The International Energy Agency (IEA), an autonomous agency, was established in November 1974. Its primary mandate was – and is – two-fold: to promote energy security amongst its member countries through collective response to physical disruptions in oil supply, and provide authoritative research and analysis on ways to ensure reliable, affordable and clean energy for its 29 member countries and beyond. The IEA carries out a comprehensive programme of energy co-operation among its member countries, each of which is obliged to hold oil stocks equivalent to 90 days of its net imports. The Agency’s aims include the following objectives:

- Secure member countries’ access to reliable and ample supplies of all forms of energy; in particular, through maintaining effective emergency response capabilities in case of oil supply disruptions.
- Promote sustainable energy policies that spur economic growth and environmental protection in a global context – particularly in terms of reducing greenhouse-gas emissions that contribute to climate change.
- Improve transparency of international markets through collection and analysis of energy data.
- Support global collaboration on energy technology to secure future energy supplies and mitigate their environmental impact, including through improved energy efficiency and development and deployment of low-carbon technologies.
- Find solutions to global energy challenges through engagement and dialogue with non-member countries, industry, international organisations and other stakeholders.

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- The European Commission also participates in the work of the IEA.
Meeting energy demand in a secure, affordable and sustainable manner is a common challenge that many countries in the world face today. However, the pressures on the energy sector in Southeast Asia are particularly powerful; strong economic and population growth, allied to structural trends such as urbanisation, point towards a rapid expansion in demand for energy. The agenda facing Southeast Asia’s governments is not a simple one: constraining growth in consumption through policies on the demand side; encouraging adequate investment in new energy supply infrastructure and mitigating concerns over security of supply; improving air quality and curbing growth in emissions; and expanding access to modern energy services for the millions of people that remain without.

Policy-makers across Southeast Asia are making strenuous efforts to address these issues, but tackling multiple challenges simultaneously is never easy and potential solutions differ among countries, depending on their national circumstances. The International Energy Agency, with a long history and experience of in-depth analysis in the global energy field, stands ready to support Southeast Asia in its endeavours. I trust that this report – the third edition of the Southeast Asia Energy Outlook since 2013 – will provide useful insights to policy-makers, industries, energy experts and other stakeholders and provide a framework that will enrich discussions on the future of energy in this critically important part of the world.

Enhancing engagement with Southeast Asia is a high strategic priority for the Agency, and an issue to which I attach great importance as Executive Director. With the support and goodwill of the countries in the region, I am delighted at the steps that we have been able to take. The IEA and Southeast Asia now have a strong and wide-ranging programme of activities, and three countries in the region – Indonesia, Singapore and Thailand – have become Association countries of the IEA. I look forward to deepening our co-operation in the future.

I take this opportunity to extend my sincere appreciation to all those who provided support throughout the preparation of this report.

Dr. Fatih Birol
Executive Director
International Energy Agency
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The ten countries of the Association of Southeast Asian Nations (ASEAN) represent one of the most dynamic parts of the global energy system, with their energy demand growing by 60% in the past 15 years. ASEAN countries are at various stages of economic development and have different energy resource endowments and consumption patterns. But they also share a common challenge to meet rising demand in a secure, affordable and sustainable manner. Ensuring sufficient investment in energy supply and energy efficiency is central to this task. These countries have made major efforts in recent years to upgrade policy frameworks, reform fossil-fuel consumption subsidies, increase regional co-operation and encourage greater investment in the region’s considerable renewable energy potential.

While there are many encouraging signs, much more remains to be done. Access to modern energy is incomplete. With a total population of nearly 640 million, an estimated 65 million people remain without electricity and 250 million are reliant on solid biomass as a cooking fuel. Investment in upstream oil and gas has been hit by lower prices since 2014 and the region faces a dwindling position as a gas exporter, and a rising dependency on imported oil. At the same time, energy-related air pollution, both indoor and outdoor, also presents major risks to public health, while rising carbon-dioxide (CO₂) emissions are contrary to the objectives of the Paris Climate Change Agreement, which has been ratified by all the countries in the region. Our analysis in this World Energy Outlook (WEO) Special Report confirms that Southeast Asian countries are looking towards a future in which energy demand is set to grow strongly. Our aim in this analysis is to provide a framework for understanding the region’s energy choices, examining the pitfalls and opportunities that lie ahead and what different pathways might imply for future energy security, the environment and economic development.

A new heavyweight in global energy

In our main scenario, Southeast Asia’s energy demand grows by almost two-thirds in the period to 2040. This represents one-tenth of the rise in global demand, as the region’s economy triples in size, the total population grows by a fifth with the urban population alone growing by over 150 million people. This scenario reflects the impact of existing energy policies in Southeast Asia as well as an assessment of the results likely to stem from the implementation of announced policy intentions, such as the country pledges made as part of the Paris Agreement. There is strong growth in low-carbon energy, but increased energy needs lead to rising consumption of all fuels. Coal alone accounts for almost 40% of the growth, and overtakes gas in the electricity mix. Oil demand expands from 4.7 million barrels per day (mb/d) today to around 6.6 mb/d in 2040, as rising demand for mobility means the number of road vehicles increases by two-thirds to around 62 million. Demand for natural gas also grows strongly, by around 60% to 2040, due to rising consumption in power generation and industry. The share of renewables, excluding solid biomass but
including hydro, solar photovoltaic (PV) and wind power, almost doubles as their deployment helps to meet rising electricity demand and to extend energy access.

