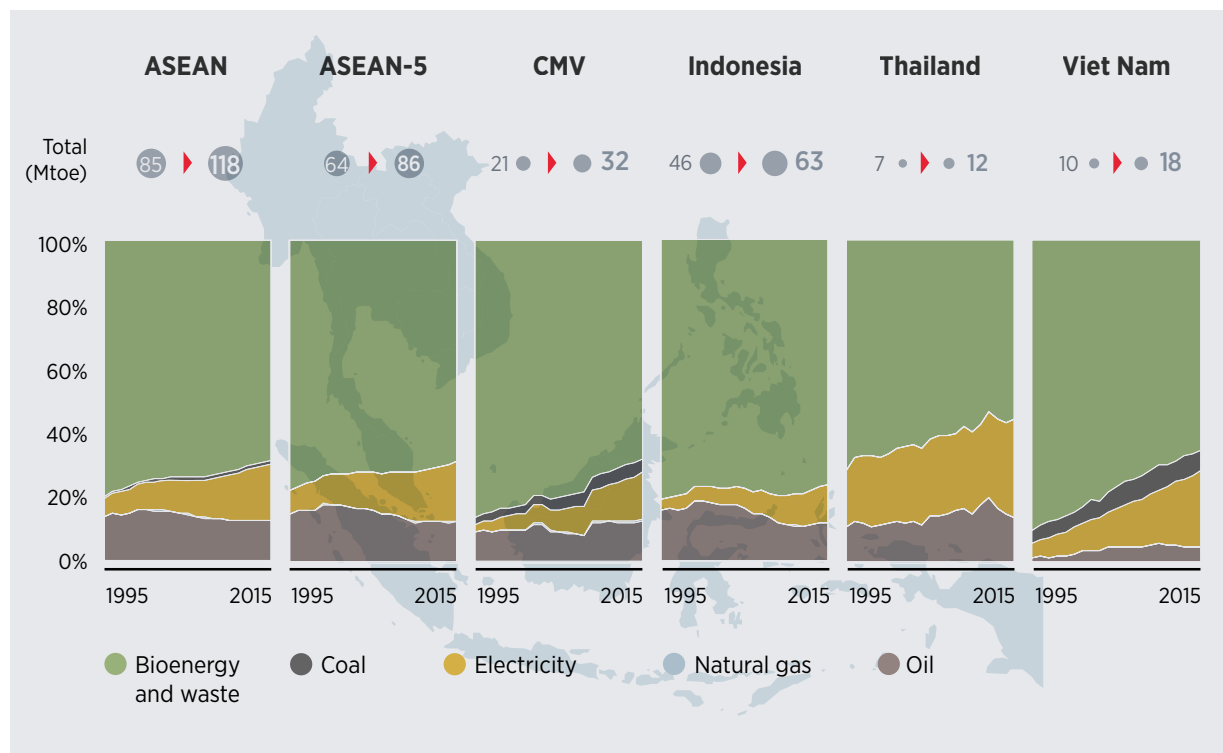
Across the region, urban migration trends coupled with improved access to modern energy services are changing consumption patterns in the residential sector. The share of bioenergy in the residential sector dropped from over 80% in 1995 to 65%, with rapid growth in the use of electricity. Since 1995, the use of electricity in the residential sector has grown five-fold, driven by improved electricity access and growing consumption in line with rising incomes.

Viet Nam has experienced a rapid transformation of energy use in its residential sector. Successful electrification programmes raised the nation's electricity access rates from 80% in 1995 to near universal access by 2014 (World Bank, 2017). The share of electricity in the residential sectors' TFEC grew from 4% in 1995 to 24% in 2015, with absolute consumption increasing nine-fold to 4 Mtoe. While the use of traditional bioenergy has decreased, the share of coal remained nearly constant, as a number of households continue to use coal briquettes and peat for cooking (ESMAP, 1996; Baruya, 2010).

Interestingly, the Philippines actually saw a decrease in energy use in the residential sector, by 23% between 1995 and 2015, despite the electricity access rate rising from 68% in 1995 to 89% in 2014 (World Bank, 2017). Electricity replaced less



Figure 2.10 Final energy consumption in the residential sector in Southeast Asia, 1995–2015



Source: Based on IEA, 2017c.

Note: The ASEAN figure does not include Lao PDR due to non-availability of data; CMV = Cambodia, Myanmar and Viet Nam. ASEAN-5 comprises Indonesia, Malaysia, the Philippines, Singapore and Thailand.

efficient oil and bioenergy, resulting in an overall decrease in energy use. Looking forward, the trend is expected to continue as the share of modern fuels, including electricity and liquefied petroleum gas (LPG), grows.



2.2 DRIVERS OF THE ENERGY TRANSITION

Energy consumption in Southeast Asia is expected to increase 4% annually, reaching 595 Mtoe in 2025 (IRENA and ACE, 2016). Growth in energy demand will be driven largely by the electricity and industry sectors. The region is becoming more industrialised, raising demand for electricity and fuels for industrial processes. Electricity is in high demand across all sectors of the region's economy. Demand for energy to produce electricity is estimated to increase 95% by 2025, and for industry by 63% (Figure 2.11). Demand for energy in transport will also grow, but its share in the total mix is expected to remain the same and to be identical with that of industry in 2025.

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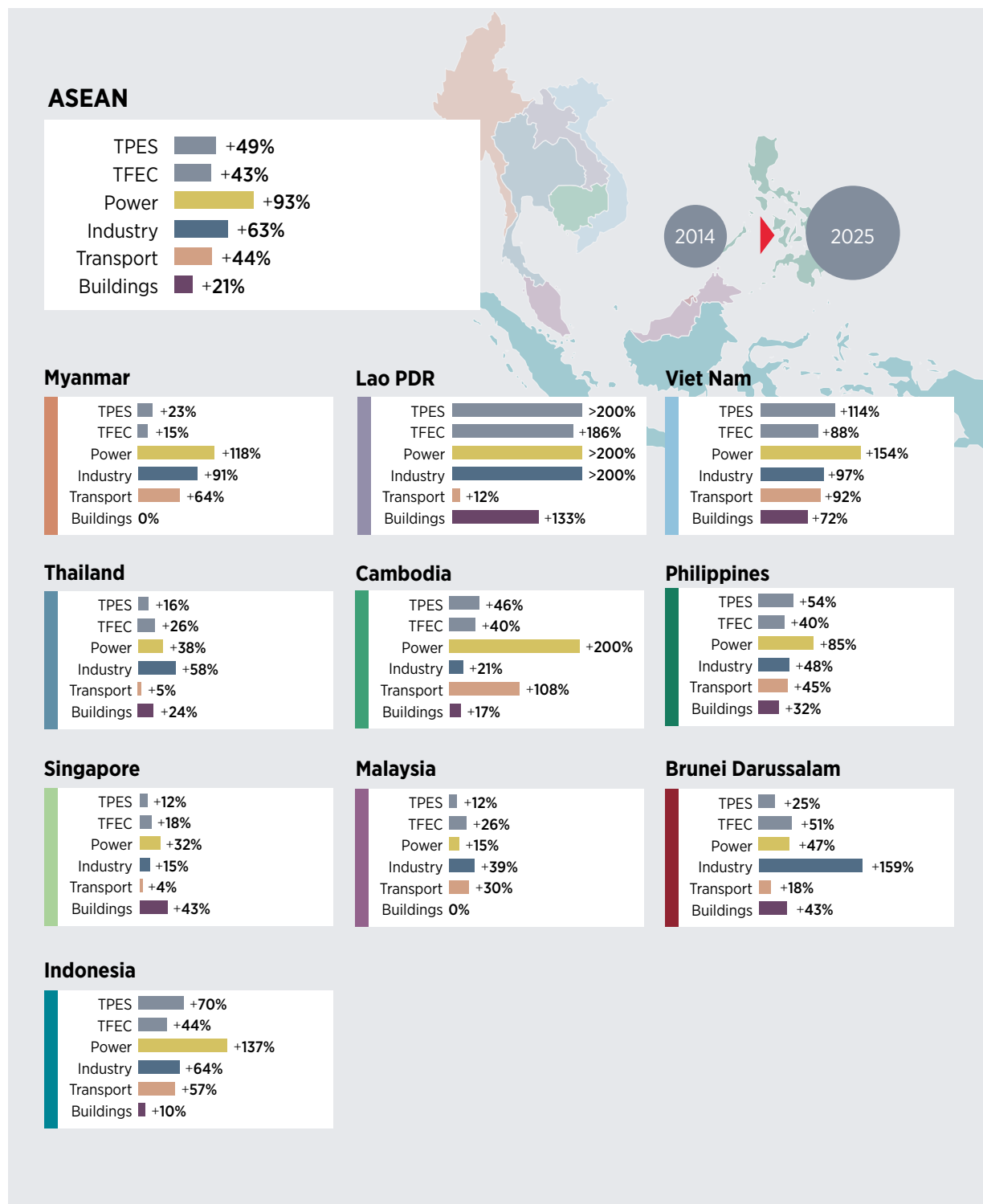
At the national-level, the growth in energy demand by sector varies. CLMV countries will see some of the largest growth over the period. Energy demand in Lao PDR, for instance, is expected to grow by an astounding 200% across most sectors; however, much of the increase in the power sector is electricity intended for export. In countries, such as Cambodia, Myanmar and Viet Nam, demand will grow by 150–200%. Indonesia, the Philippines and Viet Nam are expected to all see significant growth in energy demand for industry, buildings and transport. Some countries with higher per capita income and current energy demand levels will see their energy demand grow as well, but at a lower level compared to these high-growth countries.

While the transport sector is expected to meet most of the increased demand with oil, industry will meet demand with coal and natural gas. The buildings sector will meet demand largely with oil products or electricity. In the past, growth in energy demand has mostly been met through fossil fuels, and this trend is expected to continue. Demand for coal is expected to increase by 128 Mtoe to become the largest fuel source in 2025. Oil and natural gas use is also estimated to increase significantly.

Compared with 2014, growth in the use of fossil fuels by 2025 is estimated to range from 31% for oil, with the majority still used in transport; 90% for coal, driven largely by power generation; and 65% for natural gas, which has mixed uses (IRENA and ACE, 2016).

Despite the fact that fossil fuels are expected to continue to dominate the regional energy mix, a number of factors are driving a growing preference for diversifying the energy supply options. Energy security is gaining prominence in energy sector development plans as indigenous fossil fuels are depleted or are unable to meet growing demand. Net exporters are turning into net importers, and the security of fuel supply for long-term energy infrastructure is of growing concern for a number of countries (ACE, 2015). Meanwhile, the environmental impacts of fossil fuels and also the large proportion of the population living without modern energy services call for diversifying the energy supply mix. The next several sub-sections provide a brief overview of the main drivers of diversification. The section on renewable energy targets in chapter 4 provides deeper insights at a country level.

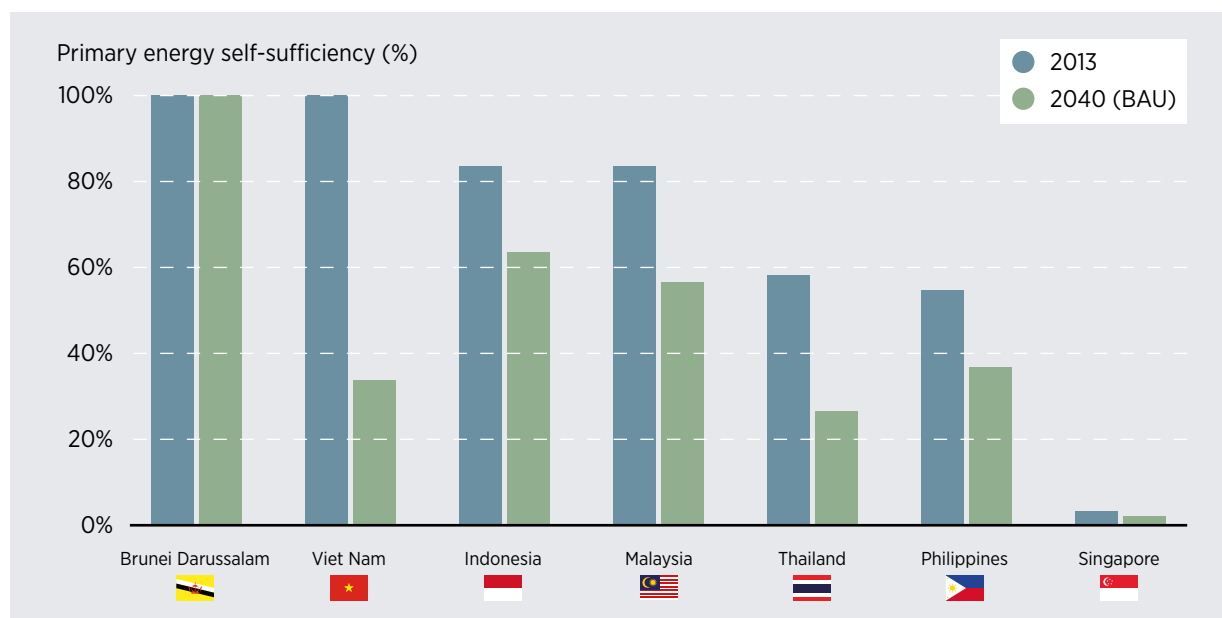


Figure 2.11 Increase in energy demand by 2025 over 2014 levels

Source: Based on IRENA and ACE, 2016.

Note: TFEC = total final energy consumption; TPES = total primary energy supply.

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Figure 2.12 Primary energy from domestic resources, as share of total, in selected Southeast Asian countries, 2013 and 2040

Source: NBR, 2016 based on APEC Energy Demand and Supply Outlook; and IEA, Key World Energy Statistics 2015.

Note: BAU = business as usual.

ENERGY SECURITY

Several countries in the region are bestowed with indigenous fossil fuel reserves, be it coal, oil or natural gas. This has enabled the largest energy consumers in the region to achieve a significant degree of primary energy self-sufficiency, as depicted in Figure 2.12.

However, with rising domestic energy demand and dwindling domestic resources, the self-sufficiency is expected to decline over the next decades. The most rapid declines are expected in frontier markets, such as Viet Nam, where growth in energy demand far exceeds domestic fuel supply. Recent trends in the domestic use of fossil fuels point to a future that will be marked by rising energy imports in the region (Hartman and Nakano, 2017):

- The region is a net importer of oil, and its reliance on imports continues to grow as domestic demand increases. Indonesia, Malaysia, Thailand and Viet Nam are the largest oil producers and all face gradually declining output from mature oilfields.
- Natural gas production in the region is plateauing, meaning that as domestic demand increases, net exports will reduce over time. Indonesia and Malaysia are the region's largest gas producers. The share of natural gas in the regional TPES is on the rise and gas is increasingly an alternative to coal for power generation and oil in the industrial sector. Under all scenarios studied in the 5th ASEAN Energy Outlook 2015-2040 (ACE, 2017), natural gas demand is expected to exceed domestic supply by 2029. Investments in LNG import infrastructure are on the rise as dependence on imports increases over the long term (ACE, 2015).
- The region is a major consumer of coal. While Southeast Asia is expected to maintain a net surplus in coal production to 2040 given concentration of production (ACE, 2017),

dependence on imports will increase with time in many countries. Viet Nam, traditionally a coal exporter, has already become an importer amid rising domestic demand for power generation and industry.

The outlook presented here – decreasing production and growing domestic energy demand exacerbates energy security concerns. Such concerns, however, have recently been softened amid over-supply in oil markets, abundance of natural gas supply from a diversified set of suppliers and falling energy prices (NBR, 2016). Regardless, the need to diversify over the long term (and reduce dependence on imports) has been emphasised in a number of national energy plans in the region.

HUMAN HEALTH AND ENVIRONMENTAL DEGRADATION

Air pollution is a growing problem in Southeast Asia. The largest contributors to outdoor air pollution are generally the power and industry sectors, particularly when coal is used to make electricity, and the transport sector, especially in urban areas. High levels of indoor air pollution are also a concern in some countries, typically in rural areas, where people use traditional bioenergy. The costs associated with health problems resulting from air pollution will rise considerably as urbanisation continues. IRENA's REmap ASEAN analysis estimated the associated external cost of air pollution at USD 167 billion in 2014 (IRENA and ACE, 2016). External costs related to air pollution from the combustion of fossil fuels across the region will increase by 35%, to an average of USD 225 billion annually, by 2025. It is estimated that exposure to outdoor air pollution in Southeast Asia resulted in 200 000 deaths in 2010 (OECD, 2014). In 2015, the number of premature deaths in Indonesia alone was estimated at 70 000 from outdoor pollution and 140 000 from indoor air pollution (IRENA and ACE, 2016).

Carbon dioxide (CO₂) is the largest source of global GHG emissions, and the energy sector is responsible for most of these emissions. But this is not the case

in some ASEAN Member States (e.g., Indonesia), where forestry and agriculture are major sources of emissions. IRENA estimates that emissions from energy could rise by 61% in the ASEAN region by 2025, driven mainly by coal-fired electricity production followed by the industry and transport sectors. Energy-related CO₂ emissions across the region will total approximately 2.2 gigatonnes (Gt) annually by 2025, or around 5% of expected global energy-related emissions in that year (IRENA and ACE, 2016). ASEAN Member States have been at the fore of making commitments to reduce their emissions as part of the 21st session of the Conference of the Parties (COP 21) climate process (Box 2.3).

ENERGY ACCESS

Substantial progress has been made over the past decade to expand access to modern energy services in the region. Yet, nearly 65 million people continue to live without electricity access and 250 million people rely on traditional use of bioenergy. Energy sector development, moving forward, has to look at the ways to bring modern energy services to all of these people – a vital pre-requisite to meeting the Sustainable Development Goals.

The electricity access landscape in Southeast Asia is diverse (as illustrated in the right-hand panel of Figure 2.13). The majority of the unelectrified populations are concentrated in emerging economies of the region, including Cambodia and Myanmar, and in archipelago countries such as Indonesia and the Philippines. Rising demand in urban centres, challenging topography, low population density as well as existing energy sector structures present barriers to traditional electrification approaches making major inroads into unconnected rural areas (CIF, 2013; EUEIPDF, 2013). Many of the unconnected areas are remote islands or deep forest areas accessible through rivers and unreachable by road.

This has given rise to the adoption of decentralised solutions based on household-level systems (powered mostly through solar) or community-level

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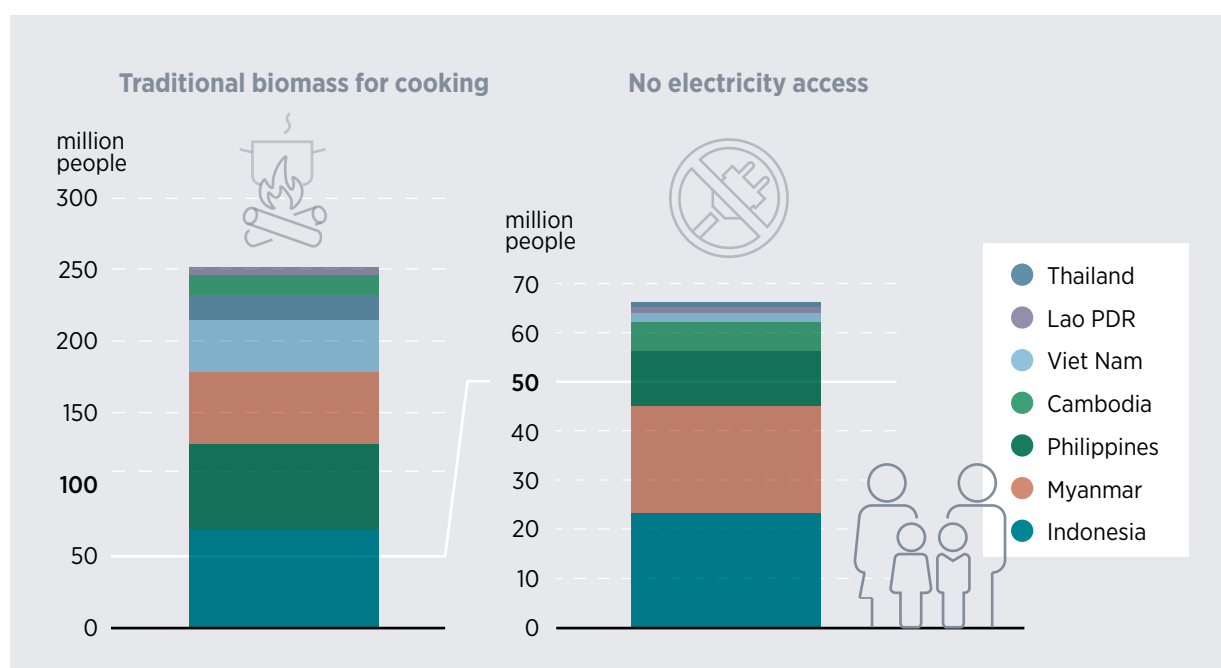
Box 2.3 Southeast Asian countries and climate pledges at COP 21

There is a region-wide recognition of the need for action to reduce greenhouse gas (GHG) emissions and mitigate the negative effects of climate change. Southeast Asia is particularly vulnerable to climate change, given the heavy economic reliance on agriculture and natural resources that are influenced by environmental changes. The region also has heavily populated coastlines, which are subject to extreme weather events and rising sea levels. The region is already facing climate extremes annually, particularly floods, droughts and tropical cyclones, while large areas of the region are highly prone to flooding and influenced by monsoons. With a significant proportion of the population living under USD 2 a day, such climatic impacts will severely threaten the livelihoods of poor people living in rural areas and with limited adaptive capacity.

To contribute to global efforts to address climate change, all countries in the region submitted Nationally Determined Contributions and ratified the Paris Agreement. Several initiatives have been announced at a regional level, including the ASEAN Action Plan on Joint Response to Climate Change and the ASEAN-UN Action Plan on Environment and Climate Change (2016–20). The ASEAN joint statement on climate change at the 22nd session of the Conference of the Parties (COP 22) also laid emphasis on “Promoting sustainable management of forests that will contribute to reducing forest degradation and deforestation, and also the enhancement of carbon sink capacity through own capacity, bilateral and multilateral cooperation”.

Source: ASEAN, 2016b; IFAD, 2009; ADB, 2009.

Figure 2.13 Number of people using traditional biomass for cooking (left) and without access to electricity (right), 2016



Source: Based on IEA, n.d.



systems (powered through renewables or conventional fuel). Off-grid solutions, such as mini-grids and stand-alone systems, are increasingly deployed to tap into locally available energy resources, such as bioenergy, solar, wind and hydro, to meet energy demand. There is widespread experience in the region – with biogas deployment in Viet Nam; micro-hydro in Indonesia, Malaysia and Myanmar; solar home systems in Cambodia; and solar/wind/diesel hybrid island mini-grids in Indonesia and the Philippines. As costs have declined and the technology has matured, off-grid solutions are emerging as a complementary solution to rapidly expand energy services.

The reliance on the traditional use of biomass for heating/cooling is high, especially in Indonesia, Myanmar, the Philippines and Viet Nam. Myanmar, in particular, is largely a bioenergy-centred economy, with wood making up 70% of its primary energy supply. Most of the population is rural and close to bioenergy resources, but only a fraction has access to the grid (Discourse Media, 2016). The social and environmental cost of this dependence is high given the negative impacts of indoor air pollution. Efforts are underway to increase access to efficient cookstoves and modern cooking fuels, in particular LPG. Throughout this report, the access dimension is discussed, culminating with a detailed look, in chapter 6, at how decentralised renewable energy solutions affect livelihoods in rural areas of Southeast Asia.

2.3 CONCLUSION

The energy sector in the Southeast Asia region is at a crossroads. Despite differences in the sector's maturity and structure across countries, as well as varying patterns of consumption and supply, the entire region faces growing energy demand, in line with rapid economic growth. All end-use sectors contribute to this growth. Per capita energy consumption is still low in most countries compared with the non-OECD average, as millions of people remain without electricity access.

Indigenous energy resources provide a cost-effective and secure supply that underpins sustainable economic growth. These resources encompass both fossil fuels and renewable options such as hydro, solar, wind, geothermal and bioenergy. Energy security concerns are increasing, as countries in the region gradually increase their reliance on imported fuels. Investments in infrastructure such as LNG terminals, signal a shift toward long-term dependency on imports.

Abundant renewable energy resources offer an opportunity to meet growing energy demand, while improving energy security, reducing environmental impacts and expanding energy access. Recent cost reductions have further strengthened the business case for relatively new renewable options, including solar PV and wind, to play a greater role in the region's future energy mix. In light of these developments, governments are encouraged to consider the long-term cost competitiveness and benefits of suitable renewable energy technologies when planning for energy sector expansion to avoid locking-in investments in energy infrastructure.

To meet the national and regional plans (ASEAN, 2015a)² currently in place, the technology-, finance-, policy- and capacity-related barriers will need to be overcome, and existing energy sector institutions and planning processes will need to realign with the energy transition opportunity at hand. The next chapter takes a closer look at the renewable energy landscape in the region before the analysis delves deeper into how the policy and finance-related challenges are being tackled at the regional and national level.

2 | With the ASEAN Plan of Action for Energy Cooperation (APAEC) 2010–20, ASEAN has set the goal of significantly increasing the use of renewable energy in the region. The different starting points of individual countries in terms of natural conditions (i.e., solar, wind, water, biomass and geothermal resources) and the political and regulatory framework, however, make it difficult to establish a uniform energy policy and renewable energy strategy (GIZ, n.d.).



RENEWABLE ENERGY LANDSCAPE

Windmills, Khao Kho, Phetchabun, Thailand



The Southeast Asia region has abundant renewable energy resources, whose deployment is being supported at both the regional and national level. This chapter provides an overview of the renewable energy sector across the ASEAN Member States, including resource potential, the costs and benefits of a renewables-driven energy transition, and trends in deployment.

3.1 RENEWABLE ENERGY RESOURCES

The Southeast Asia region has rich, largely untapped renewable energy resources. It has some of the best hydropower potential in the world, particularly in Indonesia, Myanmar and several lower Mekong countries. Global horizontal irradiation – the parameter considered for photovoltaic installations – in the region is very strong, with an annual average of 1.5-2 MWh/m² annually. Wind resources are more modest with areas of Indonesia, the Philippines, Thailand and Viet Nam, reaching average speeds between six and seven metres per second (Figure 3.1).

Indonesia and the Philippines have significant geothermal potential (IRENA and ACE, 2016). In terms of “proven reserves” – resources that can be economically exploited with current technology – Indonesia leads the region expected to be responsible for substantial future capacity increases. Although not sufficiently mapped, the region also hosts substantial potential for ocean energy, especially in

archipelago nations such as Indonesia, the Philippines and Singapore (ASEAN RESP, 2016). Bioenergy supply potential is significant across the entire region with a variety of feedstock options available, including agricultural residues, livestock waste and forest plantations.

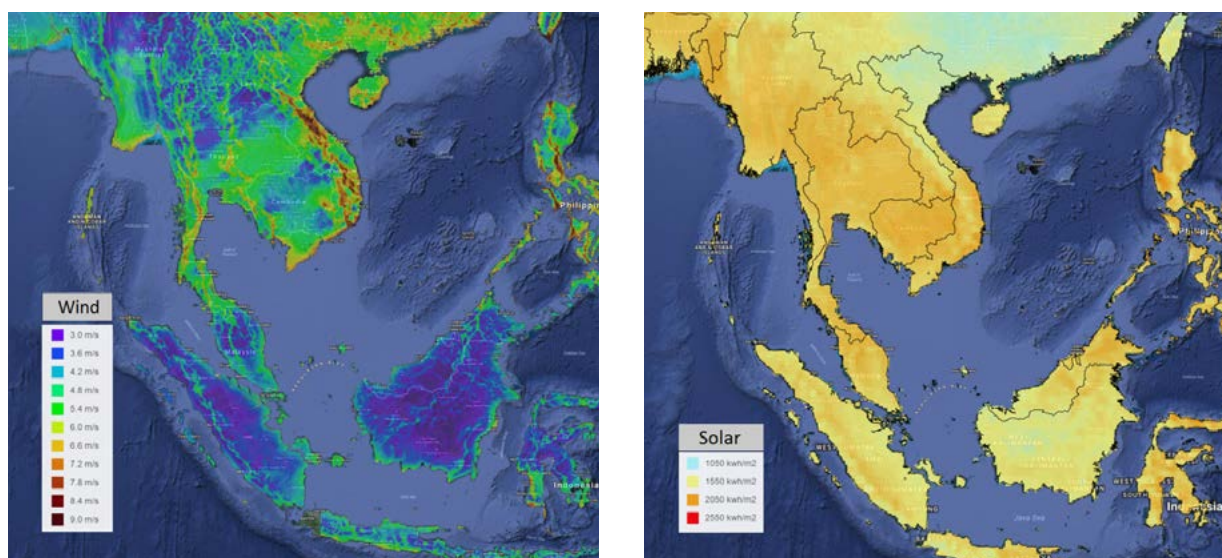
TOOLS FOR RENEWABLE ENERGY RESOURCE ASSESSMENTS

Understanding what renewable resources are available, and where, is important for different stakeholders. Policy makers need data to inform national planning, target setting and policy design; the private sector to develop project proposals, identify potential sites and conduct preliminary feasibility studies; and investors to assess financial proposals and risks.

Several tools developed by national and international agencies are available for undertaking such assessments. One such tool is IRENA’s Global Atlas, a web-based software (<https://irena.masdar.ac.ae/>), which can be used to map and assess renewable energy resources around the world. It includes over 2 000 maps for solar, wind and geothermal energy with national and global coverage. Figure 3.1 showcases the solar and wind maps for the Southeast Asia region extracted from the Global Atlas tool.

IRENA’s Global Atlas also includes several analysis tools such as the bioenergy simulator (Box 3.1).

03 Figure 3.1 Wind and solar resource maps for Southeast Asia

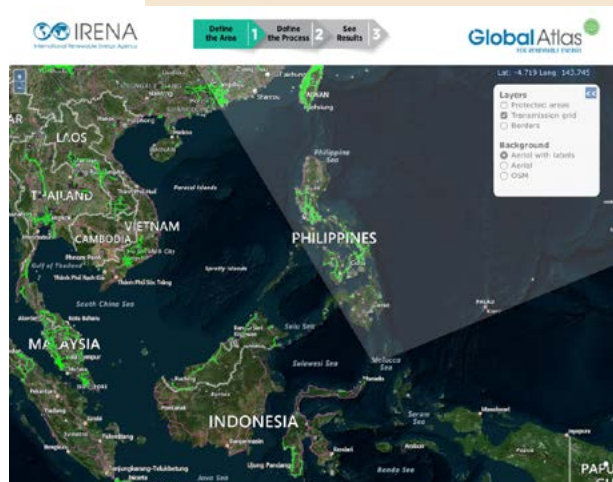


Source: Wind map (left): © VAISALA Global Wind Dataset 5km onshore wind speed at 80m height, extracted from IRENA Global Atlas www.irena.org/GlobalAtlas. Solar map (right): © METEOTEST; based on www.meteonorm.com, extracted from IRENA Global Atlas www.irena.org/GlobalAtlas

Box 3.1 IRENA's Global Atlas bioenergy simulation tool

The bioenergy simulator (<https://irena.masdar.ac.ae/bioenergy>) was developed, in partnership with the Masdar Institute of Science and Technology and Valbiom, to give users the ability to estimate the potential yields of bioenergy produced anywhere in the world.

The simulator consists of four modules differentiated by the source of the proposed bioenergy – crops, agricultural residues, livestock waste and forest plantations. Once a bioenergy source has been chosen, the user defines the land using a global map. This enables the tool to estimate the land size and the user enters further details such as the type of residue, bioenergy end-use (electricity, heat, heat and power, transport) and conversion technology.



Depending on the module selected, metrics like rain conditions, wood density and crop yields can be adjusted interactively. The results provide insights on the bioenergy yield and the outputs in terms of electricity and heat generation potential or liquid biofuel production. Applied to an approximate area of 30 hectares in Viet Nam, for example, the tool would help estimate the generation potential of rice husk residues as approximately 6 MWh. Similar estimations can be made with the tool for several areas across Southeast Asia. The tool itself is meant to be a starting point for analysis and further dimensions would need to be considered when projects are being developed.

The maps can be downloaded and used in combination with local information, such as population density, road networks, topography and distance to the transmission grid, to find suitable zones for different renewable energy applications. To demonstrate this for solar and wind applications, IRENA carried out a resource zoning exercise for Lao PDR and Viet Nam. Suitable zones for both utility-scale and off-grid solar and wind installations were mapped out and their technical installable capacity estimated.

Based on the zoning and suitability study, the technical installable capacity for on-shore utility scale wind in Lao PDR and Viet Nam was estimated to be 0.55 GW and 1.33 GW, while for utility-scale solar PV it was estimated to be 10.43 GW and 25.24

GW, respectively. For off-grid applications on the other hand, Lao PDR and Viet Nam could install up to 0.13 GW and 1.68 GW of wind and 6.25 GW and 25.49 GW of solar PV, respectively. Figure 3.2 illustrates the results for the suitability analysis for on-grid applications.

It is important to note that these figures are estimated based on current information available regarding grid networks, protected areas and population densities, and should not be compared with the technical potential of the resource itself, which will be larger. As grids are expanded and demand areas grow (and become more concentrated), a greater share of the technical potential is realisable. The methodology is detailed in Box 3.2.

Box 3.2 Suitability analysis methodology

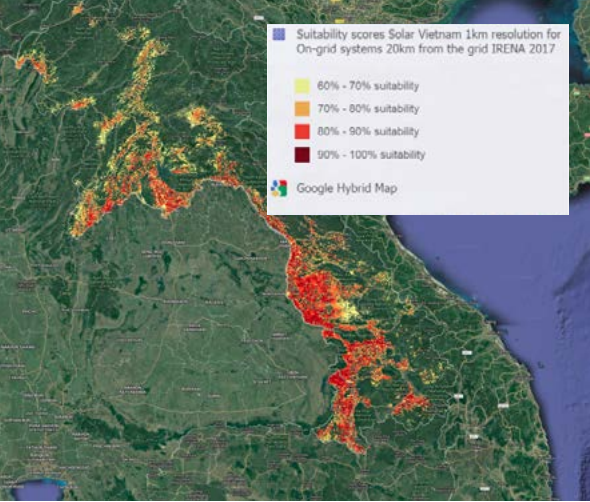
IRENA's methodology combines the solar or wind resource, distance to the grid, population density, protected area, land cover and topography in a suitability function that scores every square kilometre (km²) in each country on a scale of 0–100%. Suitable areas for solar PV and wind energy (ideally above 70%), both grid connected and off-grid,¹ are aggregated and used in conjunction with an assumed installation density (4 MW/km² for wind and 60 MW/km² for solar) to estimate the installable capacity.

The approach has been demonstrated for Lao PDR and Viet Nam because these countries have sufficient public information on local infrastructure, *i.e.*, on the transmission network. With sufficient data, the methodology can be applied to selected areas within a country or region. Its major advantage is that it provides nuanced information about the various prospective zones in a country. The installation estimates obtained using this approach only suggest possible areas of interest for further investigation, which is needed to find sites, gather "bankable" data and information on generation. As such, the estimates are a first step toward initiating a dialogue with energy authorities (*e.g.*, ministries, renewable energy promotion agencies, rural electrification agencies, etc.) and potential renewable energy investors and project developers.

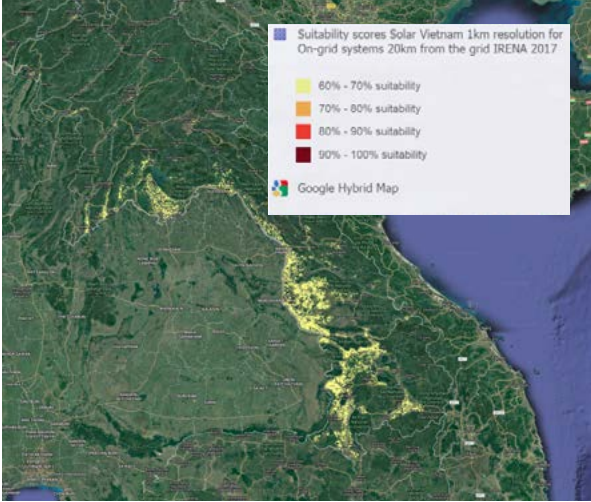
¹ | In the context of this study, off-grid can be seen as suitable locations that are far away from existing grids (for each of the grid distances simulated). It represents, for instance, potential locations for off-grid residential communities or industrial sites, *e.g.*, mines.

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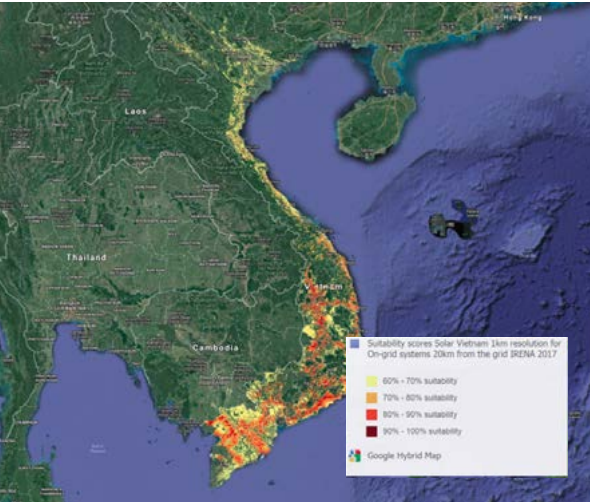
Figure 3.2 Suitability analysis results for (a) on-grid solar, (b) on-grid wind in Lao PDR, (c) on-grid solar and (d) on-grid wind in Viet Nam



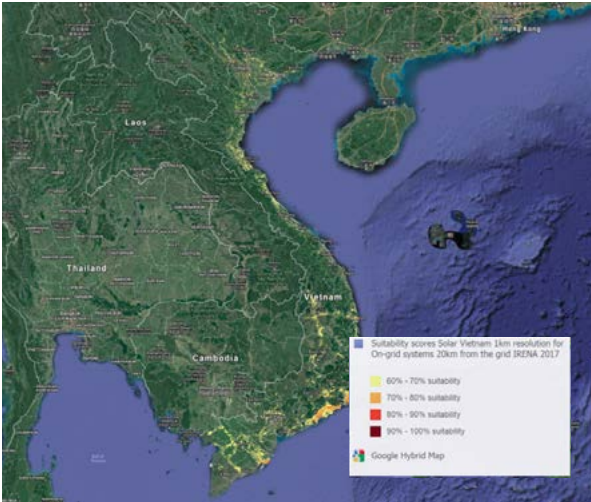
On-grid solar, Lao PDR



On-grid wind, Lao PDR



On-grid solar, Viet Nam



On-grid wind, Viet Nam

Source: IRENA



3.2 RENEWABLE ENERGY COSTS AND BENEFITS

Cost continues to be a major deciding factor in the adoption of renewable energy technologies in Southeast Asia. Several countries have tapped into hydro and geothermal energy sources for decades, given their cost-competitiveness. Recent declines in the cost of solar PV and wind have strengthened the economic case for the adoption of renewable energy. Juxtaposing a technology's cost against its benefits is important to understand the long-term impacts of transitioning to a particular energy source. This section discusses the latest trends in renewable energy costs in the region, including for solar, wind, hydropower and geothermal. It then focuses on the socio-economic benefits of renewable energy in terms of economic growth, employment and local value creation.



COSTS: OVERALL INSTALLED COSTS AND LCOE

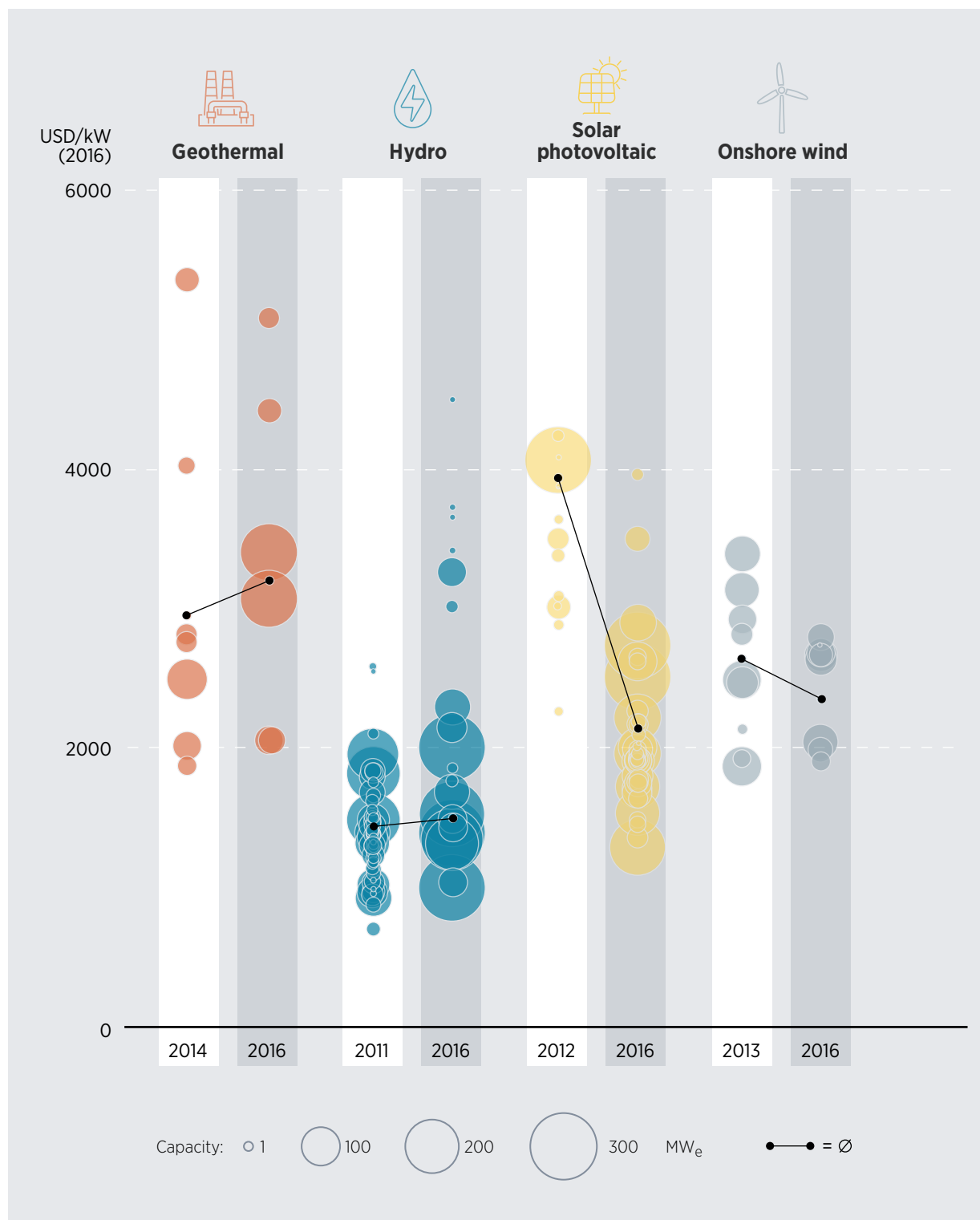
This section focuses on investment costs and the levelised cost of electricity (LCOE) which vary widely by country and technology. Given the relatively modest deployment of renewables seen in the region these costs might be spread across a wide range. Data are presented for years and technologies deemed likely to be statistically significant, as found in the IRENA *Renewable Energy Cost Database*.²

Figure 3.3 presents the evolution of investment costs for geothermal, hydro, solar PV and onshore wind. Solar PV experienced the most significant cost reduction from 2012 to 2016. Weighted average installed costs were USD 3 915/kilowatt (kW) in 2012 and USD 2 134/kW in 2016 – a 45% decline in four years, which is in line with the global average during the period. Weighted average installed costs for onshore wind also decreased, from USD 2 627/kW in 2013 to USD 2 342 in 2016 – an 11% difference also in line with the global average.

Overall, geothermal is the only technology that has seen a slight increase in weighted average investment costs, from USD 2 937/kW in 2014 to USD 3 185/kW in 2016. Geothermal costs are highly dependent on the quality and quantity of the resource (and associated economies of scale) and the technological options chosen to develop a site. The observed increase in investment costs of 8% is most likely because of the quality of sites being developed in 2014 and 2016. Hydro costs virtually stayed the same from 2011 to 2016 at around USD 1 500/kW. Capital costs of bioenergy projects vary significantly depending on size and location. Bioenergy costs (not shown in figure 3.3) for a subset of 53 projects commissioned between 2010 and 2016 ranged between USD 900/kW and USD 2 433/kW with a weighted average of USD 1 660/kW.

² | The IRENA Renewable Energy Cost Database holds information on more than 700 Southeast Asian projects spanning all renewable energy technologies from 2010 to 2016. This report discusses two main types of costs from the database: installed costs and LCOE. The installed cost data in the IRENA Renewable Cost Database are typically ex ante project data, as are capacity factor values. All costs are reported in 2016 U.S. dollars. The LCOE is calculated using a weighted average cost of capital of 7.5% for the Organisation for Economic Co-operation and Development (OECD) countries and China, and 10% for the rest of the countries, and does not include taxation.

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Figure 3.3 Investment costs of selected renewable energy technologies

Note: kW = kilowatts; MW_e = megawatts (electric).

The LCOE of renewable energy technologies in Southeast Asia has followed the trends in investment costs. Thus, the weighted average LCOE of geothermal projects increased slightly from USD 0.06/kWh in 2014 to USD 0.064/kWh in 2016, a 7% increase in LCOE mirroring almost one to one the observed increase in investment costs during the period. The LCOE of hydro projects decreased slightly from USD 0.048/kWh to USD 0.046/kWh. Box 3.3 discusses the evolution of capacity factors for key technologies in Southeast Asia.

Following rapid decreases in technology costs, the weighted average LCOE of solar PV fell sharply from USD 0.31/kWh in 2012 to USD 0.19/kWh in 2016, a 39% decline over the observed period (Figure 3.4).

Finally, the second-largest cost decline is observed in onshore wind, whose weighted average LCOE was USD 0.14/kWh in 2013 and USD 0.12/kWh in 2016, a 14% decline. Biomass costs for the sub-set of projects commissioned between 2010 and 2016 range from USD 0.045/kWh to USD 0.095/kWh, with a weighted average of USD 0.065/kWh.

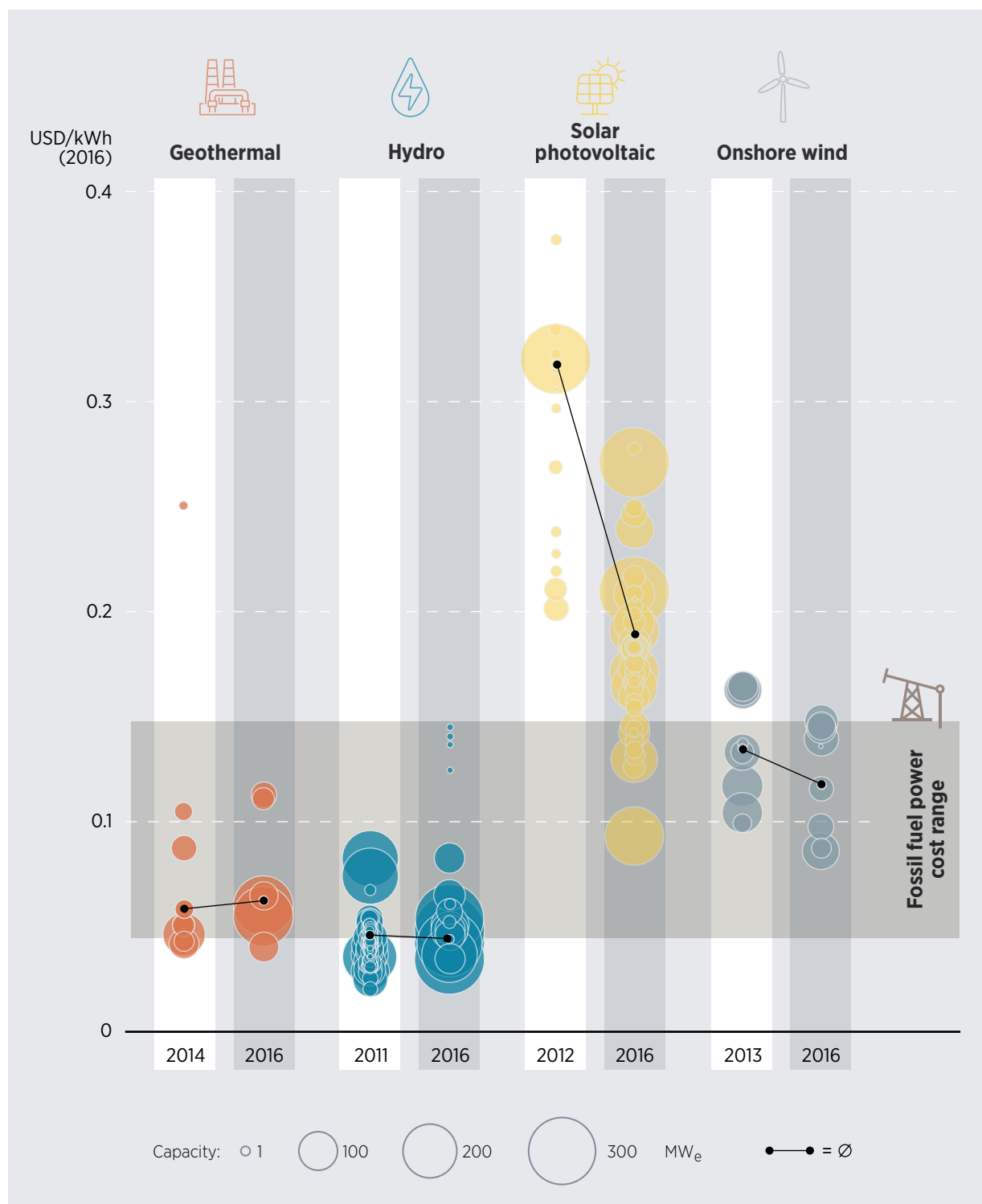
Overall, the costs of geothermal, hydro, biomass, most onshore wind projects and a significantly greater number of solar PV projects are increasingly within the estimated range of fossil-fuel costs depending on a number of factors (e.g. project location, resource availability, etc.). These costs are likely to continue to fall, which can only position

Box 3.3 Evolution of capacity factors for selected renewable energy technologies

Weighted average geothermal capacity factors declined slightly from 86% in 2014 to 84% in 2016, most likely in line with the development of more challenging projects in the region. Hydro-weighted average capacity factors remained at the same level of 46% from 2011 to 2016, while solar photovoltaic (PV) capacity factors declined from 17% in 2012 to 15% in 2016. This decline is most likely due to projects coming up in areas with lower solar resources as the market has grown, as well as due to land and grid capacity constraints which may influence capacity factors through, for instance, plant design. Onshore wind capacity factors increased from 29% in 2013 to 32% in 2016, mirroring the technological evolution toward higher hub heights and rotor diameters during the period and the very good quality of the resource base in the region.



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Figure 3.4 LCOE of selected renewable energy technologies

Note: kWh = kilowatt hours; LCOE = levelised cost of electricity; MWe = megawatts (electric).

renewable energy technologies strongly for new capacity in the region.

Compared with other regions, Southeast Asia fares best in terms of the LCOE of hydro projects. This is in line with the LCOE of hydro projects in the Rest of Asia (USD 0.046/kWh versus USD 0.04/kWh, respectively), where it is the most competitive in the world and well below the lower range of estimated fossil-fuel costs.

The narrative changes significantly for solar PV. The weighted average LCOE for solar PV in Southeast Asia is USD 0.19/kWh, which is one of the most expensive worldwide, right behind Eurasia at USD 0.2/kWh and twice the LCOE observed in Oceania at USD 0.09/kWh. More significantly, the LCOE of solar PV in Southeast Asia is 90% higher than the one observed in the Rest of Asia at USD 0.10/kWh, which is highly influenced by projects developed in China and India, some of the most competitive markets in the world and where significant capacity has been added in the past few years. However, this points to the tremendous cost reduction potential of solar PV in Southeast Asia as compared with markets such as China and India.

The weighted average LCOE of onshore wind in Southeast Asia mirrors the narrative of solar PV – at USD 0.12/kWh, it is the second highest in the world after Central America and the Caribbean. It is twice the LCOE of onshore wind, USD 0.06/kWh in North America, and more significantly is 42% higher than the LCOE observed in the Rest of Asia.

The costs of renewable energy technologies (such as geothermal, hydro and biomass) are already highly competitive in Southeast Asia and have appeared to remain stable in recent years. Both solar PV and onshore wind costs have decreased significantly in recent years in Southeast Asia, mirroring global trends, but they are still high in comparison to costs observed in the rest of Asia. While the cost structures

of project development vary from country-to-country, reductions can be achieved through a focus on enabling deployment policies, reducing the soft-costs associated with project development (e.g., licensing and permitting, grid connection, land acquisition) (ACE, 2016a), increasing efficiency of regional supply chains, improving local installation services, introducing risk mitigation products and unlocking less-costly capital.

SOCIO-ECONOMIC BENEFITS

The pursuit of renewable energy development brings a wide range of socio-economic benefits. Many countries in the region see opportunities in the development of a renewable energy value chain, with the potential to increase income, create jobs, contribute to industrial development and improve livelihoods. IRENA's workstream on *Renewable Energy Benefits* quantifies the impacts of the energy transition on key metrics such as GDP, employment and welfare.

On a global scale, IRENA's analysis, *Renewable Energy Benefits: Measuring the Economics* (2016), reveals a positive correlation between relatively high shares of renewable energy and economic growth. For the purpose of this report, IRENA analysed the impact of accelerated renewable energy deployment in the region using a macro-econometric model³. The socio-economic impacts of renewables growth based on current plans and policies (Reference Case) and accelerated deployment (REmap Case). These build on the 2030 roadmap analysis conducted as part of a study published in 2016 by IRENA and the ASEAN Centre for Energy (IRENA and ACE, 2016).

Impact on GDP

Accelerated renewable energy deployment in line with the REmap Case will have a small, but positive, impact on ASEAN GDP, compared with the Reference Case. GDP is expected to rise 0.03% in 2030,

³ / E3ME, developed by Cambridge Econometrics, links together the energy system with the world's economies to provide estimates of the macroeconomic impacts of changes in the share of renewables. The model covers 43 economic sectors in 59 countries. This includes most large economies in the world, accounting for 76% of global GDP (as of 2014) and almost 90% of global energy use.

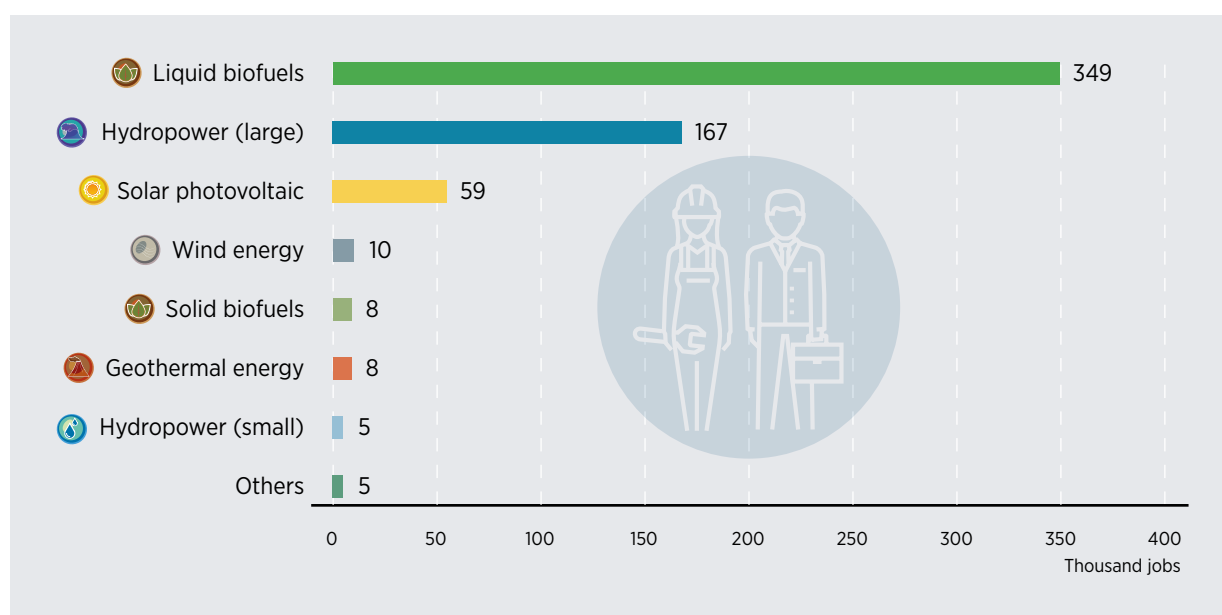
03 demonstrating that renewable energy growth does not come at a cost to growth. The scale of impact varies across different countries in the region. Among fossil-fuel-exporting countries, a loss of revenues from exports may be offset through domestic measures to increase the share of renewables, for example, by stimulating investments. It should be stressed that the loss of output is not primarily because of greater domestic use of renewables, but instead reflects actions taken in the rest of the world with regard to reducing the consumption of fossil fuels. In many fossil-fuel-importing countries in the region, the positive effect on GDP is a result of investment growth in renewables, a decrease in electricity prices as well as a decrease in fossil-fuel imports. The REmap Case replace mostly fossil fuels, which could reduce the annual fuel bill across the region by USD 40 billion by 2025 (IRENA and ACE, 2016).

Impact on employment

With around 68 million expected new entrants to the workforce by 2025, job creation will continue to be a key priority for governments in Southeast Asia. IRENA's analysis shows that renewable energy technologies are already creating jobs across the region and can lead to significant employment opportunities with continued deployment.

IRENA estimates show that the renewable energy sector in Southeast Asia had 611 000 jobs in 2016. Most of these jobs were in liquid biofuels, followed by large hydropower and solar PV (Figure 3.5). Southeast Asian countries such as Indonesia, Malaysia, the Philippines and Thailand are considerable producers of liquid biofuel. Together, they employed close to 350 000 people in the biofuel value chain with Indonesia alone accounting for close to 154 300 jobs in 2016. Biofuel employment in Thailand, Malaysia and the Philippines reached 97 400, 52 500 and 42 400 jobs, respectively.

Figure 3.5 Renewable energy jobs in Southeast Asia in 2016, by technology



Large hydropower is the dominant source of renewable electricity in the region and directly employs 167 000 people in construction and installation, operation and maintenance and manufacturing. Viet Nam is the largest labour market with around 100 000 jobs, followed by Indonesia (45 000 jobs) and Myanmar (13 100 jobs). Employment in the growing solar PV sector in the region stood at 59 000 jobs in 2016. Malaysia and the Philippines are among the largest solar PV labour markets – each with close to 25 000 jobs. Malaysia's solar PV workforce increased by 46% in 2016 and currently stands at 27 900 jobs. Around 60% of these workers are employed in the country's solar PV module manufacturing factories. Wind, solid biofuels, geothermal accounted for a smaller share of the region's renewable energy workforce.

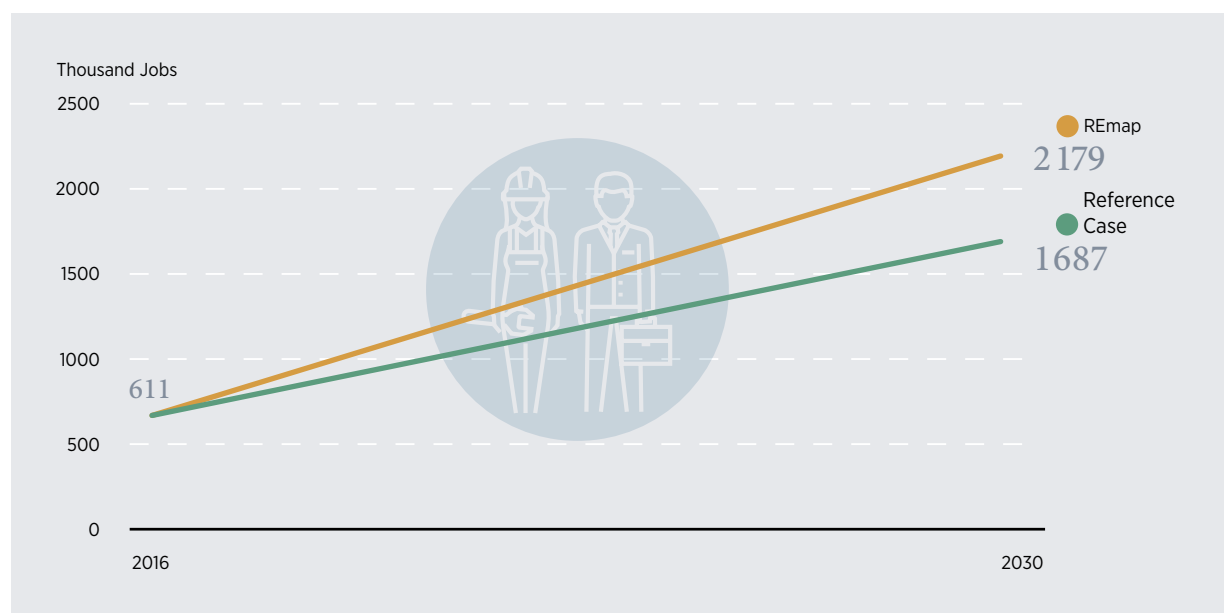
Employment in the sector could reach 1.7 million by 2030 in the Reference Case, up from current levels of 611 000. However, accelerated deployment of renewables according to the REmap Case could increase direct and indirect employment in the

sector to 2.2 million. This is an annual growth rate of 9.5% until 2030 compared to 7.5% in the Reference Case (Figure 3.6).

Indonesia and Malaysia will be among the leaders in renewable energy employment in both cases (Table 3.1). Continued growth in the liquid biofuel sector would allow Indonesia to retain its position as the largest employer in the region.





Figure 3.6 Growth in renewable energy jobs, 2016 and 2030 for IRENA REmap and Reference Case



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Table 3.1 Employment in the renewable energy sector by country (thousand jobs)






	2016	Reference Case	REmap
 Indonesia	206	1 010	981
 Malaysia	99	123	299
Rest of Southeast Asia	306	554	898
Grand total	611	1 687	2 179

Note: Totals may not add up due to rounding

Overall, jobs in the renewable energy sector in 2030 remain concentrated in the same technologies as in 2016, with some variations across the cases analysed (Table 3.2). Driven by investments in liquid biofuels, the share of bioenergy jobs in the Reference Case rises from 59% of the sector's workforce in 2016 to 76% in 2030. While jobs in hydropower, wind and geothermal increase due to continued deployment, their shares in the overall renewable energy employment decline.

In the REmap Case, employment in solar and wind energy experiences rapid growth. Driven by strong investments in solar PV, employment in solar energy increases six-fold to reach 333 000 jobs in 2030. Starting from a small base of 10 000 in 2016, jobs in wind reach 60 000 in 2030. Jobs in bioenergy, hydropower and geothermal also show significant growth. Bioenergy remains the leading renewable energy employer with 62% of the total renewable energy jobs.

Table 3.2 Employment in the renewable energy sector by technology (thousand jobs)

	2016	Reference Case	REmap
 Bioenergy ^a	362	1 278	1 355
 Hydropower ^b	172	276	387
 Solar ^c	59	61	333
 Wind energy	10	20	62
 Geothermal energy	8	35	33
Other renewable energy ^d	1	16	8
Grand total	611	1 687	2 179






Note: Totals may not add up due to rounding

a) Solid biofuels, liquid biofuels and biogas. In the region, almost all bioenergy employment can be attributed to liquid biofuels b) Small and large c) Solar PV, CSP and solar water heating. Almost all solar in the region is solar PV d) Includes jobs in non-technology specific R&D and technologies such as tidal and wave.

Depending on the technology, the jobs will be distributed along the segments of the value chain, including manufacturing, construction and installation, operation and maintenance, and fuel supply. The results show a steady increase in the number of jobs in each segment in all technologies when REmap and Reference Case is compared (Table 3.3). The fuel supply for bioenergy is by far the largest segment of the value chain and accounts for around 90% of the bioenergy jobs in both cases. Most of the jobs in hydropower and solar PV will be concentrated in the labour-intensive construction and installation segment of the value chain, in both the Reference and REmap Case. The solar PV manufacturing industry of the region will also be a key renewable energy employer.

The renewable energy sector requires a broad range of skills including technical, marketing and administrative skills. The skills that are most relevant depend on the technology, the segment of the value chain and the context of deployment, *i.e.*, whether renewables are being deployed in advanced or access settings. IRENA's work on quantifying skills requirements can help disaggregate renewable energy jobs by types of occupations, thus supporting initiatives for the development of an adequately skilled workforce (IRENA, 2017c). The results in Table 3.4 show that close to 70% of the 333 400 jobs in the solar PV sector in the REmap Case are expected to be technicians, operators and construction workers. Highly skilled engineers form a small yet crucial part of the workforce. The sector also offers non-technical career opportunities such as for marketing and sales personnel, financial analysts, and experts in regulation, real estate and taxation.

Table 3.3 Distribution of renewable energy jobs in 2030, by segments of the value chain (thousand jobs)

Segment	Case	 Bio-energy	 Hydro-power	 Solar	 Wind	 Geothermal	Others	Total
Construction and installation	Reference	73.4	199.2	50.0	15.9	24.4	11.6	374.5
	REmap	112.0	271.4	245.6	49.5	22.0	5.4	705.9
Manufacturing	Reference	9.1	35.8	7.0	2.6	6.7	3.6	64.8
	REmap	24.5	59.2	50.9	7.4	5.5	1.5	149
O&M	Reference	20.9	41.4	3.9	1.6	3.5	1.1	72.4
	REmap	35.5	56.2	36.9	5.5	5.5	1.5	141.4
Fuel supply	Reference	1 175.0	0.0	0.0	0.0	0.0	0.0	1 175.0
	REmap	1 182.7	0.0	0.0	0.0	0.0	0.0	1 182.7
Total	Reference	1 278.4	276.4	60.9	20.1	34.6	16.3	1 686.7
	REmap	1 354.7	386.8	333.4	62.4	33.0	8.4	2 178.7







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Table 3.4 Solar PV jobs in Southeast Asia in 2030, by occupation (thousand jobs)

Occupations	Temporary jobs (Construction & installation and manufacturing)	Permanent jobs (Operation and maintenance)	Total jobs in 2030
Thousand Jobs			
Technicians, operators and construction workers	209.2	20.3	229.5
Marketing and sales experts	28.3	-	28.3
Engineers	17.8	10.0	27.8
Managers and administrators	13.0	2.1	15.1
Quality and environmental experts	10.3	1.1	11.4
Health and safety	5.5	2.3	7.8
Logistics experts	4.6	1.1	5.7
Financial analysts	4.6	-	4.6
Legal, energy regulation, real estate and taxation	3.2	-	3.2
Total	296.5	36.9	333.4

Employment in the broader energy sector increases due to higher deployment of renewable energy in the REmap Case (Table 3.5). Employment in fossil fuels remains virtually unchanged between the two cases. The jobs in coal and oil decline, whereas those in natural gas increase. In contrast, jobs in almost all renewable energy technologies are higher in the REmap Case. This means that, overall, accelerated renewables deployment leads to more jobs in the energy sector in the region.

Table 3.5 Employment in the energy sector in 2030 (thousand jobs)

	Reference Case	REmap
Fossil fuels	3 028	3 049
Oil	1 637	1 559
Gas	779	889
Coal	613	600
Nuclear	16	25
Renewables	1 687	2 179
Bioenergy 	1 278	1 355
Solar 	61	333
Hydropower 	276	387
Wind 	20	62
Geothermal 	35	33
Tidal/Wave 	16	8
Grand total	4 731	5 252

Note: Totals may not add up due to rounding

3.3 CURRENT RENEWABLE ENERGY SECTOR PROFILE

This section presents a profile of renewable energy supply and demand in Southeast Asia, with a focus on power generation and consumption in end-use sectors: industrial, transport and residential.

RENEWABLE ELECTRICITY

Renewable energy sources accounted for 17% of the region's total electricity generation in 2015. Large hydro comprised the majority share (over three-quarters). A recent trend, as shown in Figure 3.7, is the rapid growth of non-hydropower renewables, the installed capacity of which more than doubled over the past decade (2006-2016), from 6 GW to 15 GW. The relative share of large hydropower in the region's total renewable energy capacity decreased from 80% in 2000 to 75% in 2016. This is in line with the trend in other regions, such as Latin America, that rely on large hydro but where the relative share of hydropower in total renewable capacity is also declining (83% in 2015 versus 95% in 2000) (IRENA, 2016b).

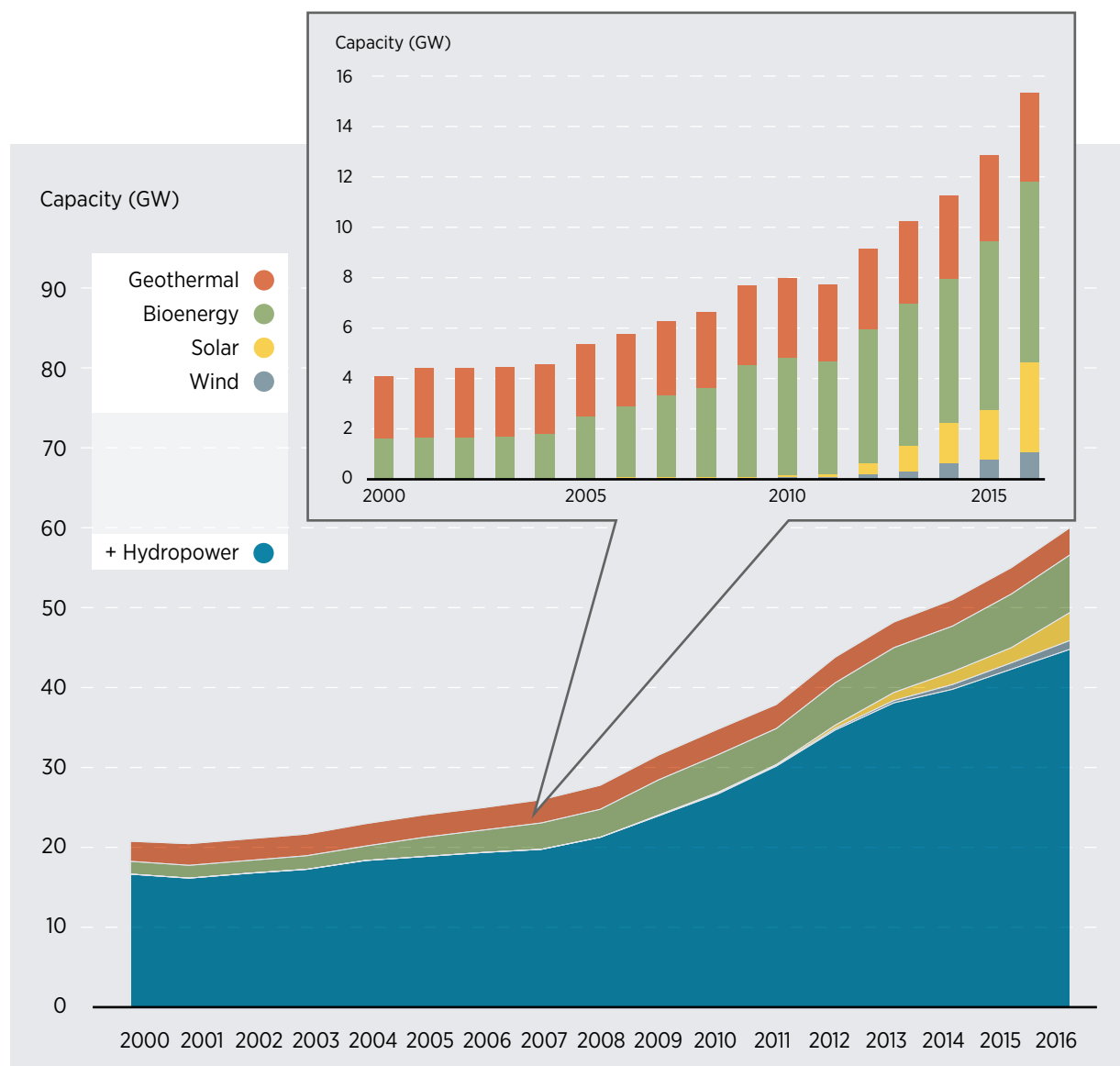
The growth in renewable energy generation across the Southeast Asia region has mainly been driven by the capacity deployment of hydro-based solutions. Between 2000 and 2016, hydropower capacity in the region grew from nearly 16 GW to 44 GW. Countries in the Mekong River Basin, including Cambodia, Lao PDR, Myanmar and Viet Nam, are leading this growth, and the development of large hydro has been substantial – it increased from 6 GW to 26 GW over the past decade. Viet Nam, in particular, has seen rapid growth in the deployment of large hydro, with substantial investments also flowing into Lao PDR primarily for export purposes. In the region, a clear distinction is made between large and small hydropower; however, the threshold for defining small hydro varies across countries: up to 10 MW in Indonesia, 15 MW in Lao PDR and Thailand, and 30 MW in Viet Nam (Liu *et al.*, 2013) (Box 3.4).

The region had pumped-hydro capacity totalling around 1.7 GW in 2016, primarily based in the Philippines and Thailand (Globaldata, n.d.). Given the important role of pumped hydro in acting as large-scale storage and in the integration of variable renewables, there is a strong pipeline of pumped-hydro development in the region. Indonesia's first pumped-hydro plant, the Upper Cisokan Pumped Storage Power Plant, is under development and is expected to be commissioned in 2019 with a capacity of 1 040 MW (World Bank, 2016a). Viet Nam's first project, the 1.2 GW Bac Ai pumped-storage hydroelectricity plant, was approved in January 2017 (Vietnam Pictorial, 2017).

Bioenergy power production has grown steadily, rising from 1.6 GW in 2000 to 7.2 GW in 2016. Much of this growth is due to deployment in Indonesia, Malaysia and Thailand. Dominant feedstock sources include bagasse, paddy husk, palm oil mill waste, wood chips, black liquor and bark. Geothermal capacity has been deployed since the 1970s; over 2.5 GW was installed in 2000, increasing to 3.4 GW in 2016. The Philippines, the world's second-largest producer of geothermal electricity after the United States, leads the region with nearly 2 GW deployed in 2016. Capacity in the Philippines remained largely stable between 2000 and 2016, with much of the regional growth coming from Indonesia, where capacity rose from 525 MW to 1 534 MW in the same time frame. Recently, Malaysia has also forayed into geothermal energy: its first plant is scheduled to be operational by May 2019.

Solar and wind are new entrants in the region's power capacity mix, registering strong growth in deployment in recent years. In 2011, both solar and wind capacity stood at around 100 MW, rising to 3.5 GW and 1.1 GW, respectively in 2016. The adoption of dedicated policies has been a key driver for deployment in the region (see Chapter 4). The Philippines and Thailand have led wind development. Meanwhile, solar deployment is more widespread: all countries in the region registered accelerated capacity additions. Thailand is the leader, with over

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Figure 3.7 Renewable energy capacity by source in Southeast Asia, 2000–2016

Source: IRENA, 2017f.

Note: ASEAN = Association of Southeast Asian Nations; GW = gigawatts.

2.1 GW deployed in 2016 – an increase from just 80 MW in 2011. The Philippines' solar capacity grew quite spectacularly from 22 MW in 2014 to about 800 MW by the end of 2016. With a significant pipeline of projects approved or under development and new rounds of auctions scheduled in some markets (e.g., Malaysia) (along with policy calibration

in others), solar and wind capacity is expected to continue to grow in the coming years.

The generation mix profile of the region (Figure 3.8) portrays a clear picture of hydropower, bioenergy and geothermal as the mainstays of the region's renewable energy power sector. Between 2000 and 2015, hydropower generation in the region grew

Box 3.4 Small hydropower development in Southeast Asia

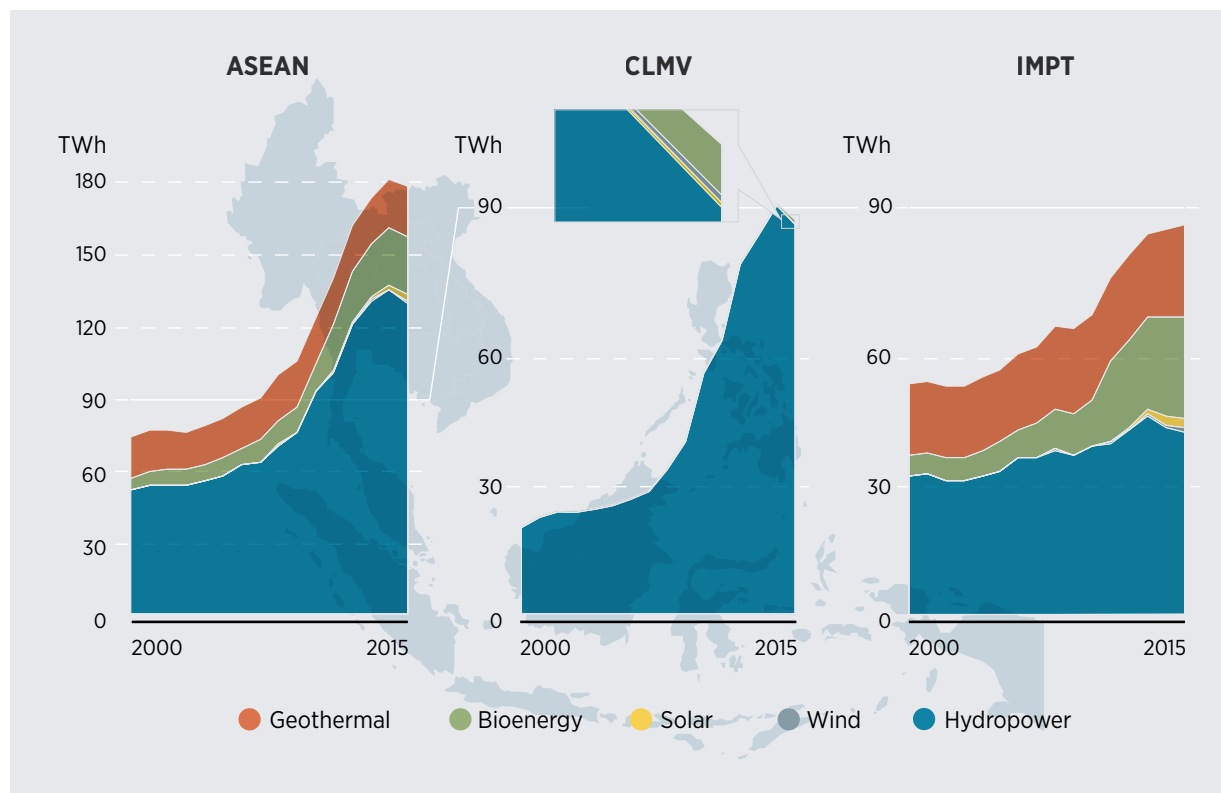
Small hydropower has thrived in Southeast Asia, meeting localised energy needs and contributing to the development of a local industry in some countries. Small hydro projects have reduced environmental and social impacts compared to non-run of river projects, shorter and simpler development, less-intense finance and construction phases than larger projects, and are being deployed in both on- and off-grid configurations. In terms of capacity, Viet Nam, the Philippines, Thailand, Indonesia and Malaysia lead the pack.

Small hydro also contributes to the development of local industry. For instance, the ASEAN Hydropower Competence Centre (HYCOM) in Bandung (Indonesia), supported by GIZ/ASEAN-RESP, facilitates region-wide knowledge exchanges on mini and micro hydropower (1 kW to 1 MW). The objective of HYCOM is to provide a region-wide competence centre that offers training as well as facilitates research and development in the small hydropower sector. It is involved in providing training on standards; testing the reliability, safety and efficiency of micro hydropower equipment in laboratories; supporting the development of mini hydropower sites and facilitating networking and the exchange of micro-hydropower-related information.

Source: Souche et al., 2016; UNIDO and ICSHP, 2013.



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Figure 3.8 Renewable electricity generation in Southeast Asia, 2000–2015

Source: IRENA, 2017f.

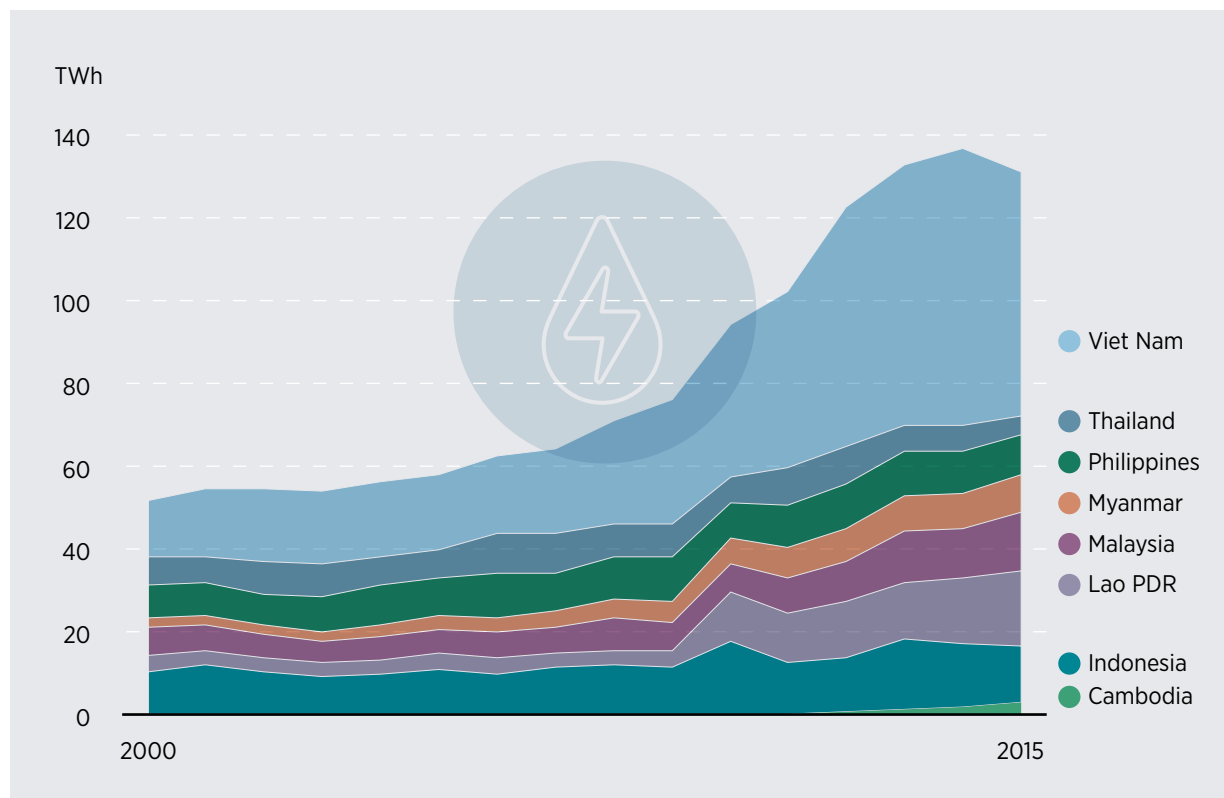
Note: CLMV comprises Cambodia, Lao PDR, Myanmar and Viet Nam. IMPT comprises Indonesia, Malaysia, the Philippines and Thailand.

153% from 51 TWh to 129 TWh. Looking more closely at the sub-regions, in the CLMV countries, renewable power is generated almost entirely from hydropower (Figure 3.9). In fact, compared with other countries, Viet Nam saw a remarkable increase in hydropower generation over the past five years. Nearly 37% of the country's power comes from hydro resources, compared with 12.4% for the region as a whole.

Bioenergy and geothermal are more prominent in the renewable generation mix for Indonesia, Malaysia, the Philippines and Thailand, together accounting for over 18% of the renewable generation in these countries in 2015. Geothermal is mostly concentrated in Indonesia and the Philippines. Despite rapid increases in capacity additions, both

solar and wind account for a small share of the renewable generation share currently.

The development of the ASEAN Power Grid (APG) is encouraging regional trade in electricity. The APG aims to connect the region first on cross-border bilateral terms, followed by sub-regional and regional interconnection initiatives. It is seen as key to meet rising demand in the region, transfer power from surplus to deficit regions, improve access to energy and improve the competitiveness of the region (ASEAN, 2015b). At present, there are nine cross-border connections accounting for 5.2 GW, with ongoing projects totalling 3.3 GW of connections (UNESCAP, 2016a). Lao PDR more than quadrupled electricity exports from 2.8 TWh in 2000 to 11.5 TWh in 2015. While it exports to

Figure 3.9 Hydropower generation in Southeast Asia, 2000–2015

Source: IRENA, 2017f.

most neighbouring countries, currently almost 80% of Laotian exports go to Thailand. Net electricity imports in Thailand more than quadrupled from 2000 to 2013. Electricity trade between Lao PDR and Thailand expanded in 2010 with the start of commercial operations of the Nam Theun 2 Hydropower station. Recently, Lao PDR, Thailand and Malaysia signed an agreement to enable Lao PDR to export 100 MW of electricity to Malaysia via Thailand's transmission lines. The agreement is seen as an important step towards multilateral trade agreements (EIU, 2017). Only Lao PDR is a net exporter on an intraregional basis. Southeast Asia as a whole is a net electricity-importing region, with imports coming from China (IEA, 2015a).



03 RENEWABLE ENERGY IN FINAL CONSUMPTION



Industrial sector

The industrial sector accounted for 29% of the TFEC in the region in 2015. As economies have expanded and the industrial base has grown, the energy use in the sector has also increased. Much of that energy continues to be met by fossil-fuel-based solutions, with renewables only being a marginal contributor. Specifically, bioenergy is the most common form of renewable energy solution deployed in the industrial sector in the region.

In Indonesia, bioenergy accounted for 16% of industrial energy use in 2015 (IRENA, 2017g). The processing of palm oil, sugar and wood is fuelled in part by residues, while small-scale kilns for brick production, for example, often rely on fuelwood and rice husk (Sopingi and Soemarno, 2015). In the Philippines, the industrial sector uses bioenergy mainly for steam and power generation, followed by commercial applications like the drying of agricultural crops and marine products, sugar mills, ceramic processing, metal works and brick making. In Thailand, many small- and large-scale industries rely on bioenergy as their primary energy resource. Many small-scale plants focusing on agroprocessing and food processing use bioenergy fuel for process heat, while large-scale plants producing sugarcane, cassava and palm oil use bioenergy in co-generation plants to produce heat and electricity mostly for their own consumption. In 2015, biomass provided 5 990 ktoe of heat for industry – an increase of 15.5% over the previous year – accounting for almost 60% of the renewable energy used in the country (IRENA, 2017d).

Other sources of direct renewable heat suitable for industrial applications are solar and geothermal. Solar thermal has been used in the region in industry for a wide range of applications. In Viet Nam, solar air-heating systems have been used in the textile industry (IRENA and IEA-ETSAP, 2015) and in Thailand, solar-heated water is used for

tanning processes (CRSES, 2014). According to the International Energy Agency (IEA) statistics, geothermal is not used in industrial applications in the region. However, there is some anecdotal evidence of such direct use of geothermal energy in Indonesia, the Philippines, Thailand and Viet Nam, especially in agricultural industries. Direct use of geothermal in industry focused on agriculture, involves fruit, cocoa or tea drying; palm sugar processing (Indonesia); cold fruit storage; salt production; catfish raising and mushroom cultivation. Geothermal balneology, which includes hot springs, spas and swimming pools, is primarily developed in Thailand but is also present in Indonesia, the Philippines and Viet Nam.



Residential sector

In the residential sector, bioenergy represents a significant share of final consumption. It accounts for nearly 69% of TFEC, although the share is decreasing as modern fuels become more accessible. By comparison, the share of bioenergy in TFEC in the residential sector in 1995 was 80%. Traditional bioenergy still represents a significant share of residential energy consumption, notably in Cambodia, Myanmar, Viet Nam, Lao PDR and Indonesia. Although the share of oil has remained nearly constant in residential TFEC at approximately 14% since 1995, in absolute terms, consumption has increased by over 25% since 1995 as an increasing number of households have gained access to LPG. The share of electricity in TFEC rose substantially – from 6% in 1995 to 18% in 2015 – as the electrification rate and consumption increased.



Transport sector

The transport sector accounted for 27% of Southeast Asia's TFEC in 2015. The share of renewables in transport fuels is small (equivalent to 3%) and primarily comprises liquid biofuels. Thailand, Indonesia, the Philippines and Malaysia are the major markets where biofuel use has grown thanks mainly to the introduction of blending mandates (see Chapter 4).

Thailand comprises the largest share of liquid biofuels use in the region with the renewable energy share in transport fuels reaching 11% in the case of gasoline and 6% for diesel (IRENA, 2017d). An option for B2 (2% biodiesel, 98% petroleum diesel) in diesel fuel was introduced in 2008, rising to a B5 mandate in 2012, a B7 mandate in 2014 and a plan to roll out B10 in the near future (USDA, 2016b). The primary domestic feedstock is palm oil, which introduces vulnerability in the efforts to reach mandates, as it is affected by weather-related issues and other factors (e.g., oil prices). Production of biodiesel accounted for 36% of the final demand for palm oil in 2015 with 41% being consumed domestically and 12% being exported (Krungsri, 2016). There are no ethanol mandates, but its use is promoted through price incentives for biofuels as well as tax incentives for the manufacturing of vehicles compatible with ethanol blending (USDA, 2016b).

Indonesia's share of biofuels in transport was at 3% in 2014. The country began developing its biofuels industry in 2006, and since then, several regulations supporting biofuel have been introduced. The latest Ministerial Regulation No. 12/2015 sets an ambitious blending target (Table 3.6). The government had introduced biodiesel to stabilise the country's palm oil prices and also to address climate change. In 2016, about 7% of the 33 million tonnes of crude palm oil produced in 2016 was used to make biofuel (CMT, 2017). The government aims to raise this figure to 26% by 2020.

The National Biofuels Policy 2006 of Malaysia provided a basis for five priority areas: biofuels for transport, industry, technologies, exports and a cleaner environment. Notably, the transport sector is the main user of subsidised diesel. The country introduced B5 mandate in 2011, followed by B7 in 2014 and is planning to raise the current B7 mandate to B10. The new measure will also require the industrial sector to start using the B7 blend. The initiative is expected to help Malaysia's palm oil stocks and support palm oil prices in the international market. The rapid decrease in crude oil prices has made it difficult for both Indonesia and Malaysia, the world's top palm oil producers, to fulfil their plans for palm-oil-based biofuel production. Due to high global demand, it is more economically viable to sell palm

Table 3.6 Indonesian biodiesel mandate according to Ministerial Regulation No. 12/2015 (percent of biofuel blending required)

Sector	April 2015	January 2016	January 2020	January 2025
Micro-business, fisheries, agriculture and public service (subsidised)	15%	20%	30%	30%
Transportation	15%	20%	30%	30%
Industry and commercial	15%	20%	30%	30%
Electricity	25%	30%	30%	30%

Source: ICCT, 2016

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oil directly to international markets than use it to produce biofuels.

In the Philippines, the share of renewables in transport fuel was 4% in 2014. There is currently an E10 ethanol mandate for gasoline (i.e., 10% ethanol in gasoline), and B2 biodiesel mandate for diesel. It is expected that the E10 requirement will increase to E20 by 2020, and the B2 blend requirement will increase to B10 by 2020 and B20 by 2030 (Reyes, 2017). Sugarcane and molasses are used in ethanol production, while coconut oil is the preferred biodiesel feedstock (USDA, 2016c). While supply issues have not been a concern for biodiesel, domestic ethanol production has fallen short of meeting the mandate-driven demand, requiring imports albeit at much cheaper prices.

Several factors have drawn attention to the fuel efficiency of the region's transport fleet and on the possibility of a fuel switch. These include rising fuel demand as a result of population increase, economic growth and growing car ownership; environmental considerations (i.e., air pollution); the depletion of local reserves and energy security concerns. The transport sector will see energy demand increase by 45% between 2014 and 2025. It has the lowest share of renewables of any sector, but some of the highest growth potential for renewables. IRENA's REmap ASEAN analysis finds that the share of renewable energy in the sector could triple from just 3% in 2014 to 9% in 2025. Indeed, a key determinant of biofuels liquid development in the transport sector will be the availability of sustainable feedstock to meet domestic demand (Box 3.5).

Box 3.5 Sustainability of palm-oil-based biodiesel

The cultivation of palm oil for biofuel production occurs in some of the world's most biodiverse areas, therefore raising sustainability concerns. If peatland and forest are cleared to grow oil palm, not only is biodiversity in the area potentially impacted but a large amount of carbon stored in the forest vegetation and peat soil could be released back into the atmosphere, potentially negating the benefits of the reduced GHG emissions from displacing conventional fuels. Furthermore, while particularly important for rural economic development, if agricultural land once used to grow food crops is used for palm oil production, this raises concerns for food security. Both Malaysia and Indonesia introduced a nationwide certification process for smallholder farms in 2015 to help establish more environment-friendly methods of growing palm oil that also increase productivity. Its implementation and compliance will be key for the future of the sector. In April 2017, for instance, members of the European Parliament voted to ban biofuels made from vegetable oils (including palm oil) by 2020, to prevent the European Union's renewable transport targets from inadvertently contributing to deforestation.

Source: IEA, 2017a; SPOTT, n.d.; Nelsen, 2017.



3.4 CONCLUSION

The renewable energy sector in Southeast Asia boasts a long track record involving a wide range of technologies and applications. Large hydro, bioenergy and geothermal solutions have been deployed for decades in the power and end-use sectors. More recently, the declining costs of solar PV and wind have prompted several gigawatts of installed capacity. As deployment grows, the costs are expected to decline further – presenting a compelling case for adoption. The case is further strengthened by the socio-economic benefits that a renewables-based energy transition offers.

IRENA's analysis has shown that scaling up renewable energy deployment in the region does not come at the expense of economic growth. Instead, a wide range of employment and welfare benefits can be derived. Notwithstanding the pace of domestic renewable energy growth, fossil-fuel-exporting countries will be faced with reduced demand for commodities from the rest of the world as the energy transition accelerates. The

region's strong manufacturing base, private sector environment, power demand growth and rich experience with renewable energy, provides it with a unique opportunity to embrace a locally available, abundant energy resource which, in conjunction with energy efficiency, can support sustainable development objectives.

In light of this, the announcement of an ASEAN-wide aspirational target for modern, sustainable renewable sources is an important milestone. The target for renewable sources to constitute 23% of TPES by 2025, a significant increase from just under 10% in 2014, formed part of the ASEAN's Plan of Action for Energy Cooperation 2016–25, adopted by its Member States at the 33rd ASEAN Ministers on Energy Meeting in September 2015 in Kuala Lumpur, Malaysia. This objective implies a two-and-a-half-fold increase in the modern renewable energy share compared with 2014. At the same time, power generation would double by 2025, and overall energy demand would grow by almost 50% (IRENA and ACE, 2016).



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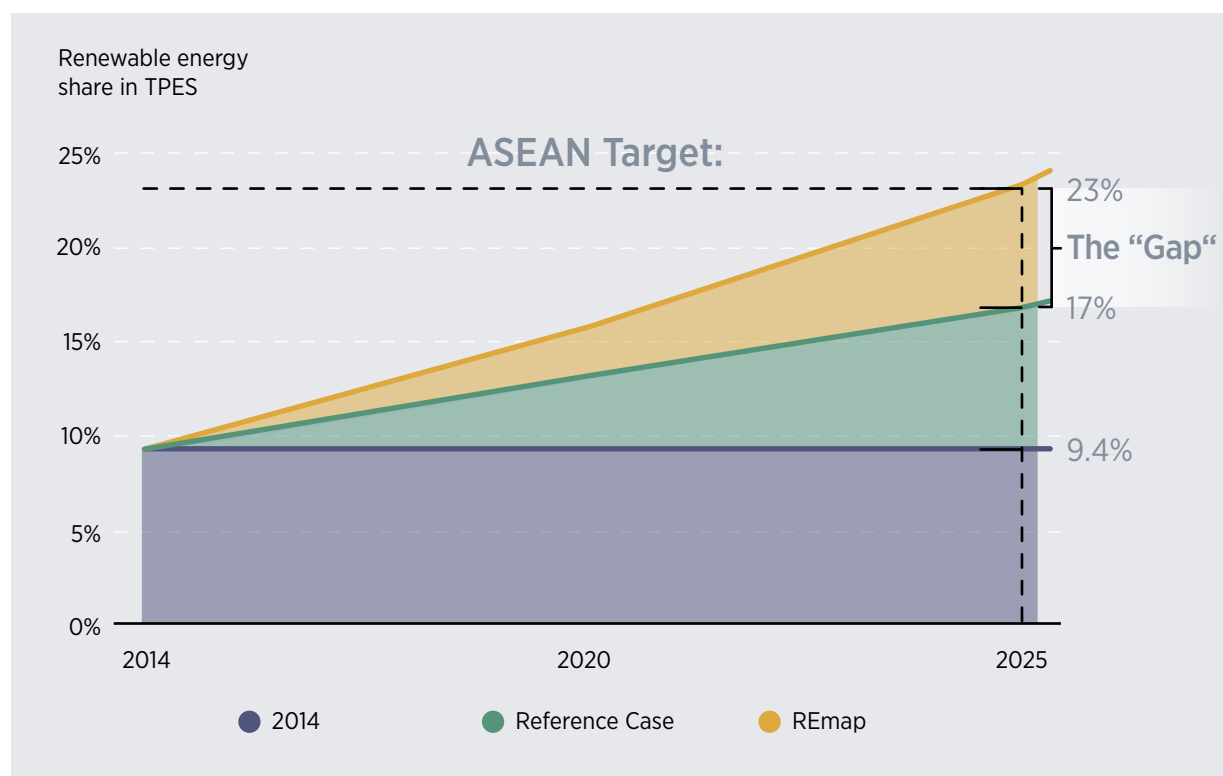
This target, while in line with global aims for renewables, would require the deployment of renewable energy to accelerate over the coming decade. Under a business-as-usual scenario, the share of renewables would increase to just under 17% by 2025 (IRENA and ACE, 2016). Thus, the region must overcome a 6 percentage-point gap to reach its goal (Figure 3.10). This would require targeted efforts to develop



an enabling environment, including in the policy and financing landscapes discussed in detail in chapters 4 and 5.

Complementing growth in renewable energy, demand-side investment is expected to make up almost a quarter of total energy sector investments to 2040, much of which will be focused on energy-efficient technologies (IEA, 2017a). These investments are strongly geared toward road transport and the buildings sector, helped by incentive schemes such as tax breaks for more fuel-efficient vehicles and soft loans for efficiency measures in buildings. Across end-use sectors (buildings, transport, and industry), countries have taken several measures to promote energy efficiency. The remainder of this section provides an overview of the trends in energy efficiency at the level of end-use sectors, concluding with insights on key barriers to scale-up.

Figure 3.10 Renewable energy share in ASEAN primary energy mix in 2025 and 2030



Source: IRENA and ACE, 2016.

IN FOCUS:

ENERGY EFFICIENCY IN SOUTHEAST ASIA

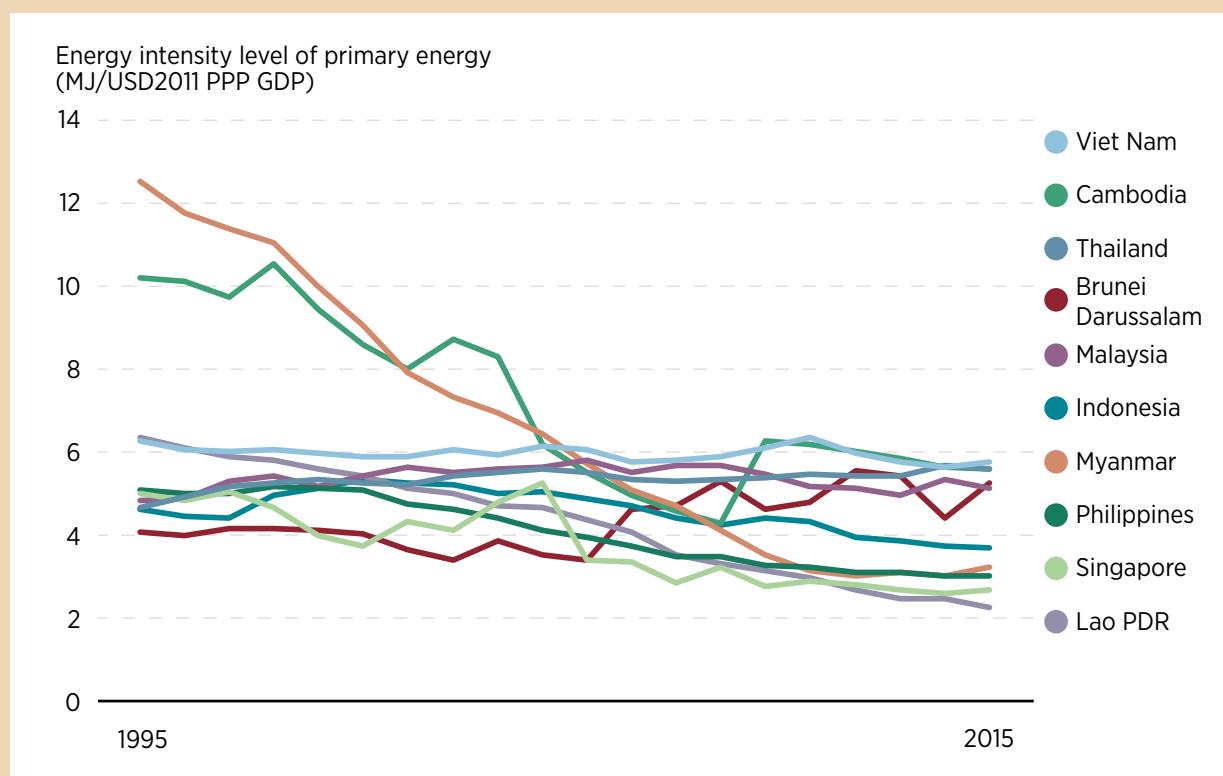
With the majority of countries in the region facing high energy demand growth, supply-side interventions alone will be insufficient to meet energy needs while also addressing broader energy security, economic and environmental objectives (EIA, 2016). Improving energy efficiency across the various end-use sectors would complement renewable energy development in efforts to reconcile the objectives of energy sector expansion with sustainable development.

Most countries in the region have set energy-efficiency targets, although they vary greatly in scope, time frame and objectives. Some target the absolute reduction of energy consumption (e.g., Brunei Darussalam, Lao PDR, Myanmar, Viet Nam), some aim to reduce energy intensity at the level of the economy or in specific end-use sectors (e.g., Malaysia, Singapore, Thailand), while others

cover both (e.g., Indonesia, the Philippines) (IEA, 2017a; MEMR, 2017). At a regional level, within the framework of the ASEAN Plan of Action for Energy Cooperation (2016–25), the ASEAN Member States collectively set an aspirational goal of reducing energy intensity by 20% by 2020 and 30% by 2025 based on 2005 levels (ACE, 2017). The recently published ACE's ASEAN 5th Energy Outlook concluded that the region is well on track to meet its 2020 target and will likely meet the 2025 objective (ACE, 2017).

The energy intensity of countries in Southeast Asia has been on a downward trajectory for the past decade or so. Figure 3.11 captures this trend between 1995 and 2014. Differences in economic structure, the evolution of energy use in various end-use sectors as well as energy-efficiency interventions all contribute to an overall decrease in energy intensity over time, although the extent of

Figure 3.11 Evolution of energy intensity levels of primary energy, by country (1995–2014)



Source: World Bank, n.d. - b.

Note: PPP = Purchasing power parity.

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impact may vary substantially. The CLMV countries, for instance, experienced higher levels of energy intensity as the region emerged as a manufacturing hub with energy-intensive activities. As industrial processes have become more efficient, energy intensity has fallen.

Buildings



More than 50% of the world's new buildings are constructed in Asia every year, and the buildings sector accounts for approximately 25% of overall energy consumption. A wide range of efforts have been undertaken in Southeast Asia to enhance energy efficiency in existing and new stock. Energy performance requirements and standards, coupled with labelling, have been an effective policy tool for reducing energy demand in buildings. In Indonesia, where buildings account for 20% of energy consumption, potential energy savings of up to 30% are being targeted. This is to be achieved through measures such as standards (labels and Minimum Energy Performance Standards), public awareness programmes, energy audits and online reporting systems for commercial and government buildings (MEMR, 2017). Tools that benchmark the energy performance of buildings have been used in Indonesia, for instance, to reduce energy use in hotels. Similar benchmarking tools have also been used in Viet Nam and the Philippines.



In both Malaysia and Thailand, building codes have been introduced to guide energy-efficient design (KeTTHA, 2017; DEDE, 2017). The building codes in Thailand are mandatory for government buildings and voluntary for others (DEDE, 2017). One of the key challenges of introducing building codes has been the lack of local expertise in the design of buildings in accordance with the building codes. Viet Nam, for instance, has faced challenges with the implementation of building codes due to the lack of locally trained professionals. Malaysia's strategy to promote demand-side management explicitly focuses on education and training to increase the number of registered electrical engineer managers and on promoting ISO 50001 for buildings and industries (KeTTHA, 2017).

As ownership increases, domestic appliances are expected to account for a major share of electricity consumption. Efficiency measures, such as mandatory labelling systems, could help reduce the increase in demand. Brunei Darussalam, Indonesia, Lao PDR, Malaysia, Myanmar, the Philippines and Thailand have implemented various standards and labelling regulations for certain appliances (ACE, 2017). As of now, the protocol and methodology adopted differ by country (IEA, 2017a), but efforts are underway to harmonise standards across the region for appliances such as air conditioners, refrigerators and motors, in order to contribute to a stronger regional market (Box 3.6). Indeed, the motivation and capacity for implementing such measures depend on domestic conditions, including policy priorities such as extending electricity access. For energy-efficiency standards and labelling programmes to be successful, they need to be forged in partnership between relevant government entities and manufacturers and retailers (IEA, 2017a). The use of efficient appliances is not limited to buildings alone, but also to municipalities whose energy costs will increase alongside urbanisation and rising demand. Energy-efficient street lighting, water treatment and distribution systems, and sewage treatment are all avenues for achieving savings.



Transport

The region's population and economy is growing, as is demand for transportation services. Increasing the energy efficiency of the transport sector is key for reining in demand for energy and its corresponding impacts on energy security, especially in oil-importing countries. Together with industry, the transport sector is expected to be the largest contributor to the rise in regional demand for energy over the coming decades (ACE, 2017). In Indonesia, an energy-saving potential of 15–35% could be achieved through support for mass transportation (BRT/MRT/LRT), fuel switching (oil to gas and biodiesel) and transport management systems (MEMR, 2017). Measures introduced in the region to improve transport efficiency include incentives to purchase relatively efficient vehicles and fuel-economy standards (IEA, 2017a).

Singapore has a fuel-labelling and emissions scheme (including CO₂ emission limits) that includes providing rebates or imposing surcharges on vehicle purchases. Thailand also introduced a CO₂ tax-based incentive scheme and a labelling programme that rates the fuel economy of passenger cars. Brunei Darussalam, Indonesia and the Philippines currently are discussing plans to introduce fuel-economy standards (IEA, 2017a). Singapore was the first to launch a voluntary Fuel Economy Labeling Scheme in 2003 and has since made it much more stringent.

A global shift toward low-emissions mobility has already started and its pace is accelerating. This offers major opportunities for car manufacturers to modernise, embrace new technologies, drive global standards and export their products. Automobile manufacturing hubs in Southeast Asia (such as Thailand) are already taking measures (such as introducing tax incentives) to attract local manufacturing, for example, with the launch of the first Technology and Innovation Learning Center for Electric Vehicles. The two/three-wheeler market is particularly attractive given its substantial size in the region (as discussed in Chapter 1) and the increased availability of cost-effective electric mobility solutions for this market segment. These actions



address key levers to tilt the transport sector in the right direction while contributing to jobs, growth and investment by promoting 1) the efficiency of public transport systems 2) a switch to a low-emissions transport fuel alternative; and 3) low- and zero emissions vehicles.

Besides promoting the energy efficiency of the transport fleet, fuel-switching efforts are also being undertaken, using liquid biofuels as an alternative to fossil-fuel-based products. As discussed earlier in the chapter, the region has abundant bioenergy resources. The adoption of electric vehicle (EV) technology and increased use of biofuels in the transportation sector both have their fair share of implementation challenges. For liquid biofuels, clear incentive structures are needed to increase investments, as well as regulatory and policy frameworks to ensure a sustainable supply chain for feedstock. Necessary safeguards are also needed to ensure that these investments are sustainable and address indigenous concerns alongside large-scale land conversion and agri-business projects. Regarding the electrification of the transport fleet, challenges associated with infrastructure development and the provision of low-carbon electricity will need to be addressed.

03 Industry

The strong growth of manufacturing industries in the region is expected to contribute substantially to future energy demand. The energy efficiency of industry is, therefore, key to ensure continuing competitiveness and to help the farm-to-factory migration trend be as sustainable as possible. The region hosts a wide range of energy-intensive manufacturing processes, including of automobiles and electric appliances and steel, cement and chemicals. While most industries will see their energy intensity decrease over time, it is expected that the steel industry will see a rise as the existing capacity of electric arc furnaces is complemented by blast furnace technology, which is more energy intensive (IEA, 2017a). Enabling fuel and feedstock switching can also improve energy efficiency, as can promoting more recycling (especially in the iron and steel, paper and pulp, and chemicals and petrochemical sector). The region would also benefit from industry-specific energy-efficiency incentives that address the rise in manufacturing and production, especially in terms

of building materials and energy-intensive heating and cooling technologies.

Several measures to increase energy efficiency have been implemented in the region, including energy audits, energy management/ISO 50001, time-of-use tariffs, smart grids and meters, energy standards and labelling (MEMR, 2017; KeTTHA, 2017; DEDE, 2017). In Singapore, for instance, the industrial energy-efficiency landscape comprises regulations and standards, incentive schemes and capability development.

The Energy Conservation Act prescribes mandatory energy management practices, including appointing an energy manager, monitoring and reporting energy use and emissions and submitting energy-efficiency improvement plans. Recent enhancements in the act call for Minimum Energy Performance Standards to be applied to industrial equipment and systems, and the establishment of an energy management system for existing facilities. The incentives are designed to facilitate the design of efficient facilities, energy assessments and adoption

Box 3.6 The ASEAN SHINE initiative

The Association of Southeast Asian Nations (ASEAN) Standards Harmonization Initiative for Energy Efficiency (SHINE) focuses on the harmonisation of standards across the region for specific appliances such as air conditioners and lighting products. It contributes to the broader objective of establishing the ASEAN Economic Community. The initiative adopts a holistic approach focusing on policy, regulations, capacity building along the supply chain, and awareness raising among end-users. In the future, the initiative is expected to expand beyond appliances to include electric motors, distribution transformers and solar technologies.

Source: ASEAN SHINE, n.d.



of energy-efficient technologies. Capability development programmes include training professionals in energy management, awareness and recognition programmes (NEA, 2017).

SCALING UP ENERGY-EFFICIENCY MEASURES

In supporting the development and implementation of energy-efficiency measures across end-use sectors, several key enabling factors emerge. These include dedicated policies, action plans and institutions focusing on energy efficiency; targeted financing and business model structures; adaptive regulations to allow innovation; robust data gathering, reporting and accessing frameworks; and awareness and capacity building programmes.

Most of the countries in the region have energy-efficiency action plans and strategies. Recognising the strong linkages between renewable energy and energy efficiency, the Thailand Integrated Energy Blueprint 2015-36 brings together development plans for both power sector development (including alternatives), energy efficiency, oil and gas sectors (IRENA, 2017d). Several countries have also announced dedicated financing schemes for energy efficiency. Government guarantees are crucial to the bankability of projects that are considered high risk due to either their size or where the new technology is used. For example, the Indonesian government created the Viability Gap Fund (VGF) to reduce the investment costs of projects with high project development and construction costs or low returns.

Other examples include the Energy Performance Contract Fund in Malaysia; the Energy Efficiency Revolving Fund in Thailand (where the private sector can access dedicated funds that are repaid when the project starts commercial operations); the low-interest loan fund in Indonesia; and the Energy Efficiency Financing Programme and Energy Efficiency Fund for industries and the Building Retrofit Energy Efficiency Financing Scheme for buildings in Singapore (MEMR, 2017; KeTTHA, 2017;

DEDE, 2017; SERIS, 2017). Innovative business models, such as energy service companies and public-private partnerships, are also being tried and tested in the region to deploy energy-efficiency measures particularly in buildings and industry.

One of the key barriers to encouraging energy efficiency, specifically on the end-user side, is related to the pricing structures for electricity and fuels. Incentives to invest in energy-efficiency measures are lessened by subsidies, thereby warranting targeted pricing reforms across residential, commercial and industrial segments, and/or introducing rebate/financial support schemes to facilitate the adoption of energy-efficient technologies. Furthermore, public education campaigns are necessary to increase awareness of the long-term benefits of investments in energy efficiency and the catalogue of solutions available to end-users.

A complementary focus on energy efficiency and renewable energy will support ASEAN Member States in their national and regional ambitions to meet energy security, decarbonisation and economic growth objectives, while ensuring long-term sustainability. While not the explicit focus of this report, policy and regulatory measures are needed to accelerate energy-efficiency improvements across the various end-use sectors.





RENEWABLE ENERGY POLICIES

04



In recent years, decision makers in many Southeast Asian countries have fostered the development of a renewable energy sector in a concerted manner by setting targets and implementing policy. The ASEAN set a collective target of securing 23% of its primary energy from modern, sustainable, renewable sources by 2025.¹ At the national level, all countries in Southeast Asia have adopted medium- and long-term targets for renewable energy and have also formally joined the Paris Agreement and committed to nationally determined GHG reduction targets. These actions are expected to drive an on-going increase in renewable energy adoption.

The path to meeting relevant targets is an uphill climb, however. Based on policies both current and under consideration, the region's renewable share of TPES is expected to increase by only 17% as of 2025, leaving the region six percentage points short of reaching ASEAN's 23% by 2025 ambitions (IRENA and ACE, 2016). What might close the gap between ASEAN's renewable energy target and its actual rate of adoption? Cost-competitive renewable technologies are only part of the equation; more government actions are required to unlock the region's full potential. Moreover, 65 million people still lack access to electricity in the region and more

than 250 million rely on solid biomass for cooking (IEA, 2017a). Government intervention is needed to increase access to clean energy for electricity, motive power, and heating and cooling.

While governments have made efforts to target and support the scale-up of renewable-based power, renewables remain largely underutilised in end-use sectors such as transport and heating and cooling. Approximately half of the region's potential for the deployment of modern renewables by 2025 is in end-use sectors. However, as in many regions, only a patchwork of policies and incentives exists to support investments in and utilisation of end-use renewable energy technologies in, for example, biofuels production and industrial heating.

This chapter highlights regional- and national-level renewable energy targets and examines the policy frameworks and institutional settings in place to support them in power (on- and off-grid), heating and cooling, and transport sectors. It is important that policy makers, project developers and investors consider the contextual factors that, in addition to policy, affect market development, such as a country's available natural resources, economic standing, institutional structure, land use and public perception of land use, level of development and more.

¹ | This target includes a variety of renewable energy sources including hydropower of all sizes, but does not include traditional biomass.

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4.1 RENEWABLE ENERGY TARGETS
IN SOUTHEAST ASIA

In recent years, Southeast Asia has embarked on a plan to develop an increasingly diversified portfolio of renewable energy sources to achieve benefits in energy security, energy access, economic competitiveness and social and environmental sustainability. This section explores renewable energy targets at both the regional and national level.

RENEWABLE ENERGY TARGETS
AT THE REGIONAL LEVEL

ASEAN Member States collectively aim to secure 23% of their primary energy from modern, sustainable, renewable energy sources by 2025. In line with many individual country targets for renewables around the world, this goal requires consistent progress during a period when the region's power generation is expected to double and overall energy demand is expected to grow by almost 50% (IRENA and ACE, 2016). In addition to the regional renewable energy target, ASEAN Member States have also committed to collective energy efficiency and conservation goals. They aim to reduce overall energy intensity by 20% by 2020 and by 30% by 2025, compared with 2005 levels. ASEAN Member States' ability to meet their renewable energy and energy efficiency targets is directly linked (ACE, 2017).

For these regional goals to have a realistic possibility of being achieved, ASEAN Member States need to address their energy targets and programmes through a holistic policy framework.

COUNTRY-LEVEL RENEWABLE
ENERGY TARGETS

Each member of ASEAN has set some form of renewable energy target, motivated by a range of drivers.

An interest in **environmental protection** and **climate change mitigation** is a key driver, especially since, as part of the Paris Agreement, each ASEAN

Member State submitted nationally determined contributions (NDCs) to mitigating the impacts of climate change. Oil-rich Brunei Darussalam, for example, put forward plans to reduce its total energy consumption by 63% by 2035 and to supply 10% of power generation from renewables (UNFCCC, 2015). NDCs involve direct commitments to reduce overall GHG emissions, and it is widely understood that they require the support of energy-efficiency measures and accelerated renewable energy deployment to do so. Most countries in the region have set energy-efficiency targets, with varying scope, time frame and objectives (see In-focus discussion on energy efficiency in chapter 3).

In addition to environmental protection and climate change mitigation, **energy security** is a major motivation for scaling up renewable energy deployment. In Indonesia, Thailand and Viet Nam, the oil and gas resources that traditionally dominated the energy mix and served as key exports are beginning to decline. Indonesia, for example, has set a target of at least 23% and 31% of new and renewable energy in its primary energy supply mix in 2025 and in 2050, respectively. By 2050, oil will supply less than 20%, coal 25% and gas 24% of the primary supply (UNFCCC, 2016).

In fact, it is expected that the region could become a net importer of gas by 2022 and that the gap between primary oil production and requirement will expand to over five times by 2040 (ACE, 2017). The projected decline in domestic oil and gas is already prompting government action in the transport sector, where more than half of ASEAN Member States have put in place biofuel policies, with blending mandates being one of the most popular mechanisms for driving the increase of renewable fuels (see section 4.6). Thailand has set a target of 30% renewable energy in total energy consumption by 2036, with different breakdowns in each sector: biofuels are expected to supply 25% of energy needs in transport, and the share of renewables in electricity and heat is expected to be 20% and 37% respectively.

Beyond these more traditional drivers, the increasing **cost-competitiveness** of renewable energy technologies is prompting countries to increase their adoption in the national energy mix.

Renewables-based electricity is already cost-competitive with traditional power sources in some Southeast Asian countries and is expected to become increasingly affordable across a wider range of countries and markets (see section 3.2). For example, utility-scale solar power purchase agreements (PPAs) were signed in the Philippines in 2017 for USD 0.06 kWh. The purchasing utility listed diversifying supply and bringing down electricity rates as the key drivers behind this agreement (Lectura, 2017). This is reflected in the country's target to install 15.3 GW of renewable energy capacity by 2030, equivalent to 61% of the projected power demand (IRENA, 2017e). As the cost-competitiveness of renewable technologies continues to improve, countries in the region are expected to increasingly turn to renewables to achieve **socio-economic benefits**, including job creation and income generation

(see section 3.2 and access to affordable, clean and reliable energy for the large energy-poor population (see chapter 6). The renewable energy targets of countries in Southeast Asia are presented in Table 4.1 together with energy efficiency targets.

Southeast Asian countries are facing the added challenge of significantly scaling up renewable energy investment and deployment while simultaneously addressing a wide range of barriers that impede investment, such as countries' financial standing, or relatively cumbersome policy or regulatory environments.

Table 4.1 Renewable energy and energy efficiency targets in Southeast Asia

Country	Renewable energy and energy efficiency targets	Reference document (year)
Brunei Darussalam	<ul style="list-style-type: none"> • Reduce energy intensity (TFEC/GDP) by 45% by 2035 based on 2005 level • 124 GWh of renewable power generation by 2017 and 954 GWh by 2035 (10% renewable share in power generation) 	Energy White Paper (2014)
	<ul style="list-style-type: none"> • 63% reduction in total energy consumption by 2035 • 10% power generation from renewables by 2035 	UNFCCC (2015)
Cambodia	<ul style="list-style-type: none"> • Reduce TFEC by 20% in 2035 as compared with business-as-usual, including sectoral targets: <ul style="list-style-type: none"> - Industry: 20% in garment factories and 70% in ice factories - Residential: 50% - Commercial: 20–30% - Rural electrification energy savings: 80% - Replacement of biomass use: 30–50% 	National Policy, Strategy and Action Plan on Energy Efficiency in Cambodia (2013)
	<ul style="list-style-type: none"> • Hydro: 2 241 MW (approximately 80% of the total installed capacity) by 2020 	Power Development Plan 2008-21 (2007)
Indonesia	<ul style="list-style-type: none"> • Reduce energy consumption in 2025 by 17% in industry, 20% in transportation, 15% in household, 15% in commercial buildings as compared to business as usual • 23% renewable share of TPES (around 92.2 Mtoe in 2025), which consists of 69.2 Mtoe (45.2 GW) for electricity and 23 Mtoe for non-electricity • 31% renewable share in 2030 	National Energy Policy (Government Regulation No. 79/2014)

Note: GDP = gross domestic product; GW = gigawatts; ktoe = kilotonnes of oil equivalent; Mtoe = million tonnes of oil equivalent; MW = megawatts; TFEC = total final energy consumption; TPES = total primary energy supply.

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Table 4.1 Renewable energy and energy efficiency targets in Southeast Asia (continued)

Country	Renewable energy and energy efficiency targets	Reference document (year)
Lao PDR	• Reduce TFEC by 10% in 2030 as compared with business as usual	National Energy Efficiency Policy (2016)
	• 30% renewable share of total energy consumption by 2025 (approximately 1 479 ktoe), excluding large hydro (>15 MW capacity)	Renewable Energy Development Strategy Policy (2016)
Malaysia	• Reduce electricity consumption by 8% in 2025 as compared with business as usual	National Energy Efficiency Action Plan (2014)
	• Renewable energy installed capacity of 2 080 MW (excluding large hydro) by 2020 contributing to 7.8% of total installed capacity in Peninsular Malaysia and Sabah	National RE Policy and Action Plan (2011) and 11th Malaysia Plan 2016-2020 (2015)
Myanmar	• Reduce electricity consumption by 20% in 2030 as compared with business as usual	National Energy Efficiency and Conservation Policy, Strategy and Roadmap (2015)
	• By 2030–31, achieve an energy mix of 38% (8 896 MW) hydro, 20% (4 758 MW) of natural gas, 33% (7 940 MW) of coal and 9% (2 000 MW) of other renewable sources	National Renewable Energy Policy and Planning (Draft)
Philippines	• Reduce TFEC by 1% per year as compared with business as usual until 2040, equivalent to the reduction of one-third of energy demand • Reduce energy intensity (TFEC/GDP) by 40% in 2040 as compared to 2005 level	Energy Efficiency Roadmap for the Philippines, 2017-20 (2017)
	• 15.3 GW renewable energy installed capacity in 2030: • Renewable energy additional targets: - Additional biomass capacity of 277 MW in 2015 - Additional wind capacity of 2 345 MW in 2022 - Additional hydro of 5 398 MW in 2023 - Additional ocean energy capacity of 75 MW in 2025 - Additional solar capacity of 284 MW in 2030 - Additional geothermal capacity of 1 495 MW in 2030	National Renewable Energy Program Roadmap 2010-30 (2010)
Singapore	• Reduce energy intensity (TFEC/GDP) by 35% from 2005 levels by 2030 • Solar power installation of 350 MW by 2020 and 1 GW beyond 2020 • 10 140 tonnes per day by 2018 for waste-to-energy plant	Singapore Sustainable Blueprint (2009)
Thailand	• Reduce energy intensity (TFEC/GDP) by 30% in 2036 compared with 2010 level	Thailand Energy Efficiency Policy 2015 Plan (2015)
	• 30% renewable energy in total energy consumption by 2036, in the form of electricity (20.11% in generation, approximately 19 684 MW), heat (36.67% of heat production, approximately 25 088 ktoe) and bio-fuels (25.04% in transportation sector, approximately 8 712.43 ktoe)	Alternative Energy Development Plan (2015)
Viet Nam	• Reduce TFEC by 8% in 2020 as compared with business as usual • Reduce energy intensity of energy-intensive industries by 10% by 2020	National Target Program for Energy Efficiency and Conservation (2015)
	• 21% renewable energy of 60 GW installed capacity in 2020, 13% renewable energy of 96 GW in 2025 and 21% renewable energy of 130 GW in 2030 consisting of 2.1% wind, 15.5% hydro, 2.1% biomass and 3.3% solar.	Decision 428/QĐ-TTg dated March 18, 2016 (2016)

Sources: ACE, 2016b; EIDPMO, 2014; IEA and IRENA, n.d.-a; IEA and IRENA, n.d.-b; EPPO, 2015b; EPPO, 2015c; EPU, 2015; GOVPH, 2010; GOVPH, 2017; Kettha, 2014; MCSD, 2009; MIME, 2013; SRV, 2016; UNFCCC, 2015.

Note: GDP = gross domestic product; GW = gigawatts; ktoe = kilotonnes of oil equivalent; Mtoe = million tonnes of oil equivalent; MW = megawatts; TFEC = total final energy consumption; TPES = total primary energy supply.

4.2 RENEWABLE ENERGY POLICY AND INSTITUTIONAL FRAMEWORKS

To achieve the set targets, countries in the region have made concerted efforts to develop policy frameworks and robust institutions, and taken steps toward the liberalisation of their energy markets to encourage competition in the sector.

From a legal standpoint, the presence of framework laws and an institutional structure of the energy sector will help guide the formation and nature of a country's renewable energy policies and investments. In Malaysia, the renewable energy law constituted a building block of an enabling environment for systematic and robust renewable energy development (Box 4.1).

The majority of countries have some form of renewable energy national policy (law) or official strategy, most often for specific renewable energy power sources (Table 4.2). Yet, despite the prevalence of laws geared toward renewable energy-based power, most countries still lack comprehensive legal

frameworks or mandates for renewable energy-based transport or heating and cooling.

While strong policies are essential, institutional frameworks are also important indicators of a country's renewable energy market maturity and investment climate. Countries with well-defined institutions and energy regulatory structures, such as Thailand and the Philippines, have created dynamic and competitive energy markets and attracted renewable energy investment from the private sector. In those advanced renewable energy markets, the existence and functionality of regulatory and policy bodies are more advanced than in early-stage renewable energy markets such as Cambodia and Myanmar. In Myanmar, for example, no energy regulator currently exists and the government has little experience with private energy sector investment or contracting of independent power producers (IPPs).

A robust regulatory and institutional framework provides the basis for overcoming some of the most prevalent barriers to renewable energy deployment

Box 4.1 Malaysia's institutional approach to renewable energy











Malaysia supports renewable energy development through the National Renewable Energy Policy, Renewable Energy Act, Sustainable Energy Development Authority Act, Green Technology Policy, Green Technology Financing and National Biofuel Policy. The costs of the policies implemented are transferred to electricity consumers in the form of an additional surcharge of 1.6% on top of their electricity bills. This charge is collected by the distribution licensees and deposited into the Renewable Energy Fund. However, residential customers who consume less than 300 kWh/month are exempted from contributing to the fund.

Source: ACE, 2016b.



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Table 4.2 Renewable energy policies in Southeast Asia

	National policy							Fiscal incentives						Grid access			Regulatory instruments				Others	
	Renewable energy target	Renewable energy law/strategy	Solar heating law/programme	Solar power law/programme	Wind power law/programme	Geothermal law/programme	Biofuels law/programme	Vat exemption	Income tax exemption	Import/export fiscal benefit	Carbon tax	Accelerated depreciation	Other fiscal benefits	Priority/dedicated transmission	Grid access	Preferential dispatch	Guaranteed offtake via feed-in tariff or auctions	Quota (e.g. renewable portfolio standards)	Renewable energy certificate system	Net metering	Renewable energy in rural access programmes	Local content requirements for equipment
 Brunei Darussalam																	*	*	*	*		
 Cambodia																	*					
 Indonesia																						
 Lao PDR																	*		C			
 Malaysia																			C			
 Myanmar																						
 Philippines																						
 Singapore																						
 Thailand																						
 Viet Nam																			C			

Source: based on ACE, 2016b.

* = under planning

C = under Clean Development Mechanism (CDM)

in all end-use sectors. Barriers range from physical, such as poor infrastructure and grid-related issues, to bureaucratic, such as unclear regulations, unsteady incentives and lengthy permitting processes. These barriers can have negative economic impacts, primarily in the earlier investment-intensive project cycle phases. Investors are likely to require higher risk premiums in the presence of risk of policy changes affecting renewable energy project development (ACE, 2016b).

4.3 RENEWABLE ENERGY POLICIES IN THE POWER SECTOR

Looking at parameters such as renewable energy installed capacity, and policy maturity and comprehensiveness, Indonesia, Malaysia, the Philippines, Thailand and Viet Nam are leading in renewable energy policies in the region, especially in the power sector. All five countries have established the following key policy measures: set medium-to long-term and technology-specific renewable energy targets, offered guaranteed purchase

of renewable power at set tariffs, introduced additional incentives for project developers and investors, provided financing schemes to support projects and developed permitting and licensing mechanisms and technical standards to facilitate grid interconnection (Box 4.2). To date, this combination of policy instruments appears to be the critical mix of legal, regulatory and financial support necessary for increasing renewable energy investment and deployment in Southeast Asia.









With the falling cost of technology (mostly for solar PV and onshore wind) and increasing maturity of the sector, policies that support the deployment of renewables and their integration may evolve. New mechanisms such as auctions are being introduced to supplement the traditional instruments that have driven the region's renewable energy growth. In the power sector, policies are evolving to address growing challenges and adapting to changing conditions relevant to solar PV, wind, hydropower and geothermal power among others.



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Box 4.2 Permits for power production and grid access in Southeast Asia

The single-buyer model with IPPs is most prevalent in the region. In Indonesia, Malaysia, the Philippines, Singapore and Thailand, IPPs contribute more than half of aggregate installed capacities and in Viet Nam, power generators are allowed to sell electricity to Vietnam Electricity at competitive prices since 2016. The Philippines and Singapore operate liberalised retail electricity markets. Singapore expects to fully liberalise its electricity market in 2018 allowing all consumers including households to choose their electricity suppliers. Almost all countries in the region have enacted a law that permits power production and grid access:

-  In **Cambodia**, the *Electricity Law of 2001* provides guidelines for issuance of power licenses by the Electricity Authority of Cambodia.
-  In **Indonesia**, IPPs can sell renewable electricity to PLN (the state-owned power distribution company) through a direct selection process. Since 2015, permit procedures for electricity production have integrated into a one-stop service to streamline the procedure.
-  In **Lao PDR**, the permitting procedure consists of numerous feasibility studies, impact assessments and submission of proofs of technical and financial capabilities.
-  In **Malaysia**, the Renewable Energy Act outlines the terms for obtaining a feed-in approval certificate to generate renewable electricity and the tariffs offered. The rules and regulations outline the laws related to renewable energy generation and plant operation.
-  In the **Philippines**, a web-based platform, “the energy virtual one-shared system,” is used to facilitate and streamline applications. The evaluation process cannot exceed 45 working days.
-  In **Singapore**, licensing requirements for intermittent generators depend on the size of the installation. Enhancements made in 2015 clarify the licensing framework and streamline market registration and settlement procedures.
-  In **Thailand**, the Energy Industry Act of 2007 established the Energy Regulatory Committee that grants permits to any energy operation, with or without remuneration.
-  In **Viet Nam**, a circular was issued in 2015 that regulates the sequence, procedures for issuance, revocation and duration of power operation licenses required for power plants with an installed capacity of 50 kilowatts (kW) and above.

Source: ACE, 2016b.

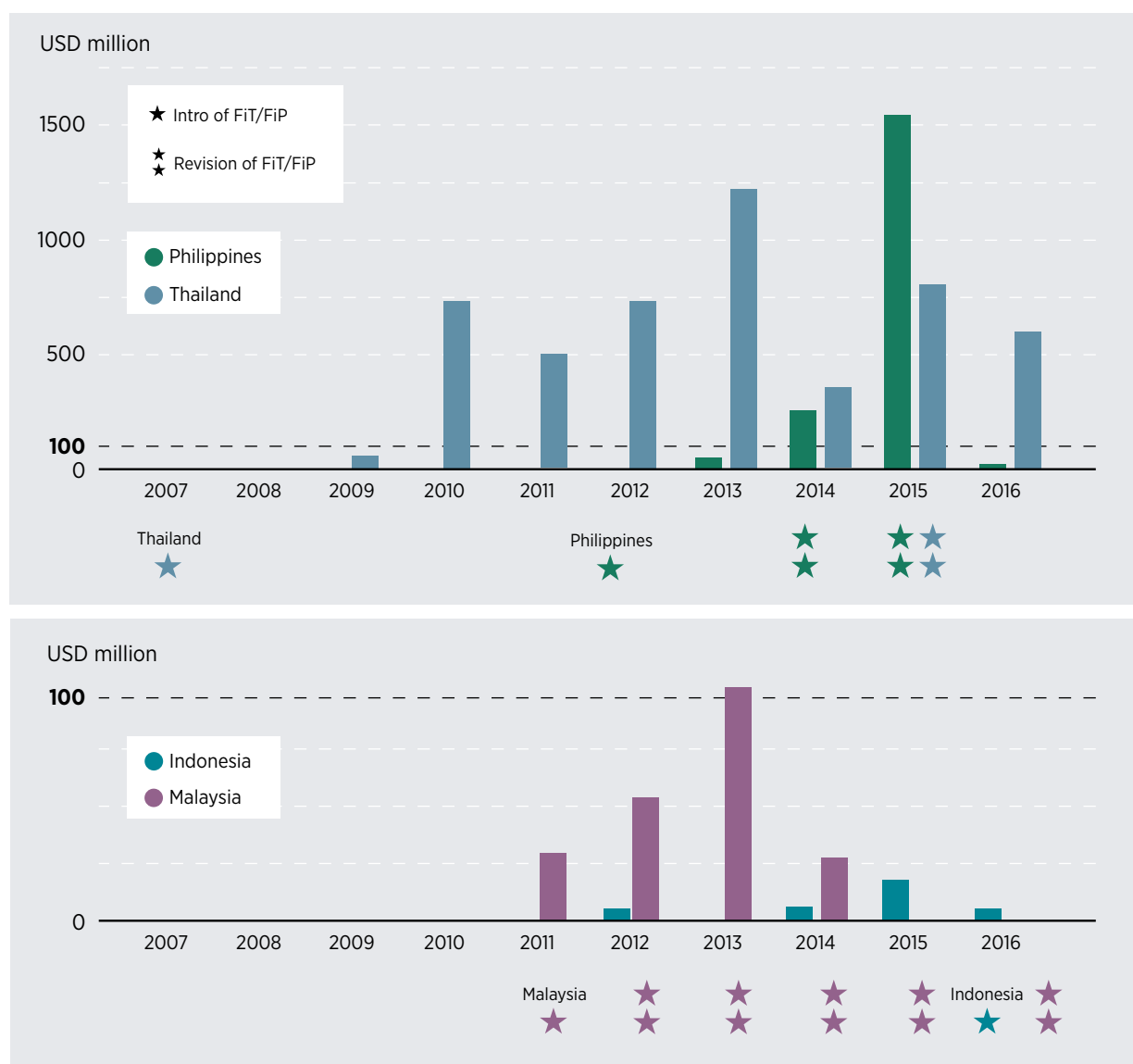


POLICIES TO SUPPORT THE DEPLOYMENT OF SOLAR ENERGY

Using project financing as a yardstick, solar PV continues to lead non-hydro clean energy investment in the region given the abundance of solar resources, its increasing cost-competitiveness and its developing market. Investment in solar projects in Southeast Asia totalled USD 892 million in 2016, attracting 1.5 times more than the USD 588 million invested in wind power

projects (although this solar-to-wind investment ratio is expected to shift in 2017 after significant wind power deals totalling more than USD 1 billion were finalised). Since 2010, at least USD 8.3 billion of solar project financing deals have been made, an indicator of the sector's strong standing in the region (Conergy/Clean Energy Pipeline, 2017). There is a clear correlation between the countries where significant levels of investments have occurred and the countries that have enacted price support policies (Figure 4.1).

Figure 4.1 Investments in solar PV in the Philippines, Thailand, Indonesia and Malaysia, as a result of FiTs, 2007-17



Source: Investment data from BNEF, 2017.
Note: FiT = feed-in tariff; FiP = feed-in premium.

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Thailand

Thailand currently accounts for the largest share of the region's installed solar capacity at more than 2 GW as of 2016 (IRENA, 2017f). Solar is expected to continue being a priority; the aim is to install 6 GW by 2036 as part of the overall target of 30% renewables in the energy mix that year. Thailand also envisages

robust growth in rooftop solar installations, in response to constraints on land availability for utility-scale installations, as is the case for the Bangkok metropolitan area (IRENA, 2017d). Private investment has been so far mainly incentivised through support programmes like feed-in policies.

Thailand kick-started solar investment in 2007 with a feed-in premium known as the Adder Program, but

Table 4.3 Solar FiTs in selected Southeast Asian countries

FIT (USD cents/kWh)								
	Thailand ^a		Philippines ^b	Malaysia** ^c		Indonesia*** ^d	Viet Nam	
2012			23.11/kWh with 0.6% degression yearly after the first year	4–72 kW	39–40			
				72 kW–1 MW	37.6			
				1–10 MW	31			
				10–30 MW	28			
2013	Rooftop 0–10 kW	21.5	No change	4–72 kW	30–36			
	Rooftop 10–250 kW	20.2		72 kW–1 MW	32			
	Rooftop 250 kW–1 MW	19		1–10 MW	24.3			
	Solar farm > 1 MW	21*		10–30 MW	21.8			
2014	No change		19.58/kWh with 0.6% degression yearly after the first year	4–72 kW	22.9–31.5			
				72 kW–1 MW	22.1			
				1–10 MW	18.4			
				10–30 MW	16.5			
2015	Rooftop 0–10 kW	19	19.08/kWh	<4 kW	25.67			
	Rooftop 10–250 kW	17.78		4–72 kW	21.42–25.04			
	Rooftop 250 kW–1 MW	16.69						
	Solar farm > 1 MW	15.73						
2016				<4 kW	19.92	14.5–25		
				4–72 kW	14.83–19.44			
2017				<4 kW	17.22		9.35 (solar rooftop)	
				4–72 kW	12.1–16.8			

Sources: ACE, 2016b; Brohm, 2017; IEA and IRENA, n.d.-a,b,c,d, SEDA, 2017.

Notes: a | 1 USD = THB 32.36 in 2013, 1 USD = THB 35.99 in 2015; b | 1 USD = PHP 41.87 in 2012, 1 USD = PHP 44.37 in 2014; 1 USD = PHP 45.53 in 2015; c | 1 USD = MYR 3.03 in 2012, 1 USD = MYR 3.12 in 2013, 1 USD = MYR 3.30 in 2014, 1 USD = MYR 3.57 in 2015, 1 USD = MYR 4.14 in 2016, 1 USD = MYR 4.31 in 2017; d | 1 USD = IDR 66.69 in July 2016; e | 1 USD = VND 22 310 in 2017.

*Average of USD 0.29/kWh for the first three years of operation, USD 0.20/kWh for the next seven years and USD 0.14/kWh for the remaining 15 years.

** Malaysia provides a bonus FiT for the use of PV as an installation in buildings or building structures or building materials, and for the use of locally manufactured or assembled solar PV modules and inverters.

*** Local content requirement of 40%. FiT = feed-in-tariff; IDR = Indonesia rupiah; kW = kilowatts; kWh = kilowatt hours; MW = megawatts; MYR = Malaysian ringgit; PHP = Philippines peso; THB = Thailand baht; USD = US dollar; VND = Viet Nam dong.

in recent years shifted to a fixed feed-in tariff to enhance investors' confidence. Table 4.3 presents the tariffs offered in selected Southeast Asian countries.

Since the introduction of the FiT, Thailand has regularly increased the targeted volume of installed PV and revised tariffs in a way that reflects developments in the sector while attracting further investments. Moreover, increasing the duration of the PPA from 10 to 25 years helped increase the attractiveness of investments (Pugnatorius Ltd, 2017). The rooftop market, however, is yet to be developed due largely to both technical and regulatory constraints (IRENA, 2017d). In the last quarter of 2017, Thailand is expected to end a decade-long restriction on households and commercial buildings selling leftover power generated by their solar rooftops to the Electricity Generating Authority of Thailand at a rate fixed below Thai baht (THB) 2.6/kWh. The total capacity to be allowed, however, is not determined yet (Fredrickson, 2017).



The Philippines

The second-largest increase in installed solar PV capacity has occurred in the Philippines, where the FiT drove solar PV development into high gear. With an initial FiT of USD cents 23/kWh (20-year term and 0.6% degression rate), solar capacity jumped to 62 megawatts (MW) in 2014. Tariffs were revised to USD cents 19.58 /kWh in 2014 and installed capacity reached 108 MW by 2015. By the end of 2016, with a FiT of USD cents 17/kWh, another 17 projects made the cut bringing 2016 to a close with 903 MW grid-connected installed solar PV capacity and 3.2 MW installed for self-consumption.

Experts point out that the FiTs were high due to the extra risk for investors resulting from the Philippines' unique "first come, first served" scheme which stipulated that a project would only learn of its Energy Regulatory Commission award when the project reached commissioning stage. The unique approach discouraged lenders and placed extra risk upon project developers.

Net metering regulations and interconnection standards went into effect in July 2013 and supported the deployment of rooftop installations below 100 kW. Unlike the FiT programme, which targets 500 MW awarded on a first-come basis, there is no upper limit for the net metering market. Excess electricity exported to the grid is given a credit based on the exported quantity at the average monthly cost of generation (approximately 50% of the retail tariff). Since these net metering rules have been put into effect, there has been a marked increase in activities in the industry, and it is expected that this development will accelerate due to continued solar cost reductions and retail tariff increases.

Overall, significant future growth in solar PV capacity is expected in the Philippines; 3 GW of installed capacity is projected by 2022. As of end-2017, solar developers were still waiting for Renewable Portfolio Standards (RPS) to be enacted, and auctions to take hold with the expectation that both mechanisms will reinvigorate the growth of the renewable energy sector. In the interim, renewable energy developers, particularly for solar PV, have pursued bilateral arrangements with distribution utilities to participate in the Philippines' spot market, while waiting for the next directive.



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**Malaysia**

The growth in Malaysia has been slow but steady. Malaysia's FiT was put in place in the 2011 Renewable Energy Act and the tariffs were revised every year up to 2016 in response to falling technology costs and changing market conditions. Under its FiT scheme, the installed capacity increased modestly by about 30% each year in 2015 and 2016, to 297 MW at the end of 2016 (IRENA, 2017f). The basic FiT in 2017 for installations below 72 kW was US cents 12.17/kWh with a potential bonus FiT of up to US cents 8.06/kWh (Ho, 2017).

In 2016, Malaysia introduced a net metering scheme to support a total installation of 500 MW by 2020 in Peninsular Malaysia and Sabah, with a 100 MW capacity limit a year. Consumers can generate their own electricity with one meter installed and sell excess power to the national utilities (SEDA, 2016a).

In 2017, a solar auction resulting in 563 MW (with locational distribution of 360 MW in Peninsular Malaysia and 100 MW in Sabah/Labuan) was successful in spurring market competition. Although bidders were required to have previous experience in project financing and operation of power plants, the auction attracted almost 1 632 MW of submissions in the Peninsula and 190 MW in Sabah. Project capacity was constrained to between 1 to 30 MW, and bidders were inclined toward large-scale projects in the Peninsula: 1 198 MW were received for projects between 10 and 30 MW, 172 MW for projects between 6 and 10 MW, and 72 MW for projects between 1 and 6 MW (Kenning, 2017). Foreign participation was capped at 49%, in line with the government's strategy to support the local industry, and projects were to be commissioned in 2019 and 2020 (Bakermckenzie, 2017). Prices were in the range of US cents 8-12/kWh (MYR 0.34-0.53/kWh), less than the administratively set FiT (Kenning, 2017).

Malaysia's solar market also receives fiscal support. Corporate tax incentives are available with additional incentives in place for solar systems. Solar systems

are eligible for a capital allowance (initial allowance of 20% and annual allowance of 14%) enabling tax deductions over a period of six years (Hasilnet, n.d.).

**Indonesia**


A FiT program was first introduced in 2002 when the Ministry of Energy and Mineral Resources (MEMR) issued a regulation for small-scale renewable power plants below or equal to 1 MW. In 2013, an auction scheme for 172.5 MW of solar capacity across dozens of sites was announced (Parnell, 2013). The auction scheme was not successful and was cancelled in 2015 due to issues with local content requirements and premiums. In 2016, a new regulation on local content was issued for solar PV according to a set of requirements from the Ministry of Industry (ACE, 2016b).

A net metering scheme for residential and commercial rooftops was mandated in 2013, obliging PLN to credit excess energy produced by solar through a bidirectional meter to a customer's account. Credits were to be carried forward indefinitely.

In 2017, the government approved a decree that changed the FiT from a predetermined fixed tariff to a new tariff that is based on the cost of electricity generation, which varies from region to region. This was meant to encourage the deployment of renewable-based power outside Java-Bali. The tariff is negotiated between the IPP and PLN, as the state-owned power utility was unwilling to sign renewable power contracts with higher fixed tariffs. The new law provides a cap based on the electricity supply costs of the region where the project is to be developed (costs vary greatly across Indonesia's different regions and islands). As such, regions with supply costs above the national average receive a FiT capped at 85% of the average. Regions with supply costs lower than the national average are expected to negotiate bilaterally between developers and PLN. The national average supply cost in 2016 was US cents 7.4/kWh (IDR 13 307/kWh), meaning that the new decree implies a significant reduction in

the solar tariff of almost 50% (from the previous FiT to between US cents 6.5–11.6/kWh). Moreover, the set tariff is fixed throughout the term of the PPA, whereas PPA tariffs for conventional power projects are indexed to inflation and foreign exchange rates. The new law puts solar power in direct competition with coal-fired power plants, and since coal is the predominant form of power generation in Indonesia, this puts solar options in a challenging position.

Other countries are also showing willingness to utilise new programmes to spur investment in solar. In mid-2017,  Viet Nam's first solar PV FiT programme and PPA template were launched, gaining considerable attention from regional project developers and investors. A pilot auction for 50 MW was also launched and a net metering scheme was introduced.  Cambodia, with the support of the Asian Development Bank (ADB), signed its first PPA for a large-scale solar (10 MW) project and within months announced the launch of a 100 MW solar park to be competitively tendered with ADB assistance.

Furthermore, countries with existing solar programmes have revised and increased solar targets recently. In 2017, the  Singaporean government doubled-down on its goal of 300 MW of solar PV by 2020 in the city-state, by upping its target for 1 GW beyond 2020. As of late-2017, Singaporean authorities announced plans for tendering 56.7 MW of two floating solar PV plants at reservoirs (Osborne, 2017).

POLICIES TO SUPPORT THE LOCAL SOLAR INDUSTRY

To maximise the benefits of renewable energy to their economies, Southeast Asian countries have adopted policies to support the development of a local industry for solar PV. Malaysia, for example, aims to be the second-largest producer of solar PV modules in the world by 2020. In 2015, Malaysia was the third-largest exporter of solar PV modules, contributing to 12% of total global shipments with almost 51 MW (after China at 48% and Taiwan at 20% and ahead of Japan at 6%) (SEDA, 2016b).

The development of the local solar industry was mainly driven by the proximity of Southeast Asian countries to Chinese markets and the spinoff of technologies, the existence of a competitive semi-conductor sector, the potential for Chinese companies to ship equipment to European and American markets without being subject to anti-dumping rules and the large potential for those countries to adopt solar technologies. As such, policies enabling the development of the industry were put in place, including education, research and development, and instruments to incentivise the use of locally sourced products and services.



04 Education and research and development

The development of a local industry in the region benefited from complementary policies such as those aiming at attracting foreign direct investment (FDI), which resulted in a significant share of the global investments flowing into solar manufacturing. To support those investments, countries in the region implemented a mix of policies to support research and development and education in the sector; in this regard, Malaysia's National Renewable Energy Policy and Action Plan is exemplary.

In addition to designing and implementing a renewable energy advocacy programme consisting of communication efforts with stakeholders and the general public to increase knowledge and understanding, the Malaysian plan focused on supporting technology and innovation through adequate financing and developing human capital in the field. The need for skilled people was addressed through actions designed to build local expertise and provide individuals with the appropriate incentives to acquire these skills. These actions were co-ordinated among various ministries (finance, higher education, human resources) and included (IRENA and CEM, 2014):

- Incorporating renewable energy into technical and tertiary curricula, requiring collaboration with relevant ministries and certification of training courses according to the National Skills Development Act;
- Developing training institutes and centres of excellence, meeting international quality standards for renewable energy education and promoting high-class facilities at universities; and
- Providing financial support, including technical training subsidies that are paid to individuals after they have completed renewable energy courses, and fiscal relief for higher education that allows students to treat payable fees as deductible expenses.

2 / 1 USD = MYR 4.31 in 2017

Incentivising local products and services

Some countries have introduced additional incentives for the use of locally manufactured products. For example, when introduced, the Indonesian FiT provided additional tariffs for ensuring a minimum local content of 43.8%. This was also the case of the Malaysian FiT that provided an additional US cent 1/kWh (MYR 0.05/kWh)² for the use of locally manufactured or assembled solar PV modules and an additional US cent 1/kWh for the use of locally manufactured or assembled solar inverters (SEDA, 2017). In addition, the Malaysian auction capped foreign participation at 49%.

POLICIES TO SUPPORT THE DEPLOYMENT OF WIND ENERGY

The potential for wind energy in Southeast Asia is significant, with substantial resources in several countries Indonesia, Lao PDR, Myanmar, the Philippines, Thailand and Viet Nam (see section 3.1). The Philippines and Viet Nam alone have an estimated 100 GW of combined potential. However, the hotspots of wind development in recent years reflect the fragmented policy landscape across the region. Despite stated national targets for wind energy – ranging from an ambitious 2 GW in Viet Nam and 1.5 GW in Indonesia by 2025 to a modest 73 MW in Lao PDR by 2025 – no country stands out as a thriving market, due to a dearth of long-term policy frameworks.

FiT programmes ensuring power purchases and priority grid connections have encouraged wind project development in the Philippines, Thailand and Viet Nam, leading to nearly 1 GW of collective installed capacity, but development has slowed as governments have started considering shifting from FiTs to other schemes such as auctions. In the Philippines and Thailand, wind FiTs are no longer favoured by the national governments. In the Philippines, the wind industry is waiting for the RPS to be announced in 2018, which is expected

to reinvigorate renewable energy investment. FiT incentives remain in Indonesia and Viet Nam, but in both cases, are perceived as unattractive by most international developers, due to either unfavourable tariff levels or insufficient PPA templates.

Despite the lack of supportive incentives and long-term policies, some wind developers are still finding opportunities in the market. Indonesia's first utility-scale wind power project will come online in 2018, a 75 MW project in South Sulawesi. Viet Nam has approximately 150 MW of operational wind power and more than 1 GW of additional supply in the pipeline, waiting for revisions to the PPA rules. Thailand saw an uptake of wind power investment in late-2017 when USD 1.14 billion was secured by one wind project developer to finance 450 MW of onshore wind farms (Reuters, 2017).

Looking forward, the realisation of the region's large potential in wind energy will largely depend on strong national policies and programmes. As seen with the spike in investment that corresponded with FiTs, developers in the region will be poised to move forward rapidly as PPA templates are revised and improved, and in some countries, as auctions and competitive tendering are rolled out.

POLICIES TO SUPPORT THE DEPLOYMENT OF HYDROPOWER

Hydropower remains the leading source of renewables-based power. More than 39 GW of hydropower is operational in the region, accounting for 75% of Southeast Asia's renewables-based capacity and almost 17% of total generation capacity. With significant amounts of the region's hydropower resources remaining untapped, a near doubling of installed capacity can be anticipated, reaching an estimated 79 GW by 2025. This holds true particularly in the Lower Mekong Basin, where hydropower takes the largest share of the power mix in Cambodia, Lao PDR and Myanmar, and plays a significant role in Viet Nam and Thailand.

As with other renewables, such as solar and wind, the main barriers to further hydropower development are inconsistent policy frameworks, unclear regulations, and mostly the social and environmental opposition that often accompanies large hydro projects. Each country is approaching these challenges differently. In Lao PDR, already nearly 100% of electricity is derived from hydro, and the government plans to develop an additional 24 GW of capacity in the coming years, primarily for export. Conversely, Myanmar is in strong need of additional power with a national electrification rate hovering around 35%, but has hesitated to proceed with large hydropower projects due to significant public and civil society opposition. Looking ahead, if developers and governments are able to scale deployment of small-hydropower and run-of-river technologies that avoid some of large hydro's social and environmental risks, countries across the region will have a significant opportunity to contribute to their clean energy targets.

POLICIES TO SUPPORT THE DEPLOYMENT OF GEOTHERMAL

While rarely receiving the same level of attention compared to other renewables, geothermal power has the potential to constitute a significant share of Southeast Asia's renewable energy mix. In fact, the region is already home to one-quarter of the world's geothermal generation capacity, with the Philippines (1.9 GW) and Indonesia (1.7 GW) ranked as the second- and third-largest producers globally. Other countries such as Malaysia and Viet Nam are also beginning to show serious interest in developing their geothermal markets.

The ability of geothermal power to provide low-carbon baseload electricity further increases its importance as a renewable energy source. Despite the high levels of installed geothermal capacity in the Philippines and Indonesia compared with other countries, Southeast Asia remains far from meeting its geothermal power potential. For example, 50% of the Philippines' potential geothermal resources

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remains untapped (2 GW), while Indonesia has utilised only 5% of its potential and its government aims to install almost 7.25 GW by 2025 (ACE, 2016b).

In some cases, national policies and regulations are spurring progress in geothermal deployment. Indonesia's Ministry of Finance launched the Geothermal Fund Facility in mid-2017, a risk mitigation scheme aimed at reducing developer risk upfront. Together with fiscal incentives such as tax allowances, tax holidays and the simplification of licensing procedures, these instruments are expected to accelerate geothermal exploration and development.

Malaysia's FiT programme for renewable energy includes geothermal and resulted in a 30 MW project in Sabah, the country's first, expected to be operational by mid-2019.

Conversely, a lack of supportive policies hinders the growth of geothermal in some cases. The Philippines, which aims to build another 1.2 GW of geothermal capacity by 2030, has seen geothermal development slow substantially because of the government's lack of support for a third round of FiTs for renewables.

Moving forward, Indonesia is expected to become a leader in geothermal development, due to its significant natural resource availability and government support programmes. Other countries will also be able to increase geothermal investment if governments implement policies to minimise investor risk upfront, a key prerequisite in an industry where exploration can be expensive and sometimes unsuccessful.

To achieve the set targets, important drivers – including clear policy frameworks and robust institutions – are needed to scale up investment and deployment of renewables in the region. In this context, Indonesia and the Philippines have joined the Global Geothermal Alliance, an initiative launched at COP21 in December 2015 with the aim to enhance dialogue, co-operation and co-ordinated action among public, private, intergovernmental and non-governmental actors to improve the enabling

frameworks for investments for geothermal power generation and direct use.

However, other areas of policy and planning still lack in several of the countries, such as dispatch planning to accommodate for higher levels of variable renewable energy entering the electricity mix in future years. Very few countries in the region have a well-developed dispatch system (i.e. SCADA systems, automatic control over generators, grid codes, etc.), typically an important criterion to scaling up an electric system's share of wind and solar.

In addition, most Southeast Asian countries continue to lack fully transparent land permitting processes, which lead to lengthy and expensive land acquisitions and project development delays and cost overruns. In some cases, land ownership is disputed by other parties, putting projects and investment in jeopardy.







4.4 POLICIES FOR RURAL ELECTRIFICATION AND ENERGY ACCESS

Policies for rural electrification and energy access are crucial in Southeast Asia, as 65 million people remain without access to electricity, primarily in Cambodia, Indonesia, Myanmar and the Philippines (IEA, 2017a). Nevertheless, collectively, Southeast Asian countries have made great progress in improving electricity access following years of government-backed policies and programmes to extend the national grid and distributed generation solutions. Between 2000 and 2016, more than 170 million people gained access to electricity across the region (largely through grid extension and diesel power for remote areas), and the total electrification rate rose from 62% to 90% by 2016 (IEA, 2017a).

The energy access landscape in Southeast Asia is diverse, with variation across and within countries. For example, more developed economies have already achieved universal or near-universal electrification (including Brunei Darussalam, Malaysia, Singapore, and Thailand) and emerging markets are pursuing

development programmes to close the access gap in remote and rural areas (including in Cambodia, Indonesia, Lao PDR, Myanmar, the Philippines and Viet Nam) (Table 4.4).

Table 4.4 Rural electrification targets, programmes and regulations

Country	Electrification rate	Rural electrification target	Programmes and regulations
 Cambodia	60%	<ul style="list-style-type: none"> • Access to electricity in all villages by 2020 • Access to quality grid electricity among at least 70% of households 	<ul style="list-style-type: none"> • Power to the Poor (P2P) programme • Rural Electrification Fund provides loan guarantees for infrastructure in high-density areas; grants and interest-free loans for low-density areas
 Indonesia	91%	<ul style="list-style-type: none"> • Universal electricity access by 2020; approximately 2 500 villages to gain access • Access to electricity in inhabited villages categorised as less-developed, remote, frontier and small islands 	<ul style="list-style-type: none"> • Rural electrification regulation provides the framework for private business entities to service un-electrified regions through business area concessions; provides ways to calculate and receive electricity subsidies from the government
 Lao PDR	78%	<ul style="list-style-type: none"> • 7th 5-year development plan of energy and mines (2011–15) • Draft 5-year plan on energy development for the period 2016–20 	<ul style="list-style-type: none"> • 2012 Electricity Law legally allows mini-grids to operate in the country • World Bank and Global Environment Facility Rural Electrification Projects
 Myanmar	52%	<ul style="list-style-type: none"> • Universal electrification by 2030 	<ul style="list-style-type: none"> • World Bank National Electrification Program • 2014 Electricity Law
 The Philippines	89%	<ul style="list-style-type: none"> • Universal electrification by 2022, according to Philippine Development Plan 2017–22 	<ul style="list-style-type: none"> • 2011 Sitio Electrification and Barangay Line Enhancement Program • Power supply in off-grid areas is mandated to electric co-operatives operating local distribution grids; power is usually supplied from diesel generators operated by the Small Power Utilities Group of the National Power Corporation
 Viet Nam	99%	<ul style="list-style-type: none"> • Universal access by 2020 • Power Development Plan VII 	<ul style="list-style-type: none"> • Cash transfer scheme to low-income electricity users • 2013 programme on electricity supply to rural, mountainous and island areas 2013–20 • 2014 MOIT Circular guidance on formulation, evaluation and approval of projects and implementation of investment projects in off-grid rural electricity supply from renewable power sources

Sources: IEA, n.d. and World Bank and SE4ALL, 2014.

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Indonesia's electricity access efforts are concentrated in the provinces that are home to the country's 2 500 un-electrified villages, mainly in East and Central Java, East Nusa Tenggara and Papua. The government's plans are tailored to each province's population density, geography and available supply, combining grid extension and distributed solutions (such as renewable, diesel and hybrid mini-grids). The national utility is providing a significant amount of financing for implementation of these electrification plans, but the government is also taking steps to incentivise private sector participation in the market. In 2016, Indonesia's Ministry of Energy and Mineral Resources published regulations that enable the private sector to serve off-grid communities through business "concession areas," where private companies can act as integrated utilities that generate (often renewable) power and transmit or distribute that power to households. The regulations also provide methods for these private companies to calculate and receive government subsidies to close the gap between their costs and customer tariffs.

In Myanmar, several international organisations are partnering with the government to stimulate the implementation of the National Electrification Plan. With the World Bank's USD 400 million loan, the government will extend electricity to over 1 million households, 60% of which will connect to the national grid and 40% through off-grid solutions, by 2021. In the near term, this translates to the government tendering over 500 000 solar home systems between 2016 and 2018. In addition, IFC Lighting Myanmar is supporting the development of a commercial market for stand-alone solar systems. The Department of Rural Development, with the technical assistance of the German government, is piloting public-private investment models for mini-grids, where companies are eligible for partial subsidies if they participate in the government programme.

In the Philippines, rural electrification is categorised at three levels, those of the barangay (village, the smallest formal political unit), sitio (informal cluster of households) and household. According

to a June 2016 report of the National Electrification Administration, the Philippines has achieved 100% electrification at both the barangay and sitio levels. Household-level electrification, however, is only at 90.65%, with some 9% of the total still not electrified. The Philippines aims to achieve 100% household-level electrification across the country by 2022. The Philippines power sector is largely unbundled and privatised, but the government maintains a National Power Corporation to provide subsidised electrification services in off-grid "missionary" areas, where project economics are not viable for private sector players, although schemes do exist for private companies to provide electrification services as well. In these missionary areas, power is usually generated from diesel or oil, both of which are costly; thus, distributed renewable energy solutions offer a promising alternative. The government issues cash incentives to developers providing renewable energy solutions in these missionary areas.

In addition, any qualified off-grid power generation is eligible to apply for the Universal Charge for Missionary Electrification subsidy, which could cover the difference between the (regulated) customer tariff and the true cost of generation. Furthermore, in Mindanao in particular, the government is offering grants to electric co-operatives to support electrification projects and the European Union has funded solar home systems in off-grid areas. With some of the highest tariff rates in the region combined with government incentives, the Philippines off-grid market is particularly primed for private investment. There are two main avenues for private sector participation: applying as a "qualified third party" or becoming a "new power provider." The first of these two schemes covers both generation and distribution in areas without connection to the national grid, while the local utility waives its right to service the un-electrified area. The second scheme covers only generation, as distribution is still through the local utility.

With falling technology costs and abundant renewable energy resources in Southeast Asia,

distributed solutions offer an increasingly attractive way to achieve electrification targets in the region. Improved policy and regulatory frameworks, cost-reflective tariffs and appropriate financial products will be essential to catalyse successful distributed renewable energy business models in the region.

Rural electrification is only part of the equation and more attention is needed for other end-uses such as heating. Many programmes have been implemented with the help of international aid, and innovative business models have been put in place to increase access to decentralised solutions and deliver benefits (see chapter 6). The focus of policies on electricity is not only in areas that lack access to energy. Even in areas with access, policies to advance heating and cooling and transport are not as developed. Nevertheless, about half of the potential for modern renewable deployment by 2025 is in end-use sectors like renewable fuels or the direct use of renewables for heating, cooking and transport.



4.5 RENEWABLE ENERGY POLICIES IN HEATING, COOLING AND COOKING

The Southeast Asian countries have ample renewable energy resources that create opportunities for the deployment of cost-effective renewable technologies for heating, cooling and cooking. The region has major potential for modern bioenergy cookstoves for households and increased use of bioenergy in process heat generation and in co-generation of power and heat, as well as in solar thermal for lower-temperature industrial processes.

CO-GENERATION

A few countries are taking advantage of co-generation to ensure reliable heat and electricity supply for industrial uses and factories. Based on the Government of Thailand's plans, co-generation is expected to account for 11% of all new installed capacity between 2015 and 2026 (IEA, 2017a) (Box 4.3). Viet Nam set 2020 and 2050 targets for increased use of biomass for heat generation and also introduced a biomass FiT for combined heat and power projects that incorporates 20-year PPAs to incentivise biomass cogeneration. Lao PDR has also set specific heating targets from biomass, biogas and solar within its broader renewable energy targets. However, governments across the region could do more to introduce financial incentives, tax exemptions or purchase guarantees for bioenergy process heat generation, the co-generation of power and heat, and solar thermal options for relatively low-temperature industrial processes. With additional bioenergy targets and supporting policy structures, Southeast Asian countries could better position themselves to take advantage of efficient, cost-effective renewable technologies for heating, cooling and cooking.

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Box 4.3 Thailand encourages co-generation through small power producers

Thailand's Small Power Producer (SPP) programme helps distributed power generators using renewables or co-generation technologies sell their electricity directly to industrial customers. The Electric Generating Authority of Thailand purchases up to 90 megawatts (MW) of co-generated power or renewable power for each small power producer. This benefits customers by increasing the reliability of supply and benefits producers by providing purchase guarantees that incentivise co-generation through renewables. The programme has successfully reinforced the national electricity system, with 15% of new installed power generation capacity in 2016 stemming from the SPP programme and co-generation facilities accounting for 70% of the SPP programme's 2016 capacity.

Source: IEA, 2017a.

**SOLAR HEATING**

For other heating applications, cost-effective technologies such as solar thermal have been underutilised. Solar water heaters are not widely used across the region, but could make up one-fourth of the additional capacity for heat generation needed for industrial processes over the next several decades – if countries introduce tax exemptions or other incentives to prompt producers to adopt this cost-effective technology. In residential or commercial buildings where natural gas or liquefied petroleum gas (LPG) is used to heat water, solar thermal can offer a technological alternative that is highly affordable across the region. And when efficiently utilised for cooking, modern bioenergy sources can be a cost-effective substitute for natural gas or LPG.

CLEAN COOKING

Robust policy frameworks to support clean cooking across Southeast Asian countries are also lacking, although nearly 40% of the population still relies on inefficient fuel wood and charcoal for cooking. The use of inefficient biomass for cooking is still prevalent, but households are gradually shifting toward LPG. With additional policy support, modern solid and biogas cookstoves have great potential to replace traditional cooking fuels, and by 2025 the region could have 12.5 million modern cookstoves, 2.5 million biogas cooking installations and 0.4 million biofuel cookers in operation (IRENA and ACE, 2016). By 2040, the portion of the population relying on fuel wood and charcoal for cooking could fall from 40% to 25% if clean and sustainable cooking alternatives are incentivised through policy-based solutions such as introducing rebate programmes to encourage households to purchase modern solid and biogas cookstoves.

4.6 RENEWABLE ENERGY POLICIES IN THE TRANSPORT SECTOR

The transport sector is an area of rapid growth across countries. Rising demand is expected to increase the number of vehicles on the roads to 62 million by 2040, a two-thirds increase from today (IEA, 2017a). The transport sector in Southeast Asia currently has the lowest share of renewables, but the highest potential for increased deployment through greater utilisation of biofuels, electric vehicles and sustainable urban transport. Biofuels have been the main focus of transport policy support across the region but policies have also been put in place for electric vehicles (EVs) and sustainable public transportation (Table 4.5).

BIOFUELS

Biofuels have significant growth potential in Southeast Asia and the majority of countries already have some form of biofuel policy in place. Blending mandates are a popular policy instrument to shift away from a transport sector dominated by oil products and diversify toward a fuel mix that incentivises domestic production of biofuels. Biofuel mandates are expected to more than double the use

of bioenergy in the transport sector by 2040. These policies are particularly impactful in major palm-oil-producing countries like Indonesia, where a 20% biodiesel blending mandate was introduced, along with ambitious targets for biodiesel and bioethanol in 2020 and beyond (Box 4.4). Policies in other key countries are also promoting the increased use of biofuels in the transport sector. These include the pioneering 2007 biofuels legislation in the Philippines, Viet Nam's E5 ethanol blending mandate, Malaysia's B7 blending policy that it has committed to increase to a B10 mandate and mandatory biodiesel blending and trial programmes in Thailand. Thailand supported E20 and E85 blends at the pump as well as a trial programme for the use of B20 in trucks and B10 for military/government use in 2016.

As countries increase their use of modern biofuels, it is important to consider sustainable land use policies to ensure that increased production does not jeopardise sustainable forest management. This balance is particularly key for major palm oil producers like Indonesia, Malaysia and Thailand, where biofuels can reduce petroleum imports, support domestic industries and reduce emissions if palm oil production is sustainably managed.

Table 4.5 Policies for sustainable transport in Southeast Asia

	Biofuels blending policy mandate	Fuel economy standards or vehicle efficiency incentives	Electric Vehicle (EV) target	Fiscal incentive or tax exemption for EVs	Sustainable public transport strategy or incentive
Brunei					
Cambodia					
Indonesia	X	X	X	X	X
Lao PDR	X				X
Malaysia	X	X	X		X
Myanmar					
Philippines	X		X	X	X
Singapore		X		X	X
Thailand	X	X	X	X	X
Viet Nam	X	X		X	X

Sources: CNN, 2017; FT Confidential Research, 2017; LTA (n.d.);

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Box 4.4 Indonesia's biofuel mandate supported by research and development funds

Indonesia is the world's largest palm oil producer and has effective policies that promote the production and use of biofuels. Indonesia introduced biofuel consumption mandates in 2008 which were increased in 2013 and again in 2015. The mandate now requires a 20% biodiesel blend that is expected to reach 30% in 2020, as well as a 5% bioethanol blend in gasoline that is planned to reach 10% in 2020 and 20% in 2025.

In 2015, the Indonesian government also established a palm oil fund to contribute to biodiesel research and development and spur the growth of the industry. These biofuel policy instruments are being utilised to advance the Indonesian government's broader efforts to reduce fuel imports and encourage economic growth in key industries.

Sources: Climatescope, 2017; Climate Policy Database (n.d.-a,b); TransportPolicy.net, 2017.



Moreover, although biofuel targets and mandates can serve as effective transport policy instruments, a range of other measures can be implemented to further increase the sustainability of transport, including vehicle efficiency incentives. Several countries have taken steps to improve efficiency in their transport sectors. Examples include Malaysia's energy-efficient vehicle incentives and Singapore's fuel labelling and emissions scheme that offers tax rebates for low-emission cars and imposes surcharges on vehicles that emit more than the designated threshold.

Viet Nam is the only country in the region with an established fuel economy standard applicable to cars with up to seven seats. Brunei Darussalam, Indonesia, the Philippines and Thailand are considering options for introducing fuel economy standards, but in the absence of significant standards across the region, Southeast Asia's fuel economy is projected to be 20% worse than the global average in 2040 (IEA, 2017a).

ELECTRIC VEHICLES

Electric mobility is attracting attention across the region. While Southeast Asian countries have not yet implemented robust policy frameworks to promote the deployment of EVs, several countries have set targets and incentives for EVs to kick-start the electrification of the transport sector.

It is estimated that by 2025, the region could have 59 million electric two- to three-wheelers and 8.9 million electric four-wheel vehicles, comprising approximately 20% of passenger automobiles on the road (IRENA and ACE, 2016). Increased demand for electric mobility has the potential to be met in part by regional manufacturers. Thailand is already the region's largest car manufacturer and is taking steps to spur EV manufacturing through policy measures like tax incentives and a target to reach 1.2 million EVs on the road by 2036 (Box 4.5). Indonesia has shown a recent interest in encouraging EV development by considering revisions to its tax scheme to offer higher tax breaks for low-emission vehicles and by making plans for the necessary charging infrastructure. The Philippines is exploring

Box 4.5 Thailand and Malaysia plan for the local manufacturing of EVs

Thailand and Malaysia are looking to boost their domestic electric vehicle (EV) manufacturing, but they are taking very different approaches to electrify their transport sectors.

Thailand is using policy instruments to incentivise EV production such as waiving tariffs, offering tax incentives for manufacturing and assembling EV parts domestically, and promoting the installation of charging stations across the country. These incentives coupled with new investments from major manufacturers like Nissan, Toyota and BMW are helping Thailand progress toward its goal of having 1.2 million EVs on the road by 2036.

Malaysia has a smaller auto industry and is taking a different approach. In 2014, Malaysia eliminated its tax incentives for EVs and instead redoubled its efforts to work directly with manufacturers. The Malaysian government is partnering with Chinese companies on specific deals to advance Malaysian EVs and make progress toward its goal of 100 000 EVs and 2 000 electric buses on Malaysian roads and 125 000 charging stations installed by 2020.

Source: FT Confidential Research (2017).

the benefits of a tax exemption for EVs that would advance progress toward its national target of one million EVs on the road by 2020, an inclusive target that counts all electric motor vehicles that can run 30 kilometres (km) on a charge. Singapore is focusing on policy-based consumer incentives such as tax rebates for EVs and hybrids that pass specified emissions tests. Whether targeting manufacturers or consumers, Southeast Asian countries will need to adopt more comprehensive policy frameworks including fiscal incentives, tax exemptions and incentives for investments in charging infrastructure to meet the region's growing mobility demand with EV solutions that enhance economic productivity, air quality and energy security.

SUSTAINABLE PUBLIC TRANSPORT

The rapid growth of cities in Southeast Asia makes sustainable public transport a critical component of any national transport policy framework. Several countries have some type of sustainable urban transport strategy or incentive in place, but all could do more to develop a comprehensive public transport policy that fully utilises renewable technologies and makes public transport an attractive alternative to individual transport. Mass transit networks can help

alleviate traffic, reduce air pollution and shift transport from roads to rails. Most countries are still at an early stage of this process, and are taking actions such as developing Nationally Appropriate Mitigation Actions related to transport. Accelerating the adoption of more comprehensive policy frameworks with key incentives could unlock additional investment in sustainable public transport infrastructure.

4.7 CONCLUSION

Overall, Southeast Asia carries great promise for scaling up renewable energy deployment over the coming decades. Enabling environments that include comprehensive policy frameworks, fiscal incentives, strong targets and robust institutions are necessary to attract private investment and accelerate the deployment of cost-effective renewable energy solutions across a variety of sectors. To meet regional deployment targets, renewables will be needed for on- and off-grid electricity, transportation, heating, cooling and cooking applications. The current patchwork of policies across these diverse markets show that Southeast Asian countries are taking important initial steps, but ample opportunities remain for improving the overall renewable energy policy and regulatory environment.



RENEWABLE ENERGY INVESTMENT AND FINANCE

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As discussed in the previous chapter, several countries in the region have adopted a wide range of policies to support renewable energy development across the different end-use sectors. A closer look at the investments these have catalysed reveals interesting trends and also barriers. This chapter considers the investment trends, evolution of the capital mix, and identifies key financing barriers faced by the sector.

5.1 RENEWABLE ENERGY INVESTMENT IN SOUTHEAST ASIA

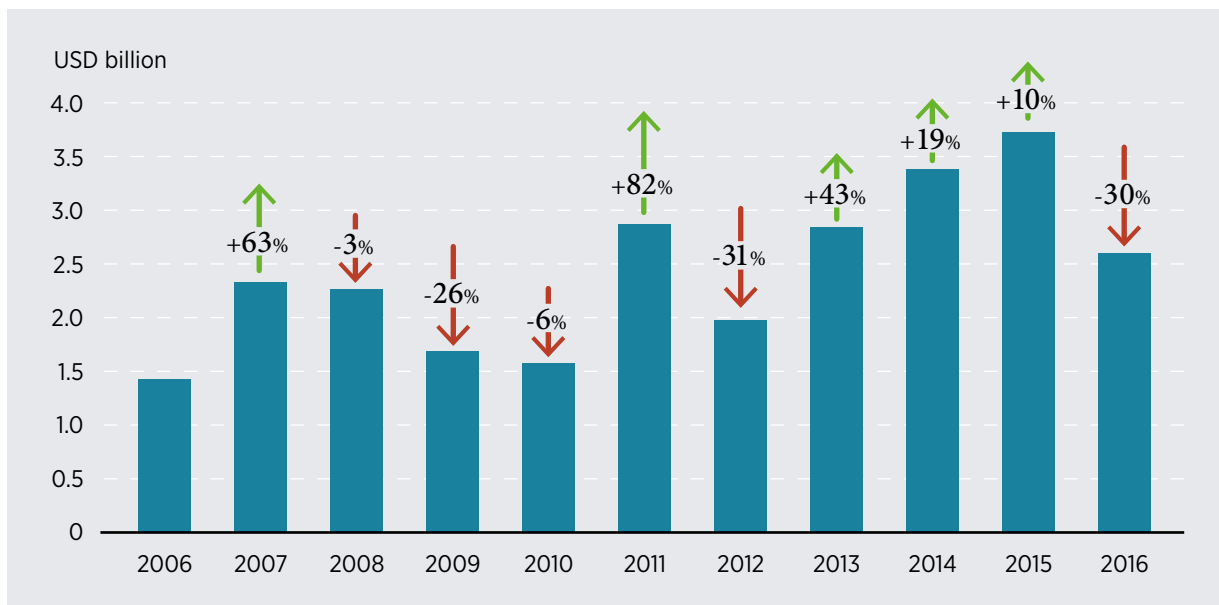
In 2016, renewable energy investment in the power sector (excluding large hydropower) was over USD 2.6 billion<<footnote 1>>. This represents about 1% and 2% of global and Asia-Pacific investment in renewable energy, respectively (BNEF, 2017). Over the preceding decade, investments in the sector had fluctuated significantly. Given the relatively small size of the market, a few large-size deals (hundreds of millions) can widely swing annual investments, as can changes in national policy and regulatory frameworks (see Chapter 4). For example, investment increased by more than 60% in 2007 driven by the development of bioenergy projects in Thailand, and steadily declined in following years, until a new, isolated, peak was registered in 2011

thanks mainly to growth in investments in Thailand and Indonesia. After 2012, investment again grew steadily at an average annual rate of 24%, peaking in 2015 at USD 3.8 billion (Figure 5.1).

Overall, nearly USD 27 billion was cumulatively invested between 2006 and 2016. Thailand attracted the bulk of cumulative financing, with over USD 10 billion invested, or close to 40% of the total. Indonesia and the Philippines followed, each accounting for about 20% of the total cumulative investment. In 2016, the order of the top investment destinations remained largely unchanged: Thailand led the pack, attracting almost USD 1.3 billion – more than half the investments across the countries – and recording the highest level of activity in the Asia-Pacific region after India and China (REN21, 2017). Indonesia and Singapore followed with USD 577 million and USD 575 million, respectively (Figure 5.2). The rise in investments in Singapore is the result of a strong focus on solar rooftop deployment (and novel applications such as floating solar). The reduction in total investments in 2016 compared with the previous year was mainly due to reduced investment activities in the Philippines (down by 90% compared with 2015), as well as the lower unit costs of solar investments.

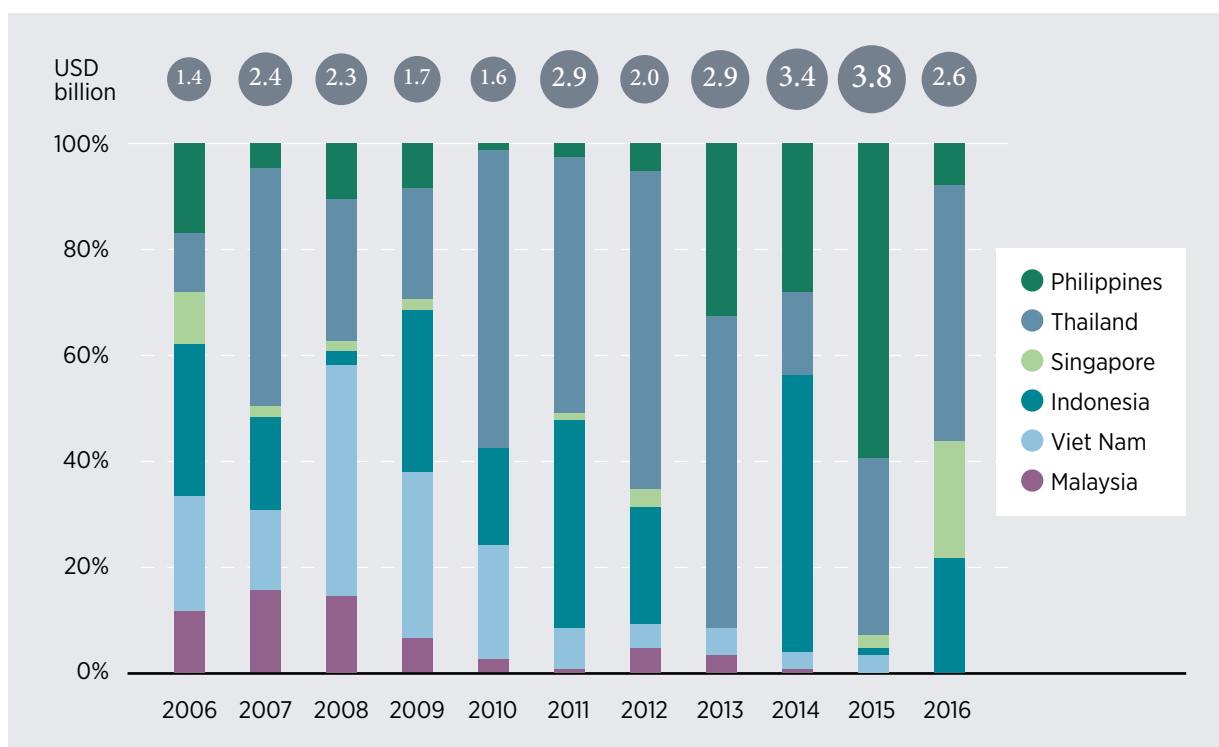
1/ This includes investment in the six major markets: Indonesia, Malaysia, the Philippines, Singapore, Thailand and Viet Nam. Because of data limitations, investments in Brunei Darussalam, Cambodia, Lao PDR and Myanmar are not included.

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Figure 5.1 Investment in renewable energy in the power sector, 2006–16 (USD billion)

Source: BNEF, 2017.

Note: Based on power sector asset finance data for Indonesia, Malaysia, the Philippines, Singapore, Thailand and Viet Nam.

Figure 5.2 Investment in renewable energy in the power sector by country, 2006–16 (USD billion)

Source: BNEF, 2017.

Note: Based on power sector asset finance data for Indonesia, Malaysia, the Philippines, Singapore, Thailand and Viet Nam.

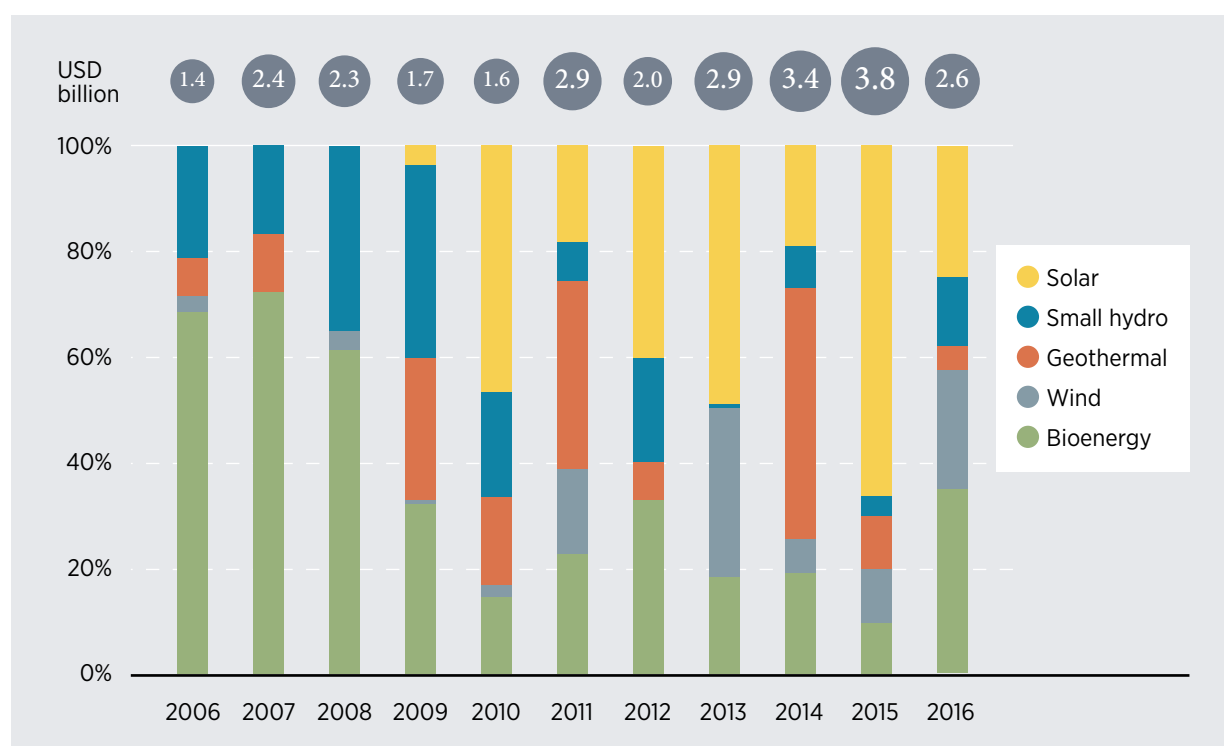
A decline in investment over the past decade was recorded in Malaysia and Viet Nam. In Malaysia, growing investments in solar photovoltaic (PV) during 2011-14 did not compensate for a drop in activities in the bioenergy sector. In Viet Nam, a decline in renewable energy investment was driven by a decrease in financing in the small hydropower and bioenergy sectors. Investment dramatically increased in the Philippines over the years 2013-15, mainly for new solar PV and wind projects.

In terms of technologies, in 2016, USD 920 million went to bioenergy, followed by solar, at USD 662 million, and wind, at USD 589 million (BNEF, 2017) (Figure 5.3). Investments in geothermal projects fluctuated dramatically from year to year, peaking in 2014 as large plants reached financial closure (including the Sarulla Geothermal Power Project in the North Sumatra Province of Indonesia, the

world's largest single-contract geothermal power project to date). Indonesia and, to a lesser extent the Philippines, attracted the bulk of geothermal investment in the region. In 2006-16, bioenergy received the majority of cumulative investment (32%), attracting USD 8.6 billion. Total investment of USD 7.4 billion went to solar PV, while geothermal and small hydropower received USD 4.4 billion and USD 3.8 billion respectively.

As seen in Figure 5.3, the technology composition of investment has changed over time. Until 2008 investment focused mainly on bioenergy and small hydropower, and then the range of technologies receiving financing widened as investment started flowing toward geothermal, solar PV and wind. This trend is reflected also at the country level. In Thailand and Indonesia, for instance, investment shifted from bioenergy to other renewable energy technologies.

Figure 5.3 Investment in renewable energy in the power sector by technology, 2006-16 (USD billion)



Source: BNEF, 2017.

Note: Based on power sector asset finance data for Indonesia, Malaysia, the Philippines, Singapore, Thailand and Viet Nam.

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In Indonesia, increasing shares of investment went to geothermal energy and small hydropower; whereas in Thailand, solar PV and wind took over as the top destinations for financing.

Due to a lack of time-series to represent investments in the entire renewable energy sector. Investments are also being made in non-power applications and in the development of renewable energy manufacturing facilities in the region. Malaysia, for instance, attracted nearly USD 400 million in 2016 for solar manufacturing.

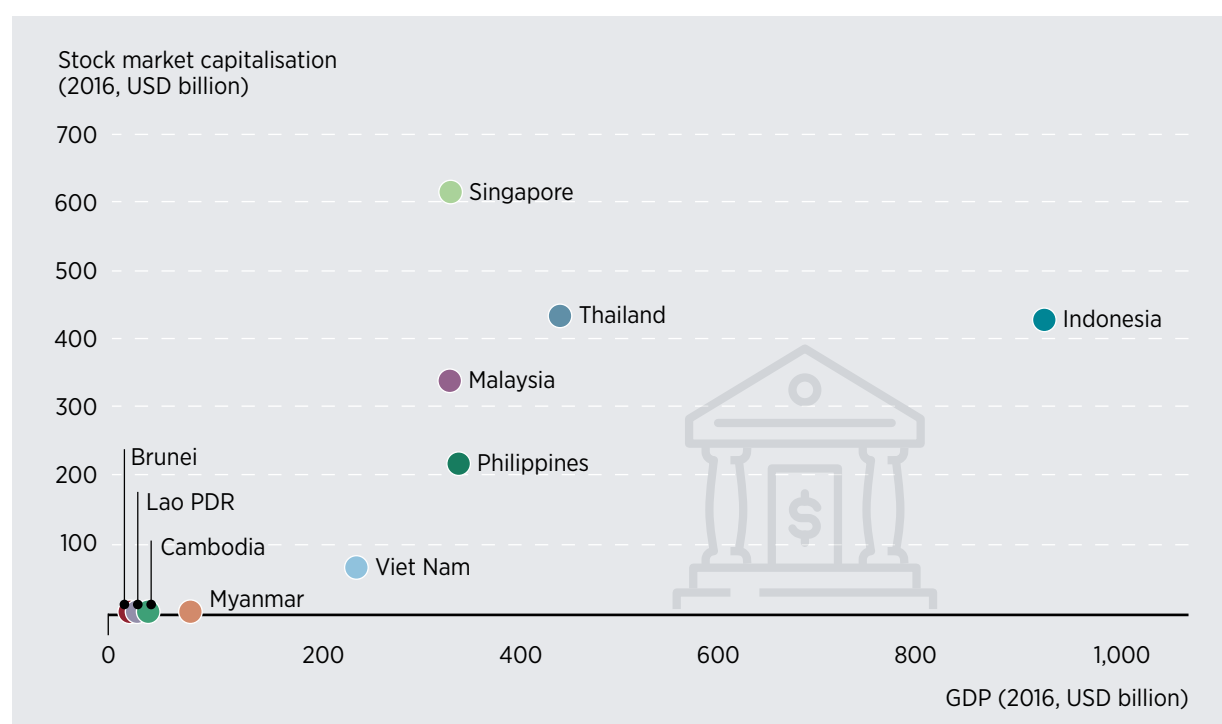
The region's renewable energy sector has reached an important milestone from an investment perspective. The sector has matured considerably over the past decade and investment activity in relatively new renewable energy technologies, such as solar PV and wind, suggests that the pool of capital available is expanding. The next section analyses renewable energy investments from the perspective of the capital mix to provide a better understanding of the different types of financing available in the region and the major stakeholders involved.

5.2. CAPITAL MIX OF RENEWABLE ENERGY INVESTMENTS

The landscape of renewable energy development in Southeast Asia is changing. The market is maturing as new financing instruments and tools are being utilised to attract wider market participation. Investment needs are significant. IRENA and ACE (2016) found that USD 290 billion of total investment in renewable energy capacity will be needed in the region to reach the target of securing 23% of primary energy from renewable sources by 2025. This means that renewable energy investment would need to be significantly scaled up to an estimated annual USD 27 billion.

The available sources of capital for renewable energy investments in the region include both domestic and international, as well as public and private. To reach the investment goal, private investments will need to be scaled up significantly requiring adaptation of financial instruments to the local conditions.

Figure 5.4 Total stock market capitalisation and levels of GDP in Southeast Asian countries



Source: World Bank, 2016b and 2016c.
GDP = gross domestic product.

Given countries' different stages of economic and capital market development, and the maturity levels of their renewable energy sectors, the capital mix varies across renewable energy projects. As Figure 5.4 illustrates, Indonesia, Malaysia, the Philippines, Singapore and Thailand are at relatively advanced stages of economic and capital market development. The country risk and general investment landscape are different in Lower Mekong countries such as Cambodia, Lao PDR, Myanmar and Viet Nam, which rely more on public institutions, such as traditional donor and development banks, to fund their infrastructure investments.

This section first discusses the role public finance institutions are playing in the region, followed by private finance institutions, private equity and capital markets, blended finance and green bonds, and climate funds. Domestic public financing institutions often offer grants or funds dedicated to supporting renewables, while international public finance institutions provide also debt and equity, increasingly in the form of blended capital. Private sources of capital include commercial banks, utilities, project developers and, to a lesser degree, specialist private equity funds. Blended finance transactions between public and private providers of capital and other industry stakeholders constitute another important and growing investment model in the region. Green bonds and climate bonds are in their initial stages, meanwhile.

PUBLIC FINANCE INSTITUTIONS

Foreign and domestic public financing institutions play an important role in funding renewable energy projects in Southeast Asian countries.

International public finance institutions

Bilateral and multilateral Development Financial Institutions (DFIs) were the most active investors in the early phase of renewable energy development in the region, up until the emergence of bankable utility-scale solar and wind projects. Even though the relative role of DFIs has decreased in the region and

that of the private sector has increased since 2010 – reflecting a transition to mainstream infrastructure investment – DFIs remain an important source of funding for infrastructure investments in many Lower Mekong countries and Indonesia.

The role of DFIs has evolved in the region, as their portfolio of financing instruments and risk exposure has expanded over the past few years. They now operate on many fronts, including capacity and awareness building, technology transfer programmes, feasibility studies, as well as technical co-operation with other donor-funded public agencies, such as Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), SNV and the United States Agency for International Development (USAID). Table 5.1 lists examples of active donor-funded technical co-operation programmes in Southeast Asia. DFIs increasingly focus on developing blended investment structures to support private-sector-led renewable energy development.

Around USD 6 billion was invested cumulatively by development banks in renewable energy in Southeast Asia between 2009 and 2016.² Figure 5.5 shows the cumulative investment in renewables provided by each development bank over the period 2009 to 2016. The World Bank, Asian Development Bank (ADB) and Japan Bank for International Cooperation (JBIC) were the largest investors, with over USD 1 billion invested by each.

As shown in Figure 5.6, development banks provided funds mainly in the form of loans (73%). While concessional loans constituted about 10% (USD 611 million) of the total investments, equity investments accounted for only 3% (USD 185 million). This represents a higher level of concessional finance and lower level of commercial rate loans when compared with global investments. Indonesia received about 60% (or USD 3.7 billion) of cumulative renewable energy investments in the region, due to high interest in geothermal energy. Other countries that attracted significant investment from development banks were Lao PDR, the Philippines, Thailand and Viet Nam.. Over recent

2 / Due to lack of available data, KfW is not included although the bank is reported to have invested in renewable energy in ASEAN countries.

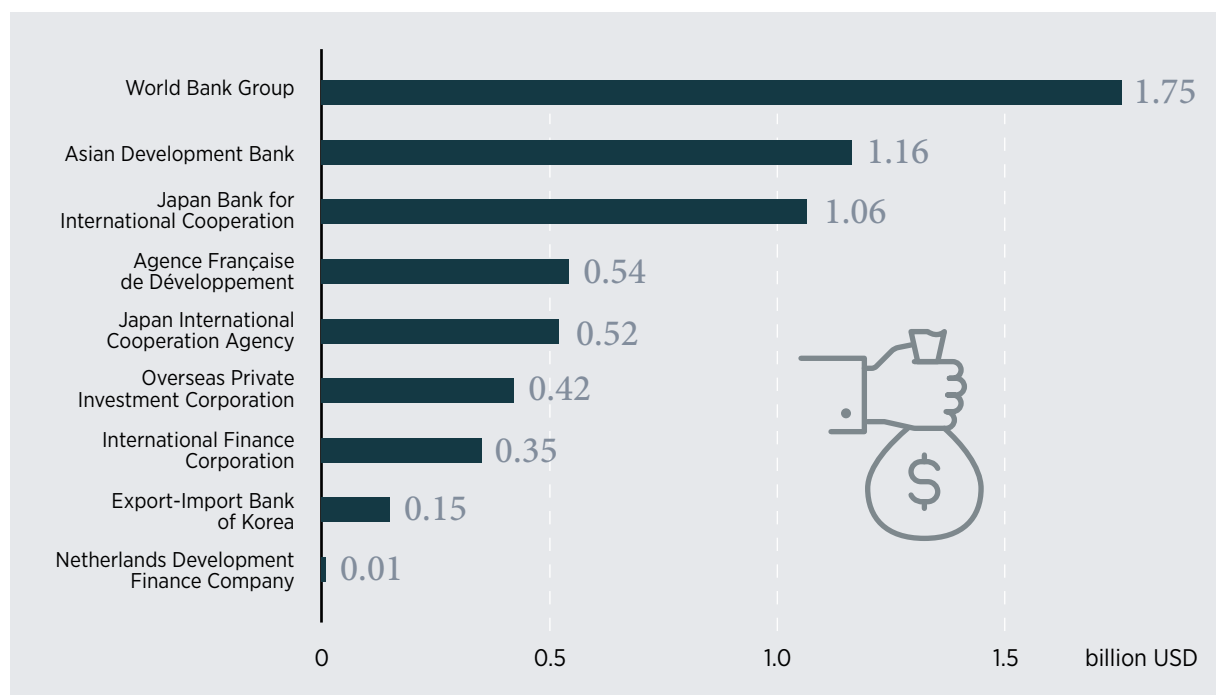
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Table 5.1 Examples of donor programmes in renewable energy in Southeast Asia

Programme name – Manager	Mission and instrument coverage
ASEAN – German Energy Programme (AGEP) – ASEAN Centre for Energy and GIZ	In contribution to the ASEAN Plan of Action for Energy Cooperation 2016 – 2025, the overall objective of AGEP is the improvement of regional coordination for the promotion of renewable energy and energy efficiency towards sustainable energy for all ASEAN Member States.
The Energy and Environment Partnership Mekong (EEP Mekong), Finland	Thirty-nine projects have been supported by providing partial grant-based funding to project developers for feasibility studies and pilot and demonstration projects in Cambodia, Lao PDR, Myanmar, Thailand and Viet Nam.
Energy Support Programme (ESP) – The Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ)	The ESP is supporting the Vietnamese government with a total budget of EUR 6 900 000 in the period 2014-18. One aim is to encourage the development of wind energy in Vietnam through technical assistance (in policy and regulation, capacity development, data collection, etc.). The GIZ also has renewable energy programs in Thailand and Indonesia.
Mekong Biogas Program and Solar Microfinance Programme (SMP) – SNV Netherlands	SNV SMP works with all programme stakeholders to ensure smooth collaboration, and manages the accreditation and verification process for solar products and suppliers. SNV also has programmes focused on the biogas segment in Viet Nam and Cambodia.
Green Prosperity Indonesia – United States Agency for International Development (USAID)	The mission of this project is to catalyse sustainable development at the local level. One of the key objectives of this USD 308.35 million project is to reduce reliance on fossil fuels and emissions of land-based greenhouse gases by expanding the utilisation of renewable energy.
Clean Power Asia (CPA) – USAID	USAID CPA is expected to mobilise at least USD 750 million in clean energy investments over the next five years in the region. It will also support installing at least 500 megawatts (MW) of grid-tied renewable energy generation and help implement laws, policies, strategies, plans or regulations that contribute to reducing greenhouse gas emissions.
Country programmes – Global Green Growth Institute (GGGI)	GGGI supports countries in developing their green growth plans. It also develops finance mechanisms and investment instruments in its member countries. It has active renewable energy programmes in Indonesia, Viet Nam, Cambodia, Thailand, Lao PDR and Myanmar.
InfraCo Asia – Private Infrastructure Development Group	InfraCo Asia funds pre-financial close, early stage, high-risk infrastructure development activities by taking an equity stake with a focus on socially responsible and commercially viable infrastructure projects that contribute to economic growth, social development and poverty reduction. By mitigating early stage development risks, InfraCo Asia facilitates private sector participation.

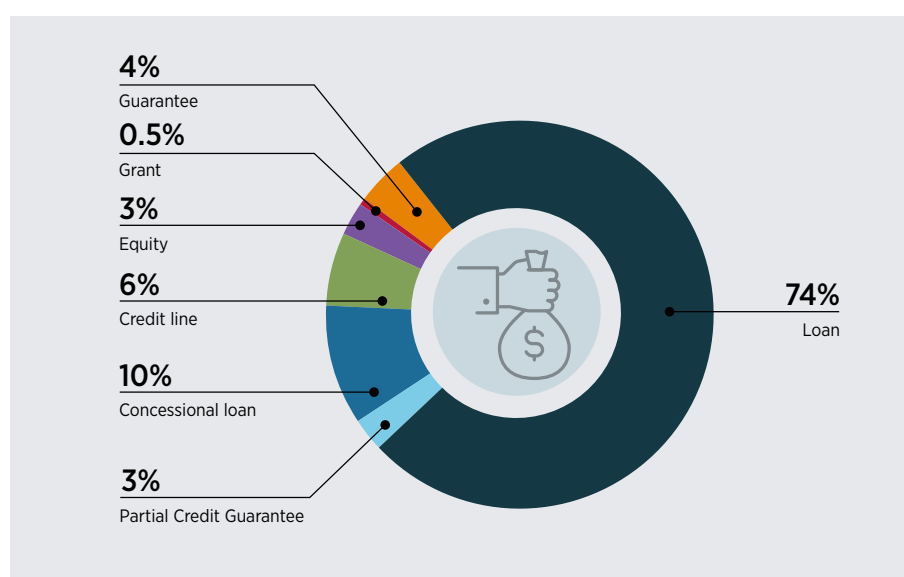
Source: EEP, n.d.; GIZ, n.d.; SNV, n.d.; GIZ, 2016; Millennium Challenge Account, n.d.; USAID, 2017; GGGI, n.d.

Figure 5.5 Cumulative investment of selected development finance institutions in Southeast Asia, 2009–16 (USD billion)



Source: IRENA, 2017h.

Figure 5.6 Development banks' cumulative investments in renewable energy in Southeast Asia by type of financial instrument, 2009–16



Source: IRENA, 2017h.

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years, development banks have started to support renewable energy deployment in Myanmar, which has one of the lowest rates of rural electrification in the Southeast Asia region.

Figure 5.7 shows the breakdown of cumulative investment by technology during the period 2009 to 2016. Geothermal energy accounts for the largest share (40%), having attracted around USD 2.4 billion. The share of geothermal was much lower in Asia (10%) and in the world (5%). Development banks have supported the geothermal sector in countries with significant geothermal resources, such as Indonesia and the Philippines, to address resource risk and fill the financing gap. The support generally targeted large geothermal plants, including the Sarulla Geothermal Power Project, which required a combination of financing from several investors, including ADB and JBIC.

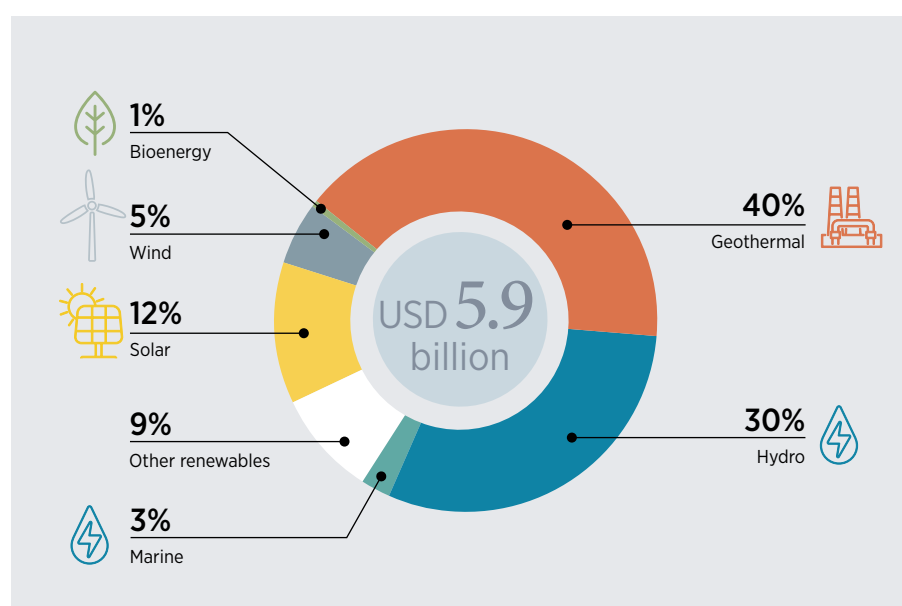
Hydropower attracted USD 1.8 billion from development banks, accounting for 30% of

cumulative investment over the period 2009–16. As in the case of geothermal, development banks supported the development of large hydropower plants such as the 290 MW Nam Ngiep 1 Hydropower Project in Lao PDR, which received financing from ADB, JBIC and the Japan International Cooperation Agency (JICA). Solar power received only about 12% of the total, and most solar investments were made in Thailand and, to a lesser extent, Viet Nam.

Domestic public finance institutions

The landscape of national financing vehicles in Southeast Asia is still fairly underdeveloped in terms of project implementation, even though several countries are now aiming to build national financing vehicles and green banks to gain access to international climate finance. Technical structures are up and running and the next defining phase is the move from piloting to scale-up. The donor

Figure 5.7 Development banks' investments in renewable energy by technology, 2009–16



Source: IRENA, 2017h.



organisations channel funds via these vehicles that act as implementing agencies on behalf of the investor. It is assumed that the national financing vehicles know their target markets well, are better equipped to disburse and manage the funds in their markets and ultimately can have greater impact. These dedicated agencies aim to develop a pipeline of bankable projects to deliver inclusive, pro-poor green growth, as well as climate action. Renewable energy is one of the main drivers of the national financing vehicles. Table 5.2 lists examples of renewable energy national financing vehicles and agencies in the region.

DEBT FINANCING BY PRIVATE FINANCE INSTITUTIONS

Domestic and international commercial banks are gaining experience in the financing of renewable energy in the region. Table 5.3 provides some examples of commercial banks and their activities in the region.

International commercial banks

Among the international banks operating in the region, the first movers were, for instance, Standard Chartered Bank, Sumitomo Mitsui Banking Corporation of Japan, Rabobank and Macquarie Capital. These banks sometimes work jointly with DFIs – an example is the collaboration of Rabobank with ADB and ORIX to form the Asia Climate Partners (ACP), an investment fund specialising in renewable energy with an Asia mandate. Another example is that of project financing of the 75 MW Sidrap wind farm project in Indonesia provided by the US government's Overseas Private Investment Corporation and PT Bank Sumitomo Mitsui Indonesia, the Indonesian subsidiary of the Sumitomo Mitsui Banking Corporation of Japan (Baker McKenzie, 2017b).

Table 5.2 Examples of renewable energy national financing vehicles in Southeast Asia

Country	Name of agency
 Thailand	Office of Natural Resource and Environmental Policy and Planning (ONEP)
 Indonesia	PT Sarana Multi Infrastruktur (SMI) and Indonesia Climate Change Trust Fund (ICCTF)
 Lao PDR	Laos Energy Promotion Fund (LEPF) and Energy Access Solar-Home-Systems (SHS) Fund Environment Protection Fund (EPF)
 Malaysia	The Malaysia Green Technology Corporation (GreenTech Malaysia)
 Cambodia	National Council for Sustainable Development (NCSD)
 Viet Nam	Vietnam Development Bank (VDB)

Source: ONEP, n.d.; ICCTF, n.d.; VDB, n.d.; GreenTech Malaysia, n.d.; NCSD, n.d.; Mayer Brown JSM, 2017; GIZ, 2014.

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Table 5.3 Examples of commercial banks active in renewable energy in Southeast Asia

Renewable energy investment profile and benchmark transactions	
DOMESTIC BANKS	
Kasikorn Bank (Thailand)	This is the first commercial bank in the ASEAN to be selected as a member of the Dow Jones Sustainability Indices (DJSI) World Index and DJSI Emerging Markets Index. In its recent deal in late 2016, the bank provided financial support of USD 50 million to Sermuang Power Corporation involving Thailand's 40 MW solar power plant partly owned by the company.
Siam Commercial Bank (SCB) (Thailand)	In 2012, SCB acted as financial adviser and lead arranger for the construction of three large-scale solar power plants with a total capacity of 270 MW, helping Thailand to secure its position as a solar energy leader in Southeast Asia. SCB has financed the majority of the wind capacity in Thailand with the 450 MW project by the Wind Energy Holding under construction.
BDO Unibank (Philippines)	The bank has an exposure of over USD 500 million to the renewable energy sector in the Philippines. San Carlos Sun Power Incorporated partnered with BDO Unibank for PHP 3.7 billion (USD 78.25 million) to finance its solar power project in Negros Occidental.
The Bank of the Philippine Islands (Philippines)	The first in the Philippines, this bank works in close partnership with the International Finance Corporation (IFC) in renewable energy investments. The bank financed the renewables project of Raslag Corp. to expand its existing 10 MW solar power plant (RASLAG 1) to 23.14 MW in the Pampanga area. BPI also participated in the issue of climate bond to fund the Tiwi-MakBan geothermal project in the Philippines.
United Overseas Bank (UOB) (Singapore)	The bank selected an investment approach in the lower-income Mekong countries. It has supported hydropower developer Bitexco Power in Viet Nam and a lighting programme in the Mawlamyine township of Southern Myanmar. In 2017, UOB lent USD 15 million to Sunseap Group for a series of solar projects in Singapore. The projects include the 9.5 MW solar systems at Jurong Port, and 2.4 MW solar systems at the consumer electronics company Panasonic.
Maybank (Malaysia)	The bank has been actively financing renewable energy projects including solar, biomass and hydropower over the past decade, especially in Malaysia and Indonesia. In 2016, it invested in and advised infrastructure projects worth several billions. In 2016, Maybank, together with Middle East & Asia Capital Partners, ADB, IFC and OPIC, launched a ten-year private equity fund investing in projects in the Asia-Pacific region.
Bank Mandiri (Indonesia)	The largest bank in Indonesia in terms of assets, loans and deposits. The bank has played an important role in channeling Agence Française de Développement and ADB-sponsored long-term loan facilities to clean energy projects in Indonesia. In 2013, AFD signed a USD 100 million financial commitment with Bank Mandiri to finance clean and renewable energies in Indonesia. It was the second environmental credit line allocated to the bank following an initial operation in 2010. The first financed power generation capacity of over 90 MW, included hydro and biomass power.

Table 5.3 Examples of commercial banks active in renewable energy in Southeast Asia **(continued)**

Renewable energy investment profile and benchmark transactions	
INTERNATIONAL BANKS	
Standard Chartered Bank	Standard Chartered Bank and a Malaysian company sponsored by SunEdison, together with the Malaysia-based Sun Energy Ventures, provided loan facilities amounting to MYR 134 million (USD 41 million) for two utility-scale solar projects (10 MW and 5 MW) in Malaysia in 2013.
Rabobank	Rabobank's asset management arm, Robeco, is one of the founders of Asia Climate Partners (ACP), together with ORIX and the ADB. ACP is a specialist renewable energy investment fund with an Asia mandate.
Macquarie Capital	Macquarie has advised, managed and invested in 2.5 GW of renewable energy in Asia. STEAG Energy Services GmbH and Macquarie recently founded a joint development and investment platform, which is intended to design, construct and operate energy projects in Southeast Asia, predominantly in Indonesia, the Philippines, Malaysia and Thailand.
Australia and New Zealand Banking Group (ANZ)	ANZ, together with lead managers Nord LB, DZ Bank, and ING Bank acted as mandated lead arranger for a syndicate of banks providing a USD 315 million debt portion of funding for the Philippines' largest wind farm, the Burgos Wind Farm project. The funding consists of three 15-year tranches: a Philippine peso (PHP) tranche (provided by domestic bank syndicate members), making up 40% of the total debt portion, and two USD tranches that combine to make up the remaining 60%.

Source: Kasikornbank, 2016; Pande, 2013; Private Equity Wire, 2014; Rappler, 2015; STEAG GmbH, 2016; SCB, 2012; Das, 2011; Bank Mandiri, 2014; Reuters, 2017.

Note: MYR = Malaysian ringgit; PHP = Philippine peso.

Some local markets lack risk mitigation vehicles – for example, where PPAs are denominated in local currency and banks are reluctant to carry exchange risks or provide competitively priced hedging. Also, the cost of debt finance and limited length of loan tenures are acute problems.

Local commercial banks

In Malaysia, the Philippines, Singapore and Thailand, banks are fairly knowledgeable regarding the project finance of renewable energy and are able to conduct relevant transactions. While in some cases local banks provide financing without support from international capital, some transactions are made with participation from DFIs and other international banks. Of the listed countries, Thai banks have the

longest tradition and highest level of expertise in providing support to renewable energy developers. The Industrial Finance Corporation of Thailand was the pioneer financial services firm in the region engaging and providing debt instruments. It started its work in close collaboration with the Energy Policy and Planning Office at the Ministry of Energy in the early 2000s. In emerging markets, such as Indonesia and Viet Nam, often the local financial institutions lack capacity to finance renewable energy projects due to limited knowledge of technical solutions (reflecting past experience in only fossil-fuel power projects), as well as lack of top-level commitment. To counter this trend, building the capacity of these institutions is key.

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PRIVATE EQUITY AND CAPITAL MARKETS

As is the case in other emerging renewable energy markets (e.g., see the case of the Latin America region in IRENA, 2016b), equity is a key component in the capital mix of renewable energy projects, as perceived higher financial risks translate into a lower share of debt. The main sources of equity in the region are utilities, renewable energy developers and, to a lesser extent, specialist private equity funds.

Utilities

Power utilities were the most important source of on-balance-sheet finance and project-level equity capital in the region in 2016. A number of utilities in the region, including in the Philippines and Thailand, are looking to diversify their portfolios away from coal and toward renewables. In the Philippines, many utilities that used to engage in coal-fired power generation and other forms of fossil fuels are already diversifying into renewable energy or preparing to go in that direction. Alsons Consolidated Resources Inc. and Aboitiz Power Corp. both have a portfolio of coal and hydroelectric power projects and they are now targeting large-scale solar projects.

Thailand-based Banpu Public Company Limited – a major mining and power company with coal mining operations in China, Indonesia and Thailand, and coal-fired power generation operations in China, Lao PDR and Thailand – is diversifying investments in the CLMV countries and expanding its renewable energy portfolio (Olchondra, 2015; Wiriyapong, 2017).

Listed renewable energy developers

Table 5.4 lists several examples of stock-market-listed renewable energy developers in the region. Thailand has the largest number of renewable energy firms listed in capital markets with a combined capitalisation of over USD 100 million. Also, the firms listed in Thailand use the largest array of technologies in their renewable energy activities. Thailand has introduced a new listed product, an “infrastructure fund,” as a financial tool to raise inexpensive funding and investment in infrastructure projects. Under the Securities Exchange Commission’s strategic plan, Thailand aims for the Thai capital market to become the Greater Mekong Sub-region connector and thus strengthen the relationship with neighbouring Lower Mekong countries. Singapore is the main regional hub for large public placements and it also has plans for an infrastructure fund type of listed product

Table 5.4 Selected renewable energy developers listed on stock markets in Southeast Asia

Country/ stock exchange	Listed renewable energy firms
 Thailand	Superblock Public Company Limited (PCL), Better World Green PCL, Thai Solar Energy PCL, Global Power Synergy PCL, B. Grimm PCL, SPCG PCL, Gunkul Engineering PCL, Energy Absolute PCL, BCPG PCL and Banpu PCL
 Indonesia	PT Terregre Asia Energy
 Philippines	Greenergy Holdings Inc., Pure Energy Holdings Corp
 Malaysia	Future NRG Sdn Bhd
 Singapore	Anwell Technologies Ltd, Renewable Energy Asia Group Ltd, Sunpower Group Ltd

Source: SET, n.d.; IDX, n.d.; PSE, n.d.; Bursa Malaysia, n.d.; SGX, n.d.

to attract international capital and renewable energy developers. Several other stock-exchange-listed firms in the Philippines such as Energy Development Corp., First Gen Corp., Manila Electric Co., Trans-Asia Oil and Energy Corp. and Semirara Mining Corp. have similar plans. Major business conglomerates, such as Ayala and Sys, have also jumped on the renewable energy investment bandwagon via partnerships. Ayala Corp., the country's oldest conglomerate, started exploring solar energy prospects in 2010 through a joint venture with Mitsubishi and in run-of-the-river hydropower via a joint venture with Sta. Clara Power Corp.

Specialist private equity renewable energy funds

Specialist private equity funds are mandated to develop and invest in economically viable renewable-energy-related businesses. Table 5.5 provides some examples of specialist equity funds and investors in countries. The typical equity invested is in the range USD 5-20 million for a minority stake, and investors can also provide mezzanine or convertible debt funding and co-operate with peers to syndicate larger investments. The expected

Table 5.5 Examples of specialist equity funds investing in Southeast Asia

Fund Manager – Fund (Size)	Target investments
Armstrong Asset Management – The Armstrong South East Asia Clean Energy Fund (USD 164 million)	Utility-scale renewable energy and resource efficiency projects in Southeast Asia.
Dragon Capital – Mekong Brahmaputra Clean Development Fund L.P.	Focused on development using clean technology in the Mekong River Region and the Brahmaputra River Region.
Asia Climate Partners (ACP)	Mandated to make private equity investments in the clean energy, resource efficiency and environmental sectors in East Asia.
Berkeley Energy – Renewable Energy Asia Fund I (USD 112 million) and closing of the Renewable Energy Asia Fund II (REAF II) is pending	Invests in small hydro, wind, geothermal, solar, landfill gas and biomass projects in Asian markets, with a primary focus on the Southeast Asia region.
Equis Energy – in the process of being sold to a group of investors including Global Infrastructure Partners, a Canadian pension plan and a unit of China Investment Corp, for USD 5 billion	Invests in the development, construction and operation of solar, wind and hydropower projects across the Asia-Pacific region. It has the largest IPP portfolio of energy assets in Asia, comprising 180 projects totalling 11.1 GW.
Olympus Capital – Asia Environmental Partners II (USD 240 million)	Makes equity and equity-related investments in renewable energy and environmental services companies in Asia.
Nexus for Development and Pioneer Facility – Clean Energy Revolving Fund (CERF)	Funds renewable energy, and encourages an early shift away from fossil-fuel-based energy sources.
SUSI Partners and South Pole Group – Asian Renewables Infrastructure Fund (USD 285 million fund-raising pending)	Supports the financing and structuring of renewable energy and energy-efficiency projects in the energy transition market.

Source: Armstrong Asset Management, n.d.; Dragon Capital, n.d.; ACP, n.d.; Berkeley Energy, n.d.; Equis Energy, n.d.; Olympus Capital Asia, n.d.; Nexus for Development, n.d.; Susi Partners, 2017.

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holding period is five years on average. Such funds rarely co-invest with major local or regional electric utilities or local business families. The region is a challenging landscape for this type of investment, given the expected high return on equity thresholds and overall requirements of fund sponsors. As a result, it has taken several years of marketing for funds focused on Southeast Asia to close their commitments. However, the October 2017 announcement of the sale of Equis Energy, Asia's largest independent renewable energy firm, to a group of investors for USD 5 billion, has been seen as a very positive event by specialist private equity funds in the region. This would be the largest renewable energy acquisition in history, and showcases to investors that exit strategies can be successful for renewable energy investments in the region.

BLENDED FINANCE

To unlock and attract more foreign and domestic capital to be invested in renewable energy assets, blended finance, which may also include public-private partnerships (PPPs), is increasingly being deployed in countries.

Private sector capital deployment

To support and attract a greater share of private-sector capital in renewable energy investments, DFIs and other donor agencies are increasingly focused on developing co-operative blended finance initiatives.³ For instance, the Private Financing Advisory Network – Asia (PFAN-Asia) programme is a network of over 200 investors and financiers that assists the private sector and governments in attracting financial investments in clean energy to Asia. The programme's duration is from 2013 to 2018 and it aims to mobilise at least USD 700 million in funds for clean energy investments in 12 countries within South and Southeast Asia. Since 2013, the programme has helped 38 clean energy projects obtain financing worth more than USD 500 million (USAID, 2017).

DFIs also help establish privately owned and managed investment funds. ADB established the Leading Private Infrastructure Fund (2016) to catalyse such projects in Asia; the fund has equity capital of USD 1.5 billion from the JICA. DFIs also continue to provide technical assistance: e.g., USAID Clean Power Asia and Energy and Environment Partnership (EEP) Mekong primarily aim to support early-stage project development by providing investment grants for project piloting, technology transfers and feasibility studies.



³ | Blended finance is defined by the World Economic Forum as “the strategic use of development finance and philanthropic funds to mobilize private capital flows to emerging and frontier markets.”

Credit enhancement

Another key objective of blended finance is utilising public finance to mobilise private investment through risk mitigation or credit enhancement. An example in the region is GuarantCo's Thai baht (THB) 425 million (USD 13.5 million) guarantee facility to support Thai Biogas Energy Company's⁴ (TBEC's) wastewater-to-biogas plants in rural Thailand. Using GuarantCo's credit enhancement facility, TBEC was able to obtain a loan of THB 402 million (USD 13 million) from the Industrial and Commercial Bank of China (ICBC), Thailand. This would enable TBEC to construct two plants with capacity to treat 600 000 cubic metres (m³) of wastewater per year, and generate 7 MW of electricity to meet local electricity demand. GuarantCo's support enables TBEC to move forward in its plans to expand into other developing countries in the Mekong Region. Such expansion plans will be further helped and accelerated by the Viability Gap Funding grant sanctioned by the Private Infrastructure Development Group (PIDG) technical assistance facility (Guarantco, 2015).

Blended finance also offers the possibility of scaling up commercial financing for developing countries and channeling such financing toward investments with a developmental and environmental impact. For example, Bank Mandiri has financed hydro and biomass power generation capacity of over 90 MW in Indonesia since 2010, using credit lines. In 2013, The Agence Française de Développement signed a USD 100 million financial commitment in credit lines to allocate funding for renewable energy. In 2016, Maybank, together with Middle East and Asia Capital Partners, ADB, IFC and OPIC, launched a ten-year private equity fund investing in wind, solar, geothermal, small hydroelectric, biomass, biofuels and energy-efficiency projects in the Asia-Pacific region.

Public-private partnerships

Public-private partnerships (PPPs), as a form of blended finance, have the potential to bring together skills and resources of both public and private sectors. Renewable energy PPPs can facilitate risk sharing, help develop larger projects, improve awareness and consensus on a project in general and increase stakeholder understanding of technical solutions and related risks. PPPs could also gain an increasing role in energy access projects. The United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) implemented the project "Leveraging Pro-Poor Public-Private-Partnerships" (5Ps) for rural development in Lao PDR from 2011 through 2016, with the aim of identifying a private sector partnership model for rural energy access and the necessary enabling policy and institutional environment for widening private sector investment (UNESCAP, 2016b). In Cambodia, where the development of solar energy remains limited, solar PPP investments have improved overall awareness and capacity in the sector. A solar project developer, Sunseap, entered a 20-year solar PPA with Electricite Du Cambodge (Cambodia's state-run utility), to which the ADB agreed to lend USD 9.2 million to build a 10 MW solar facility. The financing package, which was provided by ADB's Private Sector Operations Department, includes co-financing from a private-sector financial institution through ADB's B Loan program and a concessional loan from the Canadian Climate Fund for the Private Sector in Asia (ADB, n.d. - b).

The Sustainable Development Investment Partnership (SDIP) recently established an ASEAN regional hub in Cambodia to advance blended finance for sustainable infrastructure investment in the region. SDIP, a collaborative initiative managed by the OECD and the World Economic Forum, brings together a community of 35 governments, banks, pension

⁴ | Established by PEMF (a fund supported by Finnfund) and ATE (a fund supported by Prince Moulay Alaoui of Morocco) in 2003, TBEC is the leading biogas producer in the Mekong Region, with eight power plants in Thailand and one plant in Lao PDR. TBEC's plants clean wastewater from various agri-factories, generating biogas in the process.

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funds and philanthropic organisations committed to mobilising over USD 100 billion globally in projects supporting sustainable and climate-resilient infrastructure.



GREEN BONDS AND CLIMATE FUNDS

Green bonds and climate funds are growing asset classes for investors around the world. In the Southeast Asia region, both types of investment instruments are still at an early stage.

Green bonds

Green bonds are fixed income securities that finance environmental or climate-related investment. They include qualifying debt securities issued by development banks, central and local governments, commercial banks, public-sector agencies and corporations, asset-backed securities and green mortgage-backed securities and project bonds. Most green bonds in renewable energy are asset backed, or ring-fenced, with investors being promised that all funds will only go to a specified climate asset class. For investors, green bonds offer a way to meet environmental, social and corporate governance investment principles. In 2016 the total volume of green bonds was estimated at USD 170 billion of which over USD 80 billion was issued (Climate Bonds Initiative, 2017a). In Asia, the first green bond was issued by the Export-Import Bank of Korea in 2013

and the most fertile sources of green bonds issuance markets have been China and India.

In the region, very few issuances have taken place, although the ASEAN Capital Markets Forum of Regulators is soon to announce green bond guidelines for the region. In 2017, Singapore announced the green bond grant scheme in which issuers can offset costs of up to Singapore dollars (SGD) 100 000 (USD 74 000) incurred from obtaining an independent review based on international green bond standards (Climate Bonds Initiative, 2017b). To qualify, the bonds can be denominated in any currency but must be issued in Singapore, with a minimum size of SGD 200 million (USD 148 million) and a tenure of at least three years. A property giant, City Developments Limited, issued a green bond of SGD 100 million (USD 74 million) in 2017 and the funds are to be used in retrofits including an upgraded chiller plant, energy-efficient lights and motion sensors to reduce energy waste (Boey, 2017). In the same year, Malaysia issued the world's first "green sukuk" for 250 million Malaysian ringgit (MYR). In 2016, ADB provided support (via credit enhancement) for the first climate bond in Asia and the first ever climate bond for a single project in an emerging market, to fund AP Renewables, Inc. and its geothermal power development in the Philippines. The USD 225 million bond was denominated in Philippine pesos (PHP) and it included an ADB partial credit guarantee support. The issue was well received and was oversubscribed by investors.

Despite such positive recent developments in the region's green bond sector, the general perception among investors is that the renewable energy market is not sufficiently developed for large-scale green bonds. The market is still lacking benchmarks and thresholds for structure, pricing and risk. Large institutional investors, such as pension funds, need standardised products with transparent risk profiles. Global climate finance could become available through new organisations such as the Green Climate Fund (GCF).

5.3. BARRIERS TO RENEWABLE ENERGY INVESTMENTS

Scaling up renewable energy investment will require concerted efforts to address the investment barriers. Project developers in the Southeast Asian countries continue to face macroeconomic, regulatory and financial challenges.

MACROECONOMIC BARRIERS

In the region, macroeconomic conditions are generally favourable. Economic growth rates are robust, economies are on a balanced path and the demand for energy is strong. In Malaysia, the Philippines and Thailand there is a strong international and local financial institution involvement. In less mature markets, the familiarity of local institutions with renewable energy is low and the risk appetite of international investors is relatively less as many local developers are not well-known.

How ready the market is to attract investors to renewable energy in the region, and the respective investment barriers vary by country. Countries with larger economic markets and stock market capitalisation tend to have more experience in renewable energy; examples include Indonesia, Malaysia, the Philippines and Thailand. The Lower Mekong countries of Myanmar, Cambodia and Lao PDR tend to have weaker capital markets and higher political and commercial risks, with smaller economic markets and market capitalisation of stocks. However, these countries offer active donor-driven investment opportunities. Viet Nam is the focus of the highest expectations for the next couple of years.

REGULATORY BARRIERS

The Southeast Asian countries to have attracted the highest investments in renewable energy in recent years have received consistently high evaluations of their legal, institutional and administrative frameworks. Conversely, countries with weaker

enabling frameworks have attracted less investment in renewable energy, even though the growth in the demand for electricity in some of these countries could result in sizeable markets. Unclear legal and regulatory frameworks, including non-bankable PPAs and weak FiT pricing, are major barriers in this context.

In some of the countries, a lack of contract standardisation is a challenge, i.e., the PPAs are negotiated and awarded on a case-by-case basis and the process is not fully transparent. The processes do not meet international standards and financiers are not satisfied with the perceived risk/return ratio of the projects. Also, the rules and procedures for obtaining, keeping and transferring land-use rights are complicated, non-transparent and uncertain, making access to land for solar energy projects difficult.

BARRIERS TO ACCESSING FINANCE

The challenges of accessing finance and attracting private-sector capital into renewables include unfavourable project scale, weak local financial markets to re-finance or exit from the project, general knowledge and capacity gaps among the project stakeholders and investment risks.

Accessing affordable capital for renewable energy projects in Southeast Asia can be challenging as the **scale of investments is usually small and transaction costs can be substantial**. For example, the Thai Biogas Energy Company faces challenges in raising long-term finance since its requirements are too small for most local banks' project finance teams, and too unconventional for the banks' small and medium enterprise financing teams. As a result, investors are less interested in renewable energy projects than in traditional infrastructure investments. This is particularly true for the Lower Mekong region. The region also has a number of foreign investment restrictions.

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In terms of the availability of capital, a fundamental problem is **the lack of equity funding coming from the private sector** for energy and infrastructure projects. In countries like India, the private sector has accounted for approximately 30% of the annual total investment in infrastructure over recent years, whereas in Viet Nam, for example, the private sector has shouldered less than 10%, an insufficient share. In countries where there is a **lack of access to bank debt** in general, the cost of debt finance and the limited length of loan tenure can be acute problems.

Some of the markets also **lack investment and financial vehicles to mitigate risks**. Currency inconvertibility risk is often a barrier to attracting investment when the PPAs are denominated in local currency and banks are reluctant to carry exchange risks or provide competitively priced hedging. Power off-taker risk (a specific type of counterparty risk) is another key risk that needs to be addressed. While various risk mitigation instruments are available and often provided by international and development finance institutions (IFIs and DFIs), many local developers in Southeast Asia do not have the necessary knowledge and skills to deal with the complex requirements of the IFIs and DFIs in the absence of intermediaries. In addition, some of the countries are not included in their core investment mandates.

While **the local financial institutions** are knowledgeable in the project finance of renewable energy and can transact deals in Malaysia, the Philippines and Thailand, local banks in the other countries often do not have such capacity. The main reason is an insufficient awareness on the part of local banks and a lack of commitment. The know-how regarding technical solutions is limited. The banks are not confident in renewable energy projects, since their experience is in dealing with fossil fuels. Currently domestic banks are supplying only a small proportion of local capital for renewable energy. This has become less of a problem with solar energy, but is still a challenge for other types of renewable energy technologies. From the commercial banks' point of view, limited local benchmark and reference projects also reduce their ability to invest.

Another barrier is a **knowledge gap in the capacity of provincial and local government entities**, particularly municipalities, to assess the appropriate technology, prepare projects and arrange financing for them. As a result, there are many instances of poorly designed and poorly performing projects. Although PPPs could help in project structuring, many local governments lack the capacity to allocate legal, political, commercial and financial risks between public and private parties and secure stable long-term revenue streams.

The general perception is that the region's renewable energy market is not sufficiently developed for large-scale **green bonds**. There is a lack of know-how regarding technical solutions, and a lack of potential for and trust in renewable energy bonds among developers, local banks and finance institutions. Current investment and entrepreneurial levels in renewable energy in the Lower Mekong countries are not sufficient to support a bond market. In the absence of pooled renewable energy assets and scale, it may take some time for the region to start issuing green bonds as actively as in other developed markets.



5.4. CONCLUSION

Investments in renewable energy have fluctuated substantially over the past decade influenced by the completion of large-scale projects and changes in the policy landscape. In the same period, the mix of countries and technologies driving investment has also changed. Investments in bioenergy, geothermal and small-hydro accounted for the majority share until 2010-11, with solar PV and wind attracting the bulk share since. Thailand has been a major investment destination, although Viet Nam, Indonesia and the Philippines took the top spot specifically in 2008, 2014 and 2015, respectively. The introduction of deployment policies has been a key driver and peaks in investment in specific countries can almost entirely be attributed to specific policies. For instance, the increase in investments in the Philippines in 2013-2015 was a result of the feed-in tariff programme, as discussed in Chapter 4.

As the renewable energy sector has grown in the region, the capital mix and the range of financing institutions engaged has also evolved. Beginning with a key role for development finance backing large-hydro, geothermal and bioenergy projects before 2000, followed by increasing private sector investments supported through public-private partnership models and carbon markets. Recently, as the chapter has shown, the diversity of financial

actors engaged in the sector has grown providing equity and debt financing, while also setting the stage for unlocking capital through less developed avenues such as green bonds and climate funds. Indeed, the countries in the region are at different stages of financial sector maturity and development of the renewable energy sector. Therefore, public finance will continue to have an important role to play – around USD 6 billion has been invested cumulatively by development banks in renewable energy between 2009 and 2016.

Scaling-up investment to the levels needed to achieve the regional aspirational target of 23% primary energy from renewable energy by 2025, will require efforts to catalyse private investments and address macroeconomic, regulatory and financing-related barriers. This entails improving project readiness and attractiveness, improving access to capital at the local level and mitigating investment risks, elaborated further in The Way Forward.





IMPROVED LIVELIHOODS THROUGH DECENTRALISED RENEWABLE ENERGY SOLUTIONS



Y Ty, Bat Xat district, Viet Nam

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Significant progress has been made in Southeast Asia over the past decade towards socio-economic development objectives. Nevertheless, in several countries, poverty persists and economic growth has been accompanied by rising disparities in income and opportunity. In many cases, inequality maps to the rural-urban divide: more than half the region's population resides in rural, often remote areas, mainly relying on agriculture for livelihood. These areas often lack access to modern energy for lighting, heating, and income-generating activities.

Populations lacking access to clean, reliable and affordable energy are concentrated in rural areas, small islands and in poor urban areas such as slums. Many islands in Indonesia and the Philippines, for instance, have insufficient population density to justify investment in grid extensions. Densely populated poor urban areas also remain underserved by unreliable and expensive sources of energy. In the slums of Manila in the Philippines, residents pay electricity rates equal to USD 0.16/kWh, among the highest in the world (Codero, 2017).

In each of these contexts, decentralised renewable energy solutions can play a crucial role in improving access to modern energy and delivering important

benefits to local populations. This chapter considers how people who otherwise lack energy access benefit from the introduction of decentralised renewables across Southeast Asia. It does so by analysing project and programme case studies from Cambodia, Indonesia, Myanmar, the Philippines and Viet Nam¹, and assessing impacts using the lenses of economic, social, environmental and health, as well as gender equality and community engagement.

6.1 LIVELIHOOD BENEFITS FRAMEWORK

The region has a longstanding track record of mobilising local resources and communities to develop decentralised energy solutions. Examples range from micro-hydro to biomass-based systems in many Southeast Asian countries. With recent cost declines, solar technologies are also increasingly deployed for improving modern energy access. Analysing the accumulated socio-economic benefits of existing projects and programmes is an important step to inform future policy decisions to support the development of rural, island, and poor urban areas.

¹ / Impacts from the projects and programmes are cited throughout the chapter. The complete case studies are published as IRENA, 2018 (forthcoming). Data for the case studies were provided by: Dipti Vaghela (Fulbright Public Policy Fellow); U Aung Myint, Daw Sane Sane, Ma Wint Winr Hlaing and Ma Phyu Phyu Winn (Renewable Energy Association of Myanmar); U Soe Tint Aung and Ma Thet Su Mya (Royal Htoo Linn Manufacturing Company); U Sai Htun Hla (Sai Htun Hla and Brothers Mini Hydropower Group); U Zaw Min (Mini Hydropower Association of Myanmar); Adriana Karpinska and Daw Maw Maw Soe (Pact Myanmar); Angéline Thieblin (Mandalay Yoma); Sandra Winarsa and Gita Meidita (Hivos); Sergina Loncle (Kopernik); Bastiaan Teune and Nguyen Thi Thu Ha (SNV); Bettina Rodarte (Qi Palawan resort).

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Building on earlier work undertaken by IRENA (Box 6.1), figure 6.1 illustrates the conceptual framework adopted to analyse the benefits of deploying decentralised renewable energy solutions. These benefits are structured in four dimensions, or pillars that underpin livelihoods at the individual, household, and community levels. Linkages to the United Nations Sustainable Development Goals (SDGs) are also articulated in relevant sections, with an overarching understanding that all the topics discussed in this volume are essential to the achievement of SDG 7 on ensuring access to affordable, reliable, sustainable and modern energy for all.



Solar home system in Myanmar

Box 6.1 IRENA's work on the socio-economic benefits of decentralised renewable energy

In recent years, IRENA published numerous reports documenting the socio-economic benefits of energy access and decentralised renewable solutions. These include: *Renewable Energy Jobs & Access* (2012), *Renewable Energy and Jobs* (2013), *Renewable Energy and Jobs: Annual Review* (2014, 2015, 2016 and 2017) and *Renewable Energy Benefits: Decentralised Solutions in the Agri-food Chain* (2016). In addition, the third edition of *Rethinking Energy* (2017) analysed the linkages between renewable energy and the Sustainable Development Goals set out by the United Nations. These reports can be downloaded from www.irena.org/Publications.

Moreover, IRENA has analysed successful policies and business models for the delivery of off-grid solutions in the International Off-grid Renewable Energy Conference (IOREC) series (details available at iorec.irena.org).

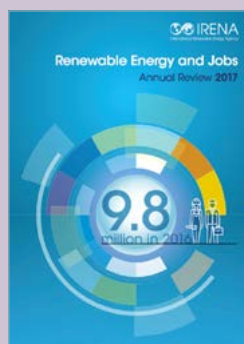
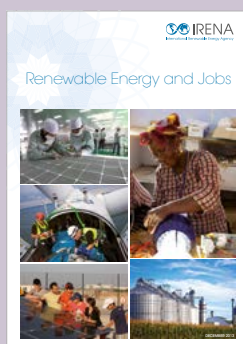
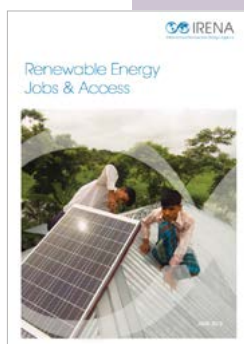
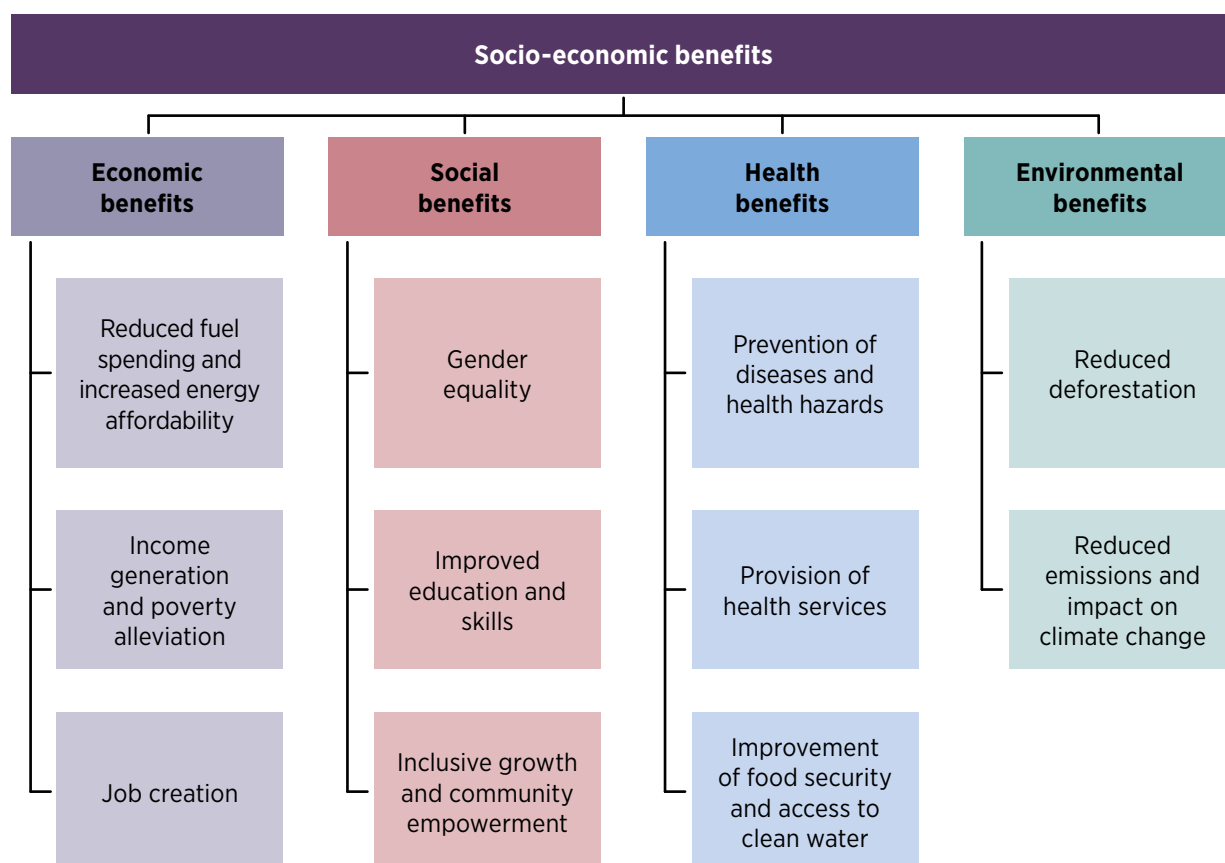


Figure 6.1 Conceptual framework adopted to analyse decentralised renewable energy benefits

It should be noted that conceptualising the four dimensions of benefits in a comprehensive framework is challenging, given their cross-cutting nature and the risk of counting overlapping benefits more than once. That said, the four dimensions can be divided as follows:

■ **Economic benefits** include energy cost savings, improved income generation and poverty alleviation (SDG1) and job creation (SDG 8 and 9) (Section 6.2).

■ **Social benefits** include increased gender equality (SDG 5), improved education and skills (SDG 4), and inclusive growth (SDG 10) and community empowerment (Section 6.3).

■ **Health benefits** are those related to the prevention of diseases and health hazards, the provision of health care services (SDG 3), and the improvement

of food security (SDG 2) and access to clean water (SDG 6) (Section 6.4).

■ **Environmental benefits** include reduced deforestation (SDG 15), reduced emissions of greenhouse gases (GHGs) and the furthering of efforts to combat climate change (SDG 13).

The environmental benefits are beyond the scope of this report and they have been analysed at length in the literature. Some aspects, such as reduced emissions and indoor air pollution are briefly covered under economic and health benefits.

Further quantitative analysis, beyond the scope of this report, is required to disaggregate these categories further to better inform practitioners and policy makers.

06 6.2 ECONOMIC BENEFITS

Renewable energy solutions can significantly reduce fuel expenditures, a significant drain on the limited resources of the poor. Access to decentralised renewables can substantially reduce poverty by empowering individuals and communities to gain control over their energy supply, reduce their energy spending and improve their livelihoods. To assess the economic benefits of decentralised renewable energy in rural areas, poor urban communities and remote islands of Southeast Asia, policy makers must look beyond the consumptive uses of energy (for household lighting and cooking, among others) to also take into account its productive uses. There is growing evidence that renewable energy solutions reduce fuel spending and facilitate income generation and job creation, both in the energy supply chain and in related activities. Moreover, benefits described in other sections of this chapter – including improved health, access to education, clean water and good nutrition – can also contribute to renewable energy's economic benefits by increasing productivity (Kapadia, 2004). The next subsections showcase the linkages between the deployment of renewable energy solutions and several key economic benefits.

REDUCED FUEL SPENDING AND INCREASED ENERGY AFFORDABILITY

The adoption of decentralised renewable energy solutions can significantly reduce the cost of fuel by eliminating or reducing the need for fuel wood, charcoal, kerosene, and diesel. Related savings are clearly seen in remote areas, where more than half the price of processed fuel is spent transporting it and where many appliances are inefficient (IRENA, 2015).

In areas that are not connected to a national grid, fuel absorbs a significant share of total household expenditure. In cases where traditional energy sources, such as agricultural and animal waste, are gathered rather than purchased, the high costs are not monetary, but take the form of significant time and associated opportunity costs. Dependence on traditional fuels for basic energy needs, such as lighting and cooking, imposes significant economic costs on households and businesses across Southeast Asia. Increasingly inexpensive renewable solutions can unlock considerable energy savings by reducing or eliminating the need to purchase kerosene or diesel or collect traditional energy sources (IRENA, 2015). Energy savings promise to be significant in rural, poor urban and remote island areas:

■ **Rural areas.** In rural Indonesia, households were able to reduce considerably their expenditure on lighting. In 2012, the average household consumed 15 litres of kerosene and consequently paid between USD 5 and USD 20 per month². This dropped to less than 1 USD per month after the installation of a micro-hydro plant (Ashden, 2012). Similar results were observed in rural Myanmar. Households connected to a solar mini-grid system reduced their lighting costs to less than USD 0.15 per month, following an initial connection fee of USD 200 and achieved savings of 25-50% on kerosene fuel expenditure (Case study: Solar mini-grid in Myanmar)³. In the poorest communities of Oriental Mindoro, in the rural Philippines, even households connected to the grid opted to use solar lanterns for lighting. Those that did, achieved savings of USD 13.11 a month, almost half their income, on electricity, kerosene and back-up candles (Box 6.2). In rural Viet Nam, a biogas plant saved participating households about USD 55 a year (Case study: Biogas programme in Viet Nam)⁴.

2 | The price of kerosene can vary according to the accessibility of the village and its distance from the main fuel distribution points. These factors can significantly increase the price of fuel on islands and in isolated rural areas.

3 | The solar mini-grid project consists of 230 kW of PV panels installed in 2016 in the two off-grid villages of Khan Tar Aye and Sel Taw in Myanmar.

4 | The Biogas Programme for the animal husbandry sector in Viet Nam was founded in 2003 with the objective of developing a commercially viable biogas market to increase sustainable lighting and heating services, and provide fuel for household cooking in rural areas.

Box 6.2 Solar lanterns bring immediate benefits in rural Philippines

In 2012, Kopernik, a non-profit organisation, partnered with the Gelacio I. Yason Foundation Family Farm School Inc. (GIYF-FFS) to make low-cost, high-quality solar lighting available for sale to some of the poorest communities in Oriental Mindoro in the Philippines. Several months following project completion, an impact assessment survey of 82 solar light customers showed immediate and tangible benefits. Of the people surveyed, 82% used the solar light every day, 80% stopped using kerosene for lighting and, on average, spending on lighting fuel was reduced by more than 50%. Some households that already had access to electricity still opted for solar lanterns and, on average, saved USD 13.11 per month on electricity, kerosene and candles. This is equivalent to approximately half of the poorest household's monthly income (The monthly income of the poorest families in Oriental Mindoro is PHP 1 000 equivalent to USD 24 using exchange rates for June 2012).

Source: Kopernik, 2012.



Wonder women group of micro-social-entrepreneurs in Larantuka, Indonesia

■ **Urban areas.** In poor urban areas, considerable savings can be achieved through the use of solar lanterns to avoid high electricity prices. This is the case in the slums of Manila, where electricity tariffs reached USD 0.158/kWh in 2017 (Cordero, 2017). Assuming that a solar lantern costs USD 15⁵ (D.light, n.d.) and that a household uses one 100 W light bulb for six hours per day, the price of a solar lantern can be repaid in fewer than five months, and a single solar lantern saves a household USD 35 per year in electricity costs.

■ **Islands.** On Lembata Island, Indonesia, a survey revealed clear preference for off-grid solutions over connection to the national grid, given the lower costs involved (Case study: Wonder Women program in Indonesia)⁶. On a remote island in Indonesia, the

Nikoi Island Resort reduced diesel consumption by 20% in 2016, after hybridising diesel plants with 27 kW of solar PV and a battery bank, resulting in cost savings of USD 8 000 in one year. In the Philippines, Qi Palawan, a resort in remote Northeastern Palawan, saved almost USD 15 000 on diesel spending in 2017 by going almost 100% solar (Case study: Hybrid solar PV in resorts in the Philippines and Indonesia)⁷. With access to modern energy, rural communities can also benefit from income-generating opportunities that further contribute to local economic growth and poverty reduction.

In addition to economic benefits, the reduced consumption of fuels also results in environmental benefits such as reduced emissions and pollution (Box 6.3)

5 | The average price of solar lantern has been selected considering the market price available for this technology in 2017 in Philippines.

6 | The Wonder Women program, an initiative of Kopernik, a non-governmental organisation in Indonesia, focuses on providing clean technologies to people in remote areas and empowering women to become energy social entrepreneurs.

7 | The case study discusses solar PV hybrid system for Nikoi Island resort in Indonesia and Qi Palawan resort in the Philippines.

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Box 6.3 Selected examples on reduced emissions and impact on climate change

Southeast Asia is highly vulnerable to the impacts of climate change, and insufficient mitigation efforts can put the region at risk of reduced freshwater availability, increased occurrence of extreme rains and associated landslides and increased flooding in coastal and delta areas. Replacing conventional energy used for lighting and cooking with decentralised renewable energy mitigates environmental impacts while also contributing to development objectives.

Lighting and electricity. In an off-grid island in Indonesia, the deployment of 22 000 solar devices (solar home systems and solar lanterns), led by the Wonder Women program, allowed households to replace the kerosene they previously used for lighting in favour of cleaner, safer and more affordable solar products. That has reduced emissions by more than 15 000 tonnes of CO₂ over the past six years (Case study: Wonder Women program in Indonesia). The Nikoi Island resort in Indonesia reduced its carbon footprint by adding a 27 kWp solar PV plant to its diesel generator. This allowed reductions of approximately 61 900 kg of CO₂ per year. The new, cleaner system also contributed to the reduction of other harmful gases, such as carbon monoxide (149 kg/year) and sulphur dioxide (121 kg/year). Similarly, the Qi Palawan resort in the Philippines has saved almost 34 000 kg of CO₂ per year by going almost 100 percent solar (Case study: Hybrid solar PV in resorts in the Philippines and Indonesia).

Similar benefits can also be achieved through the use of bioenergy for electricity generation. In Myanmar, it is estimated that if only 20% of the total production of sugarcane bagasse and rice husk were used to generate renewable electricity, this would have the potential to reduce emissions by 446 000 tonnes of CO₂ per year (UNFCCC, ACP MEAs and UNEP Riso, 2013).

Heating and cooking. The adoption of improved cookstoves or renewable cooking and heating solutions such as biogas digesters reduces emissions related to the inefficient burning of fuel wood and charcoal. In Southeast Asia, where 250 million households use solid biomass for cooking, 21% of which use improved cookstoves (ESAMP, 2015), the potential to reduce CO₂ could be as significant as 1 billion tonnes per year (considering that the use of improved cookstoves in 60 million households would result in savings of 310 million tonnes of CO₂ emissions globally each year (GACC, n.d.)). In rural Viet Nam, the SNV biogas programme deployed 250 000 bio-digesters that have reduced emissions by 800 000 tonnes of CO₂ per year (Case study: Biogas programme in Viet Nam).



Solar power plant in Qi Palawan, a resort in the Philippines



INCOME GENERATION AND POVERTY ALLEVIATION

Access to basic energy services is a prerequisite for stimulating economic activity and making progress toward SDG 1 on ending poverty in all its forms everywhere.

Many Southeast Asian countries are affected by high rates of poverty. In Lao PDR, Myanmar and the Philippines more than one-fifth of the population lives under the national poverty line. People deprived of clean and affordable energy are trapped in a cycle of lower incomes and insufficient means to improve their living conditions and meet the basic human needs for food, shelter, health and education.

The introduction of decentralised renewable energy solutions can generate income and help alleviate poverty by supporting the development of the local economy. In various sectors important to Southeast Asian economies (such as agriculture, fishing, tourism, and other commercial activities), reliable and affordable electricity for irrigation, cold storage, lighting, and mechanisation creates new income generating opportunities, raises productivity, improves access to markets and information, increases the local production of goods and services, and reduces transportation and logistics costs.

Newly created income generating opportunities and increased productivity

Renewables can boost productivity by (1) enabling the production of more and better-quality outputs and the delivery of better services, and (2) reducing the time and cost involved in doing so:

■ **In the agricultural sector in rural areas**, local renewable energy solutions can reduce vulnerability to changing rainfall patterns by powering irrigation

systems that enable advanced cropping practices and improve productivity (IRENA, 2016c). The deployment of micro-hydropower plants in Indonesia, for example, enabled the development of new businesses in egg hatchery, rice milling, coffee grinding and bread making (GIZ and NL Agency Ministry of Foreign Affairs, 2013). On Sumba Iconic Island initiative in Indonesia, solar-powered water pumps transformed dry soil into six hectares of lush arable crops. The island also benefitted from the use of solar agro-processing that saved producers at least two hours on peeling and grinding corn by hand, increasing the efficiency of their operations (Case study: Sumba Iconic Island initiative in Indonesia)⁸. In rural Myanmar, improved and mechanised irrigation powered by a micro-hydro project helped farmers improve the quality of their yields, allowing them to start exporting to neighbouring villages and increasing their profits (Case study: Micro-hydro plant in Myanmar)⁹. The use of renewables can also reduce the time and cost of production across every stage of the food chain, including agro-processing.

■ **In the fishing sector**, renewables increase yields by enabling better lighting and refrigeration. Fishermen on the Indonesian island of Lembata have increased their sea cucumber catch by almost fourfold,¹⁰ enabling additional income of at least USD 88.7 per month¹¹ (Case study: Wonder Women program in Indonesia). Around 800 small fishing ports in Indonesia have benefited from cold storage powered by decentralised renewables (Box 6.4).

■ **In the tourism sector**, providing renewable-powered services such as reliable power, internet, and hot water can help attract more tourists to remote islands. This is the case of the Qi Palawan resort in the Philippines (Case study: Solar PV in resorts in the Philippines and Indonesia).

8 | Recognising the potential of renewables on the Sumba island, Indonesia, the Dutch non-governmental organisation Hivos started an initiative, "Iconic Island," to showcase the potential for an island to depend on 100% renewable energy.

9 | This case study showcases a 80kW micro-hydro project in Myanmar that is serving approximately 450 households.

10 | Rules and regulations in the fishing industry prevent overfishing and overexploitation of natural resources

11 | 1 USD = 13 049.6 IDR, according to the exchange rate on 12 June 2017.

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Box 6.4 Renewable decentralised solutions support the fishing industry in Indonesia

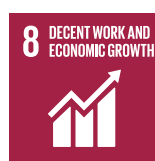
Of the 800 small fishing ports operating across Indonesia, many lack proper cold storage and ice-making facilities, leaving a significant share of fishermen's catches vulnerable to spoilage. The Government of Indonesia aims to upgrade many of these sites to eco-fishing-ports that will be both financially and energy self-sufficient. The government is also committed to mobilising renewable energy to further expand cold storage in these sites.

It is estimated that deploying decentralised renewable solutions for cold storage can increase the sellable share of the catch by up to 50%. Also, improved quality of fish and opportunities for export can result in increased income for fishing communities. These upgrades are expected to extend economic activity deeper into remote areas of Indonesia and improve the financial viability of eco-ports currently operating at a loss.

Source: REEP, 2017.



■ **For commercial entities**, the deployment of clean and affordable lighting helps extend working hours and increase profits. The deployment of a hybrid off-grid system on Sumba Island, Indonesia, allowed retail kiosks, bakeries, and handicraft, wood-working and tailoring shops to benefit from extended working hours and increased revenues (Case study: Sumba Iconic Island initiative in Indonesia). Women who earned their livelihoods from weaving were able to work longer hours and to save USD 200 a year to be spent on their children's education (Creed and Warner, 2016).

**JOB CREATION**

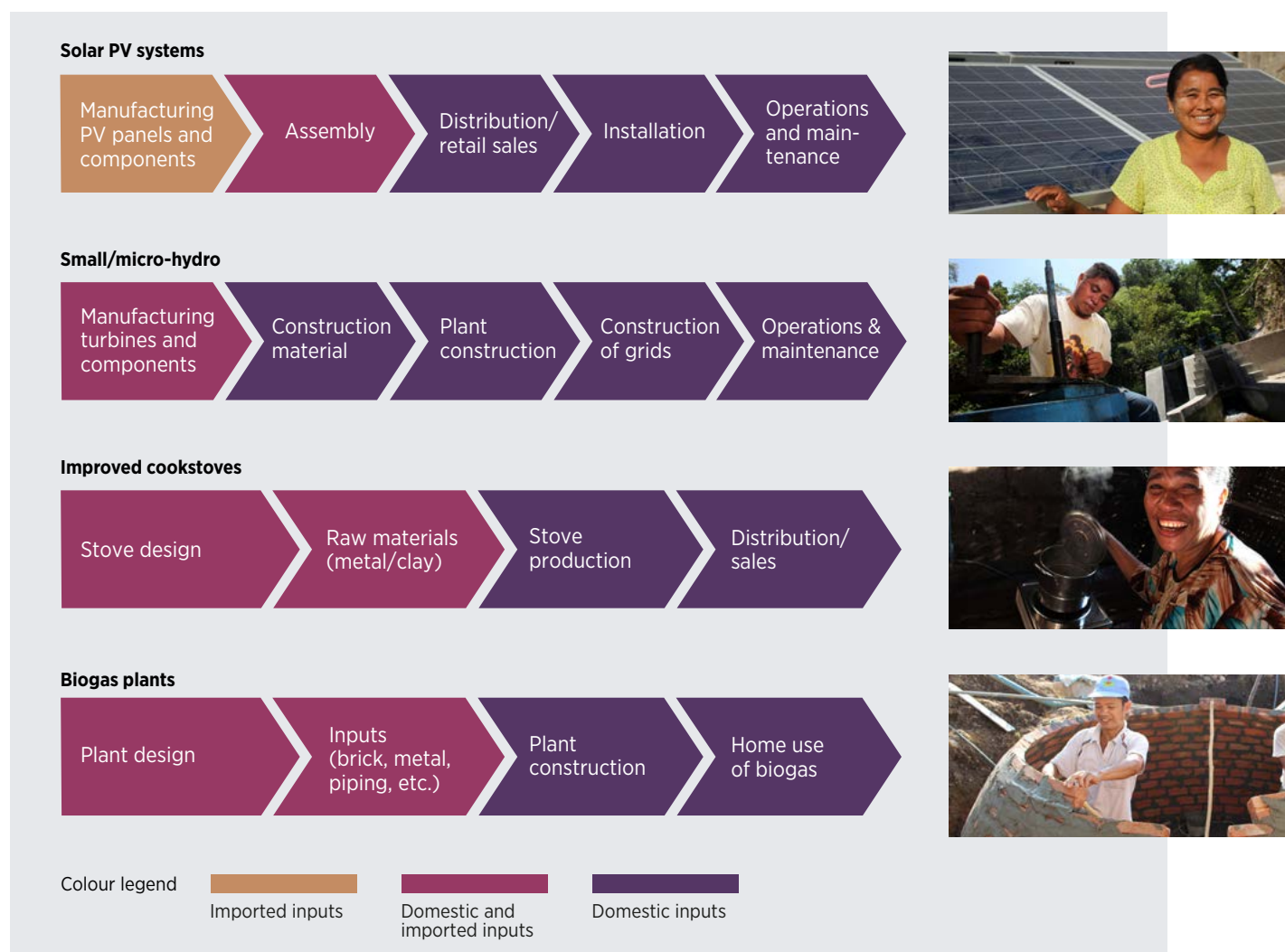
Providing off-grid communities energy for productive services enables economic development and underpins SDG 8 on promoting sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all. The deployment of decentralised renewable energy can create jobs on two fronts: in the value chain of the renewable technologies themselves, and in the induced activities that they enable.

Renewable energy jobs

Jobs can be created directly and indirectly in manufacturing and transporting renewable energy equipment, planning and installing systems, connecting households to mini-grids, and operating and maintaining equipment. Figure 6.2 illustrates

the supply chains for off-grid solar PV, small/micro-hydro, improved cookstoves, and biogas plants. Domestic job creation is technology-specific and depends on the scale of the application (stand-alone or centralised) as well as the extent of its localisation (IRENA, 2012).

Figure 6.2 Illustrative supply chains for various decentralised renewable solutions



Source: IRENA, 2012.

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The equipment for solar PV systems is often imported and then distributed to retailers, sold, assembled and installed on site (for solar home systems), all of which can offer new job opportunities in local communities. After installation, long-term jobs in maintenance are also created. In rural Cambodia, Picosol, a non-profit organisation, connects domestic manufacturers of solar home kits with local entrepreneurs from the community, who are provided with technical training. These entrepreneurs buy the kits and rent them to users, thereby ensuring a steady income and a relatively quick return on their investment (usually three months). Picosol has supported the establishment of 80 rural enterprises all over the country (Picosol, n.d.).

For mini/micro-hydropower, the main components, including the turbine, are typically produced locally and jobs are created in local manufacturing, construction, installation and servicing of facilities.

In addition, specific skills-based jobs are created in engineering, operation and maintenance. In Myanmar, the Mae Mauk Waterfall mini-hydro project employed a team of 20 people to build and install the unit and created long-term jobs for 8 people who manage the day-to-day operations of the plant. The team includes a utility manager, a powerhouse operator, two linesmen, two meter readers, a cashier and a bookkeeper (Case study: Micro-hydro plant in Myanmar).

In the case of biogas, digesters are often constructed on site using local materials. The SNV Biogas programme in Viet Nam has installed over 250 000 digesters since 2003, creating employment equivalent to 14.8 person-days per digester and an average of 16 800 full-time jobs (Box 6.5). In addition, livelihood benefits are generated in both the formal and informal economy, through, for example, jobs collecting feedstock.



Domestic use of biogas energy in Viet Nam



Biogas digester construction in Viet Nam

Box 6.5 Biogas job creation in rural Viet Nam

In Viet Nam, a biogas programme initiated in 2003 by SNV Netherlands and the Vietnamese Ministry of Agricultural and Rural Development brought significant benefits to rural communities and created thousands of jobs over a 14-year period. Over 250 000 domestic biogas digesters were locally built and installed (SNV and FACT Foundation, 2014) resulting in access to clean, renewable and reliable energy for more than 1.2 million people. The programme helped develop a commercially viable biogas market, allowing the construction, distribution and sale of the biogas technology at a local level.

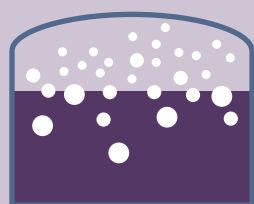
The Ministry of Agriculture employs 830 technicians to identify local needs and generate market demand among farmers. With an estimated 14.8 total person-days needed for the construction of each digester, the overall program required approximately 3.7 million person-days for 250 000 digesters. Considering 220 as the number of working days per year, the project created on average around 16 800 full-time equivalent jobs over 14 years. Moreover, the programme also trained a total of 1 000 technicians and 1 700 masons.

The trained masons earned an annual income of approximately USD 1 986 and the untrained assistants an annual income of USD 1 490. Additional income is generated from other productive activities that can be undertaken using biogas, such as cooking, preparation of livestock food, production of rice wine and tofu, and egg hatching.



Biogas digester construction in Viet Nam

250 000
BIOGAS DIGESTER



Construction team:	8 persons/unit
Working days:	14.8 person-days/unit
Total working days:	3.7 million person-days
Jobs created:	16 800 full time equivalent jobs (FTE)
People trained:	1 700 masons and 1 000 technicians
Years of employment:	14 years

Sources: SNV and FACT Foundation, 2014; IRENA, 2016c; Case study - Biogas programme in Viet Nam

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The deployment of cookstoves can create jobs in manufacturing (in the case of clay stoves, for example) and distribution, rather than in installation and operation. The distributive nature of these applications creates job opportunities for women entrepreneurs to sell cookstoves to their communities and gain valuable marketing skills.

The case of Viet Nam (Box 6.5) shows that most of the necessary skills required for the installation of decentralised renewables can be developed locally, thus boosting community involvement and building local expertise. In the region, the economic benefits of renewables are maximised through the provision of energy access that goes beyond meeting basic needs to include energy services for productive uses across sectors.



Induced jobs

The deployment of renewables can foster new local businesses and industries, advancing progress

towards SDG 9 on building resilient infrastructure, promoting inclusive and sustainable industrialisation and fostering innovation. In the Hlaingbone village of Myanmar, the number of businesses increased from 3 to 14 following the installation of a biomass gasifier plant. Jobs were created in grocery stores, stationary shops, a cold drink shop, small restaurants, tea shops, electronic accessory shops, battery charging stations, mobile phone shops, a clothing shop, a video rental shop café and a billiard facility (Case study: Biomass gasifier in Myanmar)¹².

Estimating the number of jobs created through renewable energy deployment in remote areas that otherwise lacked energy access is challenging. Information on jobs is only available for some programmes and often tends to be vague. Approximations can be obtained using employment factors and specific case studies (IRENA, 2013).

Another positive economic effect of renewable energy stems from the increased spending capacity

of the population that gains employment. Job creation translates into rising incomes and increased spending and consumption of goods and services, resulting in increased economic activity as well as job creation in other economic sectors including retail, hotels, agriculture and transport.

6.3 SOCIAL BENEFITS

The expansion of energy access through the deployment of renewable energy can improve livelihoods by offering a range of social benefits. As with all development efforts, social benefits should reach marginalised members of a community and promote local empowerment in an equitable manner. This section highlights the interlinkages between renewable energy access, gender equality, improved education and skills, and inclusive growth and community empowerment, as fundamental aspects of human rights and social justice as well as preconditions to improved livelihoods that put social concerns at the forefront of interventions.



GENDER EQUALITY

The increased adoption and use of renewable energy solutions advances the SDG 5 on

gender equality and the social and economic empowerment of women. Renewables reduce the time and burden of fuel collection and alleviate adverse health impacts of traditional biomass that disproportionately impact women and children. Renewable-based street lighting can improve safety and allow girls and women to minimise the risk of injuries or assault while participating in educational, community, or productive activities after dark (IRENA, 2017i).

While both men and women are affected by the lack of access to clean, reliable, and affordable energy, inequalities in economic capability, social standing and gender-defined roles often mean that women are impacted disproportionately. In

¹² | In 2015, a biomass gasifier was installed with a capacity to generate and distribute 200 kW, enough to cover 550 households and local enterprises in the village.

most of the developing world, including countries in Southeast Asia, household chores, water and fuel wood collection and other activities that display drudgery often fall on women and girls, thereby restricting their time and energy for other productive activities. A reliable supply of clean and affordable energy can improve the livelihoods of women in Southeast Asia by opening doors for social and economic empowerment and reducing the time spent on household chores to allow women to engage in productive and income-generating activities and educational opportunities.

Renewable energy solutions enable the social and economic empowerment of women through increased employment opportunities in renewable energy technologies including in leadership and decision-making roles. Women are often the decision makers on energy issues at the household level. Involving women in the design, marketing, and distribution of products and services related to energy is vital for the success of these efforts and advances the social and economic empowerment of women in a given community¹³.

In rural Myanmar, an integrated development programme that included credit facility to buy solar home systems required that women actively participate in village development committees and jointly manage funds for broader community development. The programme allowed women to steer development activities towards critical social priorities, such as health care centres for babies and pregnant women. In some villages, women's saving groups are actively lending to other community members to facilitate the purchase of solar home systems and further the empowerment and development of their communities (Case study: Solar Home System programme in Myanmar).

On an island in Indonesia, decentralised solutions have enabled the economic empowerment of women through a programme run by an NGO called Kopernic. The programme employs 561 women in selling and delivering solar lanterns, water filters

and clean cooking solutions, thereby gaining new business skills and additional income through their employment as renewable energy entrepreneurs (Box 6.6).

Decentralised renewable energy solutions allow women to redirect the time saved on household chores into productive and income-generating activities. Access to clean, reliable, and affordable energy reduces time spent on activities such as hauling water, processing crops, gathering fuel wood, and cooking. The time saved can then be reinvested into education or other productive activities.

Through the introduction of solar-powered water purifying systems, women in Cambodia are saving approximately 22 hours each month that were previously spent on collecting and treating water. The home delivery service of purified water provided by an NGO 100fontaines has reduced the unpaid labour of women and allowed them to engage in income-generating activities (Case study: Clean drinking water project in Cambodia)¹⁴.

Through the introduction of improved cookstoves, biogas, and solar cookers, as well as electric appliances for cooking, like rice cookers, women can benefit from reduced time spent collecting fuel wood and cooking. In Myanmar, after the installation of a solar mini-grid by Mandalay Yoma company, women invested in rice cookers and hot plates, saving up to two hours per day (Case study: Solar mini-grid in Myanmar). Access to clean and easy cooking technologies can also encourage women to start businesses in food selling.

Access to renewable energy can facilitate a range of social and economic benefits for women. The additional family income which is often invested in education and health, contributes to multiple SDGs referenced throughout this chapter, including SDG 1 on poverty eradication, SDG 3 on good health and well-being, SDG 10 on reduced inequalities and SDG 4 on education.

13 | The subject of women's empowerment in decision-making in energy matters was analysed in IRENA's workstream on jobs. It also was discussed thoroughly during IRENA's Renewable Energy Jobs Conference in Abu Dhabi in January 2014.

14 | In 2004, 100fontaines, a French non-governmental organisation, developed and deployed a social business model of providing drinking water to rural communities in Cambodia, using an off-grid solar PV system to power the ultraviolet (UV) purification of local water sources.

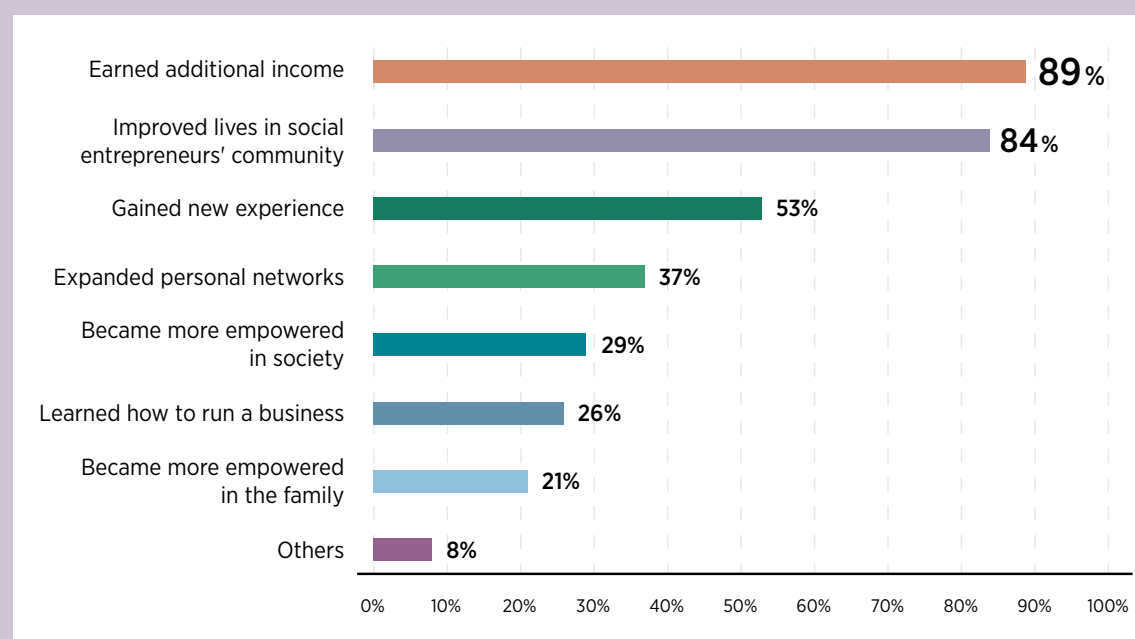
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Box 6.6 Economic empowerment of women through renewables on a remote island in Indonesia

Kopernik, an NGO operating in Indonesia, has employed local female entrepreneurs to sell and deliver solar lanterns, water filters and clean cooking solutions to some of the country's most remote island communities. Since its inception in 2011, the programme has employed 4 650 women as clean energy entrepreneurs and provided them with specific capacity building and training in selling clean energy systems on consignment. The capacity building sessions include a technical overview of the systems sold, as well as training in sales, financial management, and public speaking. By becoming technology agents, women earn margins from their sales, contributing to their family income. On average, women make profits ranging from USD 1.5 (IDR 20 000) to USD 26 (IDR 350 000)¹⁵ per unit depending on the technology.

The benefits and aspirations fulfilled by the women entrepreneurs are listed below in figure 6.3.

Figure 6.3 Aspirations of social entrepreneurs fulfilled in 12 months of the programme



Source: Case study - Wonder Women program in Indonesia

¹⁵ | Exchange rate of 1 USD = 13 333 Indonesia Rupiah in 2015.



IMPROVED EDUCATION AND SKILLS

Education and skills development is one of the most effective means to tackle the poverty trap, boost development and improve livelihoods. Renewable-based power solutions advance progress towards SDG 4 on ensuring inclusive and quality education and promoting lifelong learning opportunities for all. This is made possible by allowing study time after nightfall, opening access to information and communication technologies, freeing up time previously spent on household chores for educational activities and advancing the development of new skill sets (IRENA, 2017i).

Decentralised renewables for electricity can support education by facilitating extended hours of studying and access to information.

On Lembata Island in Indonesia, the introduction of solar lanterns has revolutionised students' lives. Bright and reliable light prevents fatigue and eye strain and eliminates the fire and safety risks of traditional kerosene lamps (Case study: Wonder Women program in Indonesia). In rural Myanmar, electricity provided by a biomass gasifier plant increased study time by up to four hours a day (Case study: Biomass gasifier in Myanmar). Additionally, the provision of clean energy services in schools can increase the likelihood that children will attend and complete school, as shown in Sumba Island in Indonesia where hybrid, off-grid systems power televisions with educational programmes during the break, attracting students and increasing their school attendance (Case study: Sumba Iconic Island initiative in Indonesia).

The deployment of renewable energy solutions can help develop skills in both the energy value chain and induced activities that benefit livelihoods in Southeast Asia. In the energy value chain, community members are trained in activities related to the operation and maintenance of renewable energy systems and these newfound skill sets lead to job opportunities. In Indonesia, local community

members are trained to perform the construction and operation of micro-hydro power plants supported by IBEKA, a non-profit organisation. Community members are also trained in how to manage revenues from the systems and prioritise development agendas. IBEKA provides courses in colleges and universities to share expertise and best practices in deploying renewables. Training and education through initiatives like this one contribute to a better understanding and use of renewable technologies and electrical appliances, encouraging future local initiatives and creating a local population with the skills to support further deployment of renewable energy in an inclusive and equitable manner.



INCLUSIVE GROWTH AND COMMUNITY EMPOWERMENT

The deployment of renewable energy technologies creates jobs and small businesses, furthering progress towards SDG 10 on reducing inequality in and among countries and leading to inclusive income generation that overcomes barriers to development (IRENA, 2017i). Countries in Southeast Asia have made significant strides towards poverty eradication, but inequality persists and disparities remain in access to food, land, social protection, health and education services. The deployment of decentralised renewable energy solutions can reduce inequality through the provision of affordable energy to all, the distribution of revenue generated from a renewable system among community members and social empowerment through equitable ownership of the system.

The deployment of renewable energy reduces inequality through the provision of affordable energy to all. As discussed in earlier sections, renewable sources provide energy that is more affordable than traditional sources (e.g. diesel generators or car batteries) that are typically accessible only to the richest members of a community. Renewable solutions can provide affordable energy to all, thereby presenting equal

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opportunities for growth and development. For example, pay-as-you-go and other renewable energy financing mechanisms (such as Pact's Ahlin Yaung Fund in case study: Solar Home System programme in Myanmar¹⁶) have been able to increase affordability for rural consumers.

Profits generated by a community-owned renewable energy system can be distributed to all community members thereby reducing social disparity. There are several examples in Southeast

Asia where renewable energy deployment helped reduce inequality and spurred more inclusive growth. In a micro-hydro project in rural Indonesia, revenues generated by a community-run cooperative that started in 2004 contributed to inclusive growth by utilising the fees that 122 households paid to connect to the system to support scholarships for 156 children from the poorest families in the community (IESR, n.d) (Box 6.7).

Box 6.7 Renewable energy for inclusive growth in rural Indonesia

The People Centered Economic & Business Institute (IBEKA), a local non-governmental organisation in Indonesia, has facilitated several community-led rural electrification projects through pro-poor public private partnership. In the Cinta Mekar village in 2004, a private company (with aid from UNESCAP) installed a micro-hydro plant and transferred ownership to the community. It established a community cooperative for the operation and maintenance of the system, whereby community members received the required training to manage the system technically and financially.

At a public meeting in Cinta Mekar, the community identified the poorest groups and prioritised for assistance those with no land, capital, employment and education. The operation of the micro-hydro system generated gross monthly revenue of approximately USD 3 300, which was divided equally with the business partner after deducting the cost of operation and maintenance. The remaining funds were then used for scholarships, an emergency health fund, a health facility and seed money for farmers. Using this same model, IBEKA has been able to support more than 60 rural communities across Indonesia.

Source: Ashoka, n.d

Children study after school with solar home systems in Myanmar



16 | Pact Myanmar, an INGO in Myanmar, introduced the Ahlin Yaung Fund – as a market-based project that addresses basic supply and demand dynamics. The project has served more than 250 000 individuals and over 12 000 households in 353 communities in Myanmar.

6.4 HEALTH BENEFITS

Health and energy are interdependent factors that impact the progress of rural development, and access to clean energy is crucial to achieve improvements in health. Southeast Asia faces challenges including high mortality rates and a lack of clean water and access to modern sanitation facility. Decentralised renewable energy technologies can contribute to improved health outcomes and advance progress towards health-related SDGs, including SDG 2 on ending hunger, achieving food security, improving nutrition, and promoting sustainable agriculture, and SDG 6 on ensuring the availability and sustainable management of water and sanitation for all. This section, explores the health benefits of decentralised renewables related to the prevention of diseases and health hazards, the reliable provision of healthcare services and the improvement of food security and access to clean water.



PREVENTION OF DISEASES AND HEALTH HAZARDS

Improved cookstoves and clean energy for lighting, cooking and

heating reduces the risks of respiratory diseases due to indoor air pollution and underpins SDG 3 on good health and well-being (IRENA, 2017i).

Inefficient cooking and heating practices produce high levels of harmful pollutants, such as carbon monoxide, which remain trapped indoors due to poor ventilation and are inhaled most often by women and children. Indoor air pollution contributes to illnesses such as pneumonia, tuberculosis, chronic obstructive pulmonary disease, low birthweight, and cardiovascular diseases among both adults and children (Fullerton *et al.*, 2008). The use of traditional cooking practices causes over 4 million premature deaths globally each year, exceeding deaths attributable to malaria or tuberculosis (GACC, n.d.). In Southeast Asia, around 270 000 premature deaths were attributed to indoor air pollution in 2015 (IEA, 2017a).

Replacing traditional methods of cooking and heating with modern renewables can reduce or avoid the health hazards of indoor air pollution through the use of biogas digesters, improved cookstoves and renewable-based electricity.

In rural Viet Nam, the deployment of 250 000 biogas digesters brought significant health benefits to users, mostly women and children. Concentrations of harmful particle matter in kitchens dropped by 80% (from 73 $\mu\text{g}/\text{m}^3$ to 28 $\mu\text{g}/\text{m}^3$), reaching a level more in line with the World Health Organisation safety guideline of 24 $\mu\text{g}/\text{m}^3$ (WHO, 2005) (Case study: Biogas programme in Viet Nam). The introduction of biogas digesters and the subsequent improvements in air quality prevented an estimated 750 premature deaths and saved 27 700 disability-adjusted life years (DALYs).

In rural Cambodia, the deployment of improved cookstoves and biogas stoves has significantly decreased exposure to harmful indoor air pollution, resulting in significant health improvements and reduced risk of disease among community members. The dissemination of 25 000 improved cookstoves and biogas stoves saved more than 4 000 DALYs (GACC, 2016).

In rural Myanmar, two clinics reported that the replacement of firewood with power from a mini-hydro plant for heating bath water resulted in a notable reduction in infant respiratory disease among local communities (Case study: Micro-hydro plant in Myanmar).

The deployment of renewables is also an efficient solution for improved waste management

and the proper treatment of organic waste including food scraps, agricultural waste, and animal manure, which can contain pathogens and other bacteria that pose hazards to human health. When left untreated, animal waste contributes to soil and water pollution, and also releases methane, a greenhouse gas that traps 21 times more heat than carbon dioxide and negatively impacts the climate and human well-being (Karapidakis *et al.*, 2010). Renewable solutions

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can help improve waste management by harnessing waste for productive uses. For example, in rural Viet Nam the installation of nine biogas digesters enabled the treatment of 8 500 tonnes of pig manure annually, thereby generating renewable power and reducing the risk of health hazards and associated diseases (IRENA, 2016c).

PROVISION OF HEALTHCARE SERVICES

Renewables support the reliable functioning of health clinics and hospitals in remote and rural areas (IRENA, 2017i). Modern health services, the facilities needed to provide them and the health sector workers who deliver them require access to clean and affordable energy. A reliable energy service ensures the proper functioning of electric medical equipment, such as emergency surgical, laboratory and diagnostic tools, allowing life-saving interventions. This has been demonstrated in rural Myanmar, where two clinics powered by a micro-hydro plant were able to provide life-saving maternity services to community members, including child delivery services that reduced health risks among mothers and infants (Case study: Micro-hydro plant in Myanmar).

In Lao PDR, a country where the under-five and maternal mortality rates are the highest in the region – 1.5 times the global average (World Bank, 2017) – reliable medical services powered by renewables can have a major impact. Some benefits have been achieved. A private company, Sunlabob, in partnership with the ADB and Lao's Ministry of Agriculture and Forestry, installed 44 solar-powered refrigeration and cooling systems across five provinces of southern Lao PDR and provided community training for their maintenance and operation. This renewable-powered system enabled safe and reliable storage of an array of medications and vaccinations, benefiting the health and well-being of 11 000 Laotians of Ta Oy (Sunlabob, 2013). Refrigeration also improves food security.



IMPROVED FOOD SECURITY AND ACCESS TO CLEAN WATER

Renewable-powered water pumping technologies increase the supply of clean water, improve agricultural yields, and reduce vulnerability to changing rainfall patterns. Renewables also provide energy for refrigeration and food preservation, which reduces food waste (IRENA, 2017i). These improved practices strengthen food security, boost nutrition and advance progress towards SDG 2 on ending hunger and achieving food security.

Renewables can improve food security by powering water pumps and irrigation technologies that increase the quantity of food produced, the frequency of yields and the diversity of products. Irrigation can increase yields by up to 300% (Energy4Impact, 2016). Renewable-powered irrigation systems help farmers broaden the range of products their land can support (cattle, fruits and vegetables), thereby balancing and improving diets and reducing malnutrition (IRENA, 2016c).

Improved yields can also be achieved through the use of treated biomass as a fertilizer instead of inorganic fertilizers (SNV, 2015). In Viet Nam, the use of farmyard manure increased crop yields between 10% and 20%. In the case of paddy rice, the increase in production was estimated at between 2.5 and 3 million tonne per year thereby boosting supplies of a key dietary staple that promotes food security and supports livelihoods (SNV, 2015).

Renewable energy can also offer solutions for food refrigeration and preservation, which impacts food security by extending the shelf-life of perishable products and reducing food losses.

Access to refrigeration can prevent the spoilage of 20% of perishable foods produced in areas that lack access to reliable energy. On Green Island in the Philippines, an ice machine powered by a newly installed 100%-renewable micro-grid provides up to 1 tonne of ice per day. The availability of locally

produced ice extends fishermen's ability to store fish by up to two days and enables the preservation of higher-quality food, leading to a 30-50% increase in local fishermen's income and underpinning food security on the island (Case study: Micro-grid in Philippines)¹⁷.

Drying produce is another method of food preservation that can be facilitated using renewable technologies. Solar dryers, for example, can be used to dry fruits, grains, rice, corn and other agricultural products that generate additional income. Solar dryers allow the production of a larger quantity of good-quality products that might otherwise have been lost to mold or left in the field unharvested because of the time required for less efficient drying practices (Agriculture Solar, n.d.). Banana chips produced in Thailand using a solar dryer can be sold for USD 0.36/kg, compared to USD 0.21/kg for chips dried over fire or in the open air that are vulnerable to insects (Shrestha *et al.*, 2014). The increase in price also reflects a considerable improvement in product quality, leading to increased incomes for producers.



Renewable-based pumping and water desalination can present an effective solution to providing access to clean drinking water and advancing progress towards

SGD6 on ensuring the availability and sustainable management of water and sanitation for all (IRENA, 2017i).

About one-quarter of the population of Cambodia and Lao PDR lack access to clean water (World Bank, 2017), and women and children often have to travel long distances to fetch drinking water. The supply of safe drinkable water can be improved through renewable energy solutions for pumping, boiling, disinfecting, purifying, distributing and storing clean water (UN, 2014).

In rural Cambodia, 100fontaines introduced solar-powered water purification systems that have helped 400 000 people gain access to clean water, bringing significant health improvements such as reduced cases of child diarrhea by 33% compared with those drinking surface water, 52% compared to those consuming bottled water, and 62% compared with those relying on ground water sources (Hunter *et al.*, 2013) (Box 6.8).



Students drinking clean water in Cambodia

¹⁷ | The solar-wind-biomass gasifier hybrid micro-grid plant provides electricity to rural households and also aims to tackle a lack of access to freshwater through an electrical water pump and to boost the local fish market with an ice machine.

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Box 6.8 Solar-powered water purification system boosts rural development in Cambodia

The 1001fontaines project in rural Cambodia installed 164 solar-powered water purification systems and sales kiosks, which provide clean drinking water to approximately 400 000 villagers (including 120 000 children who receive drinking water for free in primary schools), reducing risks of waterborne diseases.

Off-grid solar technology has enabled the operation of local water businesses. In the dry season, when demand for drinking water is at its peak, the systems produce an average of 2 000 to 4 000 litres of purified drinking water per day. In the non-peak season, each kiosk produces and sells an average of 400 to 1 200 litres per day. Beyond the health benefits, the development of water businesses also enables job creation and improved education:

- 1001fontaines generated 75 jobs in the system and an additional 466 jobs as water-selling entrepreneurs and operators in the water business, of which 24% are women.
- The provision of safe drinking water in schools helped reduce student absenteeism by 55-75% in primary schools. The increases in attendance rates were most notable in the dry season, when access to other drinking water sources (such as rainwater) is typically most limited.

Source: Case study - Clean drinking water project in Cambodia.



Providing clean water in Cambodia through solar-powered purification

6.5 CONCLUSION

Access to clean, reliable and affordable energy promises to improve livelihoods and further development in Southeast Asia. The deployment of decentralised renewable energy solutions offers a range of economic, social, health and environmental benefits for rural, poor urban and island communities of the region. These solutions offer economic benefits through reduced fuel spending and increased energy affordability, income

generation and poverty alleviation, and job creation. Social benefits include increased gender equality, improved education and inclusive growth. Health benefits encompass the prevention of diseases and health hazards, the reliable provision of healthcare services and the improvement of food security and access to clean water. The environmental benefits are widespread and cross-cutting and include reducing deforestation, reducing emissions, and advancing climate action.

The deployment of renewable energy technologies also aligns with broader global sustainable development goals (Figure 6.4). Off-grid renewables are crucial to the achievement of SDG 7 on affordable and clean energy to further all the other SDGs, including those related to poverty alleviation, health, water, nutrition, gender, education, economic growth, reduced inequalities, sustainable land use and climate action.

Policy makers and other development actors should take note of the wide range of livelihood benefits offered by decentralised renewables and

strive to integrate clean, reliable and affordable energy as a pillar of development across Southeast Asia. Maximising these benefits requires that governments implement effective policies and regulations and that the private sector use appropriate business models. Careful consideration of the policy landscape presented in chapter 4 and the finance landscape presented in chapter 5 of this report will ensure that renewable energy solutions are deployed in an equitable and inclusive manner that unlocks the multitude of livelihood benefits described throughout this chapter.

Figure 6.4 Affordable and clean energy support all SDGs



Source: IRENA, 2017i

THE WAY FORWARD



Bangkok, Thailand



Affordable, secure and environmentally sustainable energy will be crucial to underpin Southeast Asia's development over the coming decades. Diversifying the region's energy supply through renewable energy offers a viable option to support growth and achieve socio-economic and environmental benefits. To reach the aspirational target of 23% renewables in the region's primary energy mix by 2025, Southeast Asian countries will have to substantially scale-up deployment, with the essential enabling factors summarised in this chapter.

RECOGNISING THE ROLE FOR RENEWABLE ENERGY IN THE ENERGY AGENDA

Energy is a crucial enabler of economic growth and socio-economic development. Meeting growing energy demand in a cost-effective, environmentally sustainable, equitable and secure manner, however, will be a key policy and planning concern over decades to come.

1. Renewable energy technologies have advanced at a fast pace over the past decade with improvements in efficiency, rapid reductions in cost and accumulation of experience in financing and project development. **The economic case for renewable energy over the long-term is strengthening** for both fossil fuel exporters and importers. In the region, the costs of geothermal,

hydropower, bioenergy, most onshore wind power projects and an increasing number of solar PV projects are within the estimated range of fossil-fuel costs. In recognition, the accelerated adoption of renewables should be central to the energy diversification and sustainable development agenda of Southeast Asian countries.

2. In planning for the energy sector, policy makers are encouraged to **consider the long-term costs and benefits** of a renewable energy-based energy transition. The region has a real opportunity to leverage its position as a financial, manufacturing, economic and innovation hub to contribute to the accelerating global energy transition.. In the process, the region can **reap substantial socio-economic dividends** for decades to come in terms of contribution to GDP, welfare and employment. In 2016, the renewable energy sector employed 611 000 people with a potential to provide up to 2.2 million jobs in 2030.
3. As technologies improve and costs decline, it is vital to **raise the ambition of renewable energy deployment**, reflected in national and regional energy plans. This is crucial to send the right market signals and **avoid locking-in investments** in those fossil-fuel based energy infrastructure that would be more expensive on a life-cycle basis, with additional costs associated with environmental impacts and energy security.

ESTABLISHING AN ENABLING POLICY AND REGULATORY FRAMEWORK

Several Southeast Asian countries have taken important initial steps in establishing a dedicated policy and regulatory environment for renewable energy development. The strong correlation between policy and investment flows showcases the vitality of maintaining a stable, predictable, yet adaptable environment that underpins long-term investments in the renewable energy sector.

1. Setting regional and national renewable energy targets sends a **strong signal of political commitment to market participants**. Sustained government support is crucial at this nascent stage of sector development as technologies are demonstrated and adapted to the local conditions. A stop-go approach introduces investment uncertainty and impedes the achievement of long-term targets.
2. Renewable energy targets should be accompanied by a mix of policies tailored to meet both deployment and development objectives. **Deployment policies** need to be designed to provide adequate incentives for investment while also mitigating long-term risks through quality power purchase agreements and guaranteed off-take. When prevalent, these conditions have catalysed private sector interest and investment flows in several countries in the region, including Indonesia, Malaysia, the Philippines and Thailand, and, more recently, in Singapore and Viet Nam.
3. The choice of deployment policy, whether feed-in tariffs, auctions, renewable portfolios or a combination thereof, and its **design should be tailored to the local conditions**, including the technology, market segment and the maturity of the sector. Policies should also address barriers related to project development, including permitting and licensing of land, which increases transaction costs.
4. As the technology costs reduce and deployment grows, policies need to **adapt to ensure**

effectiveness and efficiency. The shift to renewable energy auctions in some countries in the region is an example of this. The process of learning and adaptation should be embedded within the policy implementation strategy and well-communicated to manage the risk of uncertainty that might arise as a result of changes to the policy and regulatory landscape. Recent changes in the policy landscape of leading renewable energy markets, including Indonesia (change in tariff-determination process), the Philippines (impending introduction of the Renewable Portfolio Standards), Malaysia (introduction of an auction scheme) and Viet Nam (introduction of the feed-in tariff scheme), point to the importance of effective adaptation.

5. Deployment policies are part of a **broader mix of policies, in line with country's development objectives, that also address** education and training, research and development, industrial policy and the broader national investment climate. These are important considerations for countries looking to attract foreign capital and technology, while maximising the socio-economic benefits of renewable energy, including the development of a local industry and employment generation. Malaysia's Renewable Energy Policy and Action Plan is an apt example that addresses technology innovation and human capital development, in addition to deployment aspects.



FOCUSING ON RENEWABLE ENERGY DEPLOYMENT ACROSS ALL END-USE SECTORS

While growth in renewable energy deployment in the power sector is evident, there is substantial untapped potential for modern renewables to meet energy needs in the heating/cooling and transport sectors. Tapping into local bioenergy resources, for instance, can be crucial in rural areas to expand modern energy services for cooking. Supporting growth in renewable energy deployment across all end-use sectors will be key to meeting regional and national renewable energy, as well as decarbonisation, targets.

1. Deployment policies for renewable energy in the heating/cooling and transport sectors are less developed than for the power sector. **Dedicated policies are needed** to encourage investments in end-use sectors, including measures such as mandates, building codes, financial incentives, tax exemptions as well as purchase guarantees for process heat generation.
2. For heating and cooling, renewable energy applications in industry and buildings are inhibited by the lack of awareness of the potential of technology and feasibility, as well as of standards. **Demonstration projects and targeted awareness-raising** initiatives would play a crucial role in highlighting the potential for reducing emissions and costs.
3. A programme to maximise bioenergy use in both industry and transport needs to also **safeguard environmental, social and economic sustainability**. Yield improvements and the use of degraded lands need to be combined with the sustainable use of residues and waste feedstock. The challenges related to seasonality of supply should be considered in planning.
4. For transport, liquid biofuels have been the main policy focus across the region through blending mandates. As countries increase their use of modern bioenergy, it is important to **consider land use policies** to ensure that increased

production does not jeopardise sustainable forest management and biodiversity. These should be reflected in the sustainability criteria and certification schemes. The balance is particularly key for major palm oil producers where biofuels can reduce petroleum imports, support farmers and industry, and reduce emissions if production is sustainably managed.

5. Policies to support liquid biofuel use in the transport sector need to be complemented with efforts to **support fuel efficiency of transport fleets, electric vehicles** (two-, three- and four-wheelers) and public transportation. Comprehensive policy frameworks are needed, including fuel efficiency mandates and fiscal incentives for encouraging investments in manufacturing, charging infrastructure and adoption of electric mobility solutions at scale. The region's status as a strong automobile production hub and market provides the opportunity to competitively position itself in the electric mobility segment.
6. **Improving the data** and information base of energy use in end-use sectors is crucial to assess the potential, set targets and incentive structures, as well as to monitor progress. Harmonising data collection and reporting methodologies across the region, and as per global standards, would improve guidance for all market actors.
7. A complete transformation of the energy system will not be possible without **tapping into the synergies between renewables and energy efficiency** among end-use sectors. The coupling of the power sector with heating/cooling and transport, together with energy efficiency improvements, will be key to realise the full potential of renewables. A more holistic approach to energy policy will help harness these synergies and allow smooth integration of renewables. Thailand's Integrated Energy Blueprint (TIEB) of 2015 is an example of efforts in this direction. TIEB combines five key energy plans, covering power, oil, gas, energy efficiency, and alternative energy development, into one integrated energy document that takes a long-term, system approach to energy policy.

CATALYSING INVESTMENTS IN THE RENEWABLE ENERGY SECTOR

Achieving the regional target of 23% of renewable energy in primary energy by 2025 requires an estimated investment of USD 27 billion a year compared to USD 2.6 billion in 2016. Reaching that investment goal requires targeted efforts focusing on improving project readiness, facilitating access to finance at the local level and introducing risk mitigation measures. To this end, various stakeholders need to be engaged, including governments, national financing vehicles, development finance institutions and the private sector.

1. Developing a pipeline of investment-mature projects requires both financial and technical support from the public and private sectors. Project facilitation tools (Box 7.1), tutoring programmes (e.g., Private Finance Advisory Network) and public finance will play an important role in **improving project readiness and attractiveness**. Public finance institutions can provide bridge finance for early-stage projects, especially for the Lower Mekong countries, where risk-tolerant capital is needed. In this context, **blended finance** structures can catalyse private investment for renewable energy projects.
2. Increased capacity of domestic banks is key to **improve access to capital at the local-level**. On-lending structures that channel concessional finance down to local financial institutions can increase the availability of financing and reduce local banks' risk. Such structures can also support the **training of the local banking staff**, as well as **local currency lending** (e.g., GurantCo) to address the mismatch between the currency of financing (hard) and the currency in which project revenues are received (local).
3. Public finance institutions can provide **risk mitigation instruments**, such as guarantees and subordinated debt instruments, to local and international banks. While several guarantee instruments are used in the region, streamlined application processes, as well as standardised and

programmatic approaches for third-party credit enhancements and bundling, can improve their utilisation.

4. There is a need for dedicated **national financing vehicles**, such as green investment banks, to facilitate, structure and support renewable energy projects in the region. Although there are examples of such institutions in the region, a large financing gap remains between international capital providers and national financing vehicles. To address this gap, enabling policies are needed as well as customised structures that reflect the risk-reward expectations of investors.
5. **Capital markets** can be further mobilised to finance renewable energy projects using instruments such as green bonds. While green bonds are in early stages in the region, governments, financial regulators and DFIs have an important role to play in their development. The Green Bond Grant scheme introduced by the Monetary Authority of Singapore to incentivise the issuance of green bonds and kick-start market development is an example. Financial regulators also play a catalytic role in regulating green bond issuance to ensure probity and transparency, as well as compliance with industry-wide definitions and procedures. Effective green bonds design should also be attractive to institutional investors, such as pension funds, and therefore help unlock a wider pool of capital for the sector.



Box 7.1 Project facilitation: Developing a pipeline of bankable renewable energy projects

Renewable energy project development can be hindered by obstacles such as lack of capacity to develop bankable project proposals, insufficient access to transparent financing options and lack of access to project stakeholder networks. To improve project quality, market visibility and access to finance, IRENA has developed several project facilitation tools, including the Global Atlas (discussed in Chapter 3), Project Navigator and the Sustainable Energy Marketplace.

The **Project Navigator** (<http://navigator.irena.org/>) is an online platform providing information, tools and guidance to assist in the development of renewable energy projects across their life-cycle. The learning section features easy-to-access knowledge materials for each technology including tools, real-life case studies and industry best practices.

The **Sustainable Energy Marketplace** (www.irena.org/marketplace) is a virtual match-making platform that connects project owners, financiers/investors, host governments, service providers and technology suppliers. Investment opportunities are made visible and identifiable for investors, and project developers can access relevant funding sources and expertise to advance their projects. Following two years of operation in Africa, Latin America and the Caribbean, the Marketplace platform is now expanding to Asia, Southeast Europe and Small Island Developing States.

BUILDING INSTITUTIONAL AND HUMAN CAPACITIES

While renewable energy targets and enabling policy and investment frameworks are essential, their success relies heavily on the ability of a wide array of public and private institutions to effectively monitor and deliver on their roles. The ability of government ministries, regulators, financing institutions and the private sector to actively participate in the sector is strongly influenced by the institutional mandate, human and financial capacity, and coordination.

1. From policy and regulatory design to project preparation, evaluation, development and financing, a wide array of **skills need to be built up** in government ministries, financing institutions and regulatory agencies. Within the renewable energy sector itself, planning for skills needs and undertaking skills-building measures is crucial to sustain deployment growth and maximise the local employment benefits. Capacity and skills needs assessments can help identify gaps and guide efforts to address these in collaboration with sector actors.
2. The public institutional landscape should comprise of **well-defined and functional** institutions and

energy regulatory structures. These are key for supporting the creation of dynamic markets and attracting investments in renewable energy. As with most infrastructure projects, clarity of institutional roles (e.g., those related to project evaluation, permitting and licensing) accompanied by **transparent and streamlined procedures** can reduce transaction costs and make projects more attractive. Institutions with a clear legislative mandate, accountability and sound financial health reduce counter-party risks of contracts and agreements (e.g., PPAs).

3. **Coordination between the different institutions** and stakeholders is vital to ensure that both deployment and development policy objectives are met in a timely and efficient manner. Achieving high shares of renewable energy in the energy mix, especially across end-use sectors, and the development of a local industry requires effective coordination and planning between ministerial bodies and other implementing agencies. There is also a strong need for **independent technology access platforms** that project owners, including public sector entities such as municipalities, can turn to for knowledge and support.

PLANNING FOR HIGHER SHARES OF VARIABLE RENEWABLE ENERGY

As variable renewable energy generation increases, measures need to be taken to ensure cost-effective integration into the energy system. This requires a careful consideration of all aspects of generation, delivery and consumption at the local, national and regional level.

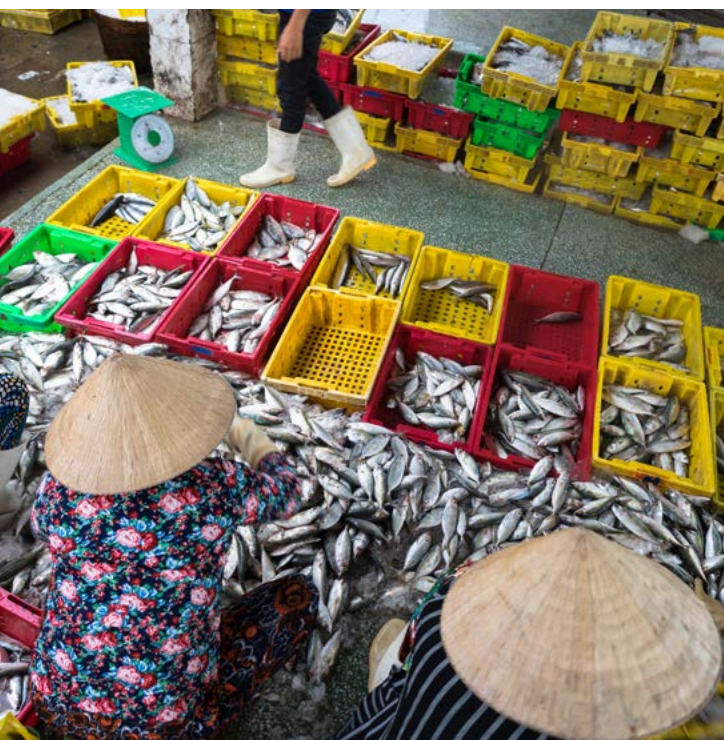
1. Investments in transmission and distribution infrastructure to cope with rising power demand and supply should be focused on solutions that also enhance the flexibility of the power system. The amount of flexibility required and the solutions (e.g., flexible thermal capacity, storage, demand response) will vary from context to context, thereby necessitating a **dedicated flexibility needs assessment** for power sector planning. This is particularly relevant for archipelago countries, such as Indonesia and the Philippines, which comprise of several island grids that require careful planning for integrating variable renewable energy.
2. **Increasing interconnection capacity** between countries and power systems is one of the key measures to improve grid access and system reliability and to accommodate higher shares of variable renewable energy. The development of the ASEAN Power Grid to enhance electricity trade to meet rising electricity demand at low costs and improve access to energy services can also enable the integration of variable renewable energy. To this end, cross-border trade of hydropower could play a role, although social and environmental sustainability of such projects needs to be ensured.
3. From a long-term perspective, there might be a need to **adapt power market design to incentivise flexibility** services and potentially establish an auxiliary market to enable power producers to contribute to maintaining grid stability and reliability. Coupling of power and end-use sectors will play an important role in supporting the integration of higher shares of variable renewable energy.

SUPPORTING DECENTRALISED RENEWABLE ENERGY SOLUTIONS FOR LIVELIHOOD IMPACT

Access to modern energy is an essential driver for socio-economic development in the region where nearly 65 million people still lack access to electricity and 250 million people rely on traditional biomass for heating and cooking. Several projects and programmes in the region – based on local entrepreneurship and strong community participation – have demonstrated the role that decentralised renewable energy solutions can play in improving access to modern energy and the ensuing economic, social, health and environmental benefits. These solutions should be fostered to complement traditional energy access efforts.

1. National energy access plans should **consider both on- and off-grid solutions** to reach universal access in a timely manner. These should identify areas to be served through each solution and implications for when the national grid arrives. In defining the role of off-grid renewable energy solutions (stand-alone systems and mini-grids) in such plans, **existing practices and projects should be considered** and their scale-up potential be assessed. In Myanmar, for instance, several thousand small-hydro and biomass gasifiers have been developed providing a wide range of consumptive and productive energy services in rural areas.
2. Greater attention is needed to reduce the use of traditional fuels for heating/cooking. Energy access plans should **prioritise the adoption of clean-cooking systems and fuel switching** towards modern fuels. Quality and standards, awareness raising and capacity building are key components for the delivery of clean-cooking solutions and should be integrated into plans. Biogas development in Viet Nam, for instance, offers important lessons for the deployment of decentralised solutions to address local energy needs.

3. Participation of **local private sector and communities** should be encouraged through dedicated and stable policy and regulatory frameworks, financial incentives and capacity building programmes (e.g., focusing on skills training). This is crucial to ensure adaptation of solutions and long-term sustainability.
4. **Tailored financial support and fiscal incentives** (e.g. import duty and value-added tax exemption) can help address the access to finance challenge for both end-users and suppliers. Adequate **standards and quality control** measures should also be implemented to avoid the proliferation of low-quality products and market spoilage.
5. Energy-service delivery should be **closely linked with productive end-uses**, aimed to foster local enterprises and support local economic growth and livelihood development. This can be done by facilitating dialogue with stakeholders at project design stage, adequate capacity building on potential productive end-uses, and the provision of high-risk innovation funding.



LEVERAGING REGIONAL COOPERATION TO ACCELERATE RENEWABLE ENERGY TOWARDS SUSTAINABLE DEVELOPMENT GOALS

Southeast Asia region represents a unique example of regional cooperation in the world despite vast differences in the composition of economies, cultures and languages. The establishment of the ASEAN Economic Community in 2015 is an important step in the direction of economic integration with energy connectivity and market integration as a key component.

1. Benefiting from the presence of a robust regional cooperation platform and the existence of dedicated institutions as the ASEAN Centre for Energy, there is **immense potential for concerted action** among countries in the region towards accelerating the pace of renewable energy development. The cooperation takes the form of facilitating technology transfer and exchange of best practices and lessons learned, harmonisation of equipment standards and taxation regimes, implementation of the ASEAN Power Grid programme, as well as developing a local renewable energy industry with well-integrated supply chains throughout the region.
2. The cross-sectoral development impacts of renewable energy solutions must be considered at all times. Deploying renewables helps to achieve SDG 7 (on energy) while also **contributing to several other SDGs**, including those related to poverty alleviation, health, water, job creation and climate. In the climate mitigation context, for instance, renewable energy components outlined in NDCs usually cover mitigation and the power sector, and should further cover end-use sectors as well adaptation. Renewable energy should be **integrated as a key pillar for development** at the national and regional level.

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SOUTHEAST ASIA



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