**Electricity accounts for the largest share of the increase in final consumption, as rising incomes in the region translate into higher ownership of appliances and increasing demand for cooling.** Two-thirds of the increase in Southeast Asia’s electricity demand comes from the residential and services sectors, largely due to a rising urban middle class. Industrial electricity demand more than doubles, pushed higher by the lighter industrial branches that are a mainstay of the region’s economic activity. One area where electrification makes less progress is the transport sector. In the absence, for the moment, of supportive policies, electric mobility does not gain much of a foothold in our projections. Instead, energy use in the transport sector remains dominated by oil products, with policy efforts to diversify the mix focusing on biofuels. Biofuels can bring energy security and environmental benefits, although that would require that palm oil production is managed sustainably, an important policy issue for the main producers, Indonesia and Malaysia.

**Meeting increasing electricity demand requires a huge expansion in the region’s power system, with coal and renewables accounting for almost 70% of new capacity.** Installed power generation capacity rises to more than 565 gigawatts (GW) in 2040 in our main scenario, from 240 GW today. The mix of fuels and technologies varies country-by-country, but overall reflects an emerging preference for a combination of high efficiency coal plants and increased deployment of renewables. By 2040, renewables account for the largest share of installed capacity (nearly 40%), but coal takes the most prominent role in the generation mix (40%) and 70% of the new coal-fired capacity uses high efficiency supercritical or ultra-supercritical technologies. Output from natural gas-fired plants rises by 60% in absolute terms, but the share of gas in the power mix falls back from the current 43% to 28% by 2040. The large penetration of renewables and wider deployment of more efficient coal-fired plants results in the carbon intensity of power sector declining by almost one-fifth, but it remains significantly higher than the world average.

**The route to universal access**

Extending connections to those without access to electricity is a top priority for policymakers in Southeast Asia. The large number of people living in island communities and remote areas makes the challenge more difficult. Countries across the region have made great strides in addressing the issue, with the electrification rate rising by 28 percentage points since 2000, and is now at 90%. The declining cost of renewables is opening new opportunities to achieve access and reduce reliance on costly diesel generators in isolated areas. But achieving universal access across a very diverse region requires careful consideration of the specific situation of different communities. This WEO Special Report includes a detailed geo-spatial analysis that considers population density and resource availability to determine the least-cost connection type and fuel technology for the four countries – Indonesia, Philippines, Myanmar and Cambodia – where 95% of those without electricity are concentrated.
In our main scenario, all countries in Southeast Asia achieve universal access by the early-2030s, using a wide range of fuels and technologies, as well as both centralised and decentralised solutions. Varying resource distribution, distance from existing demand centres and population density means that there is no one-size-fits-all approach. In Indonesia, nearly 40% of those who gain access do so through extension of the existing grids, with mini-grid and off-grid approaches playing a prominent role in areas of the country, including Papua, which are more sparsely populated. The Philippines, which fulfils its goal of universal access well before 2030, relies more heavily on grid connections that account for around 90% of new connections, while renewables-based mini-grid and off-grid also play a role, providing access to around 1.6 million people. In Cambodia, grid connections are the least-cost solution for all but 3% of the 7.6 million new connections on the path to full electrification. Myanmar has ample scope to rely on renewables in its electrification strategy. Solar PV provides the least-cost connection to around 11.8 million people, around half of new connections by 2030.

**A reversal of fortune for net energy trade**

Southeast Asia remains an important producer of oil, gas and coal, but faces several challenges, especially in the near term. The oil supply outlook in our main scenario continues the recent trajectory of decline, falling from 2.5 mb/d today to 1.7 mb/d in 2040; offsetting production declines from mature fields becomes all the more difficult in the current period of lower prices and investment. A slight rise in production in Brunei Darussalam and the Philippines is not enough to offset declines in Indonesia, Malaysia and Viet Nam. Natural gas fares better, with the region as a whole successfully keeping production at around the same level as today in the period to 2040. The production outlook would be brighter still if investment in Indonesia’s East Natuna field were secured, though this is contingent on finding a suitable solution for the very high levels of CO₂ associated with the field’s production. Coal production, centred in Indonesia, falls marginally, although this reflects policy choices rather than resource constraints.

Decreasing domestic supply and increasing demand pushes Southeast Asia’s annual net import bill to over $300 billion in 2040, equivalent to around 4% of the region’s total gross domestic product. Oil is by far the largest tranche of projected imports; net imports of 6.9 mb/d in 2040 require $280 billion in annual outlays by 2040. While the region as a whole becomes a net importer of coal, Indonesia remains an important producer as well as an exporter to its Southeast Asian neighbours and India. Southeast Asia plays an increasingly prominent role as a market for liquefied natural gas (LNG), benefiting in the near term from prices depressed by the strong global supply outlook. The use of LNG extends to smaller scale projects in Indonesia and the Philippines, and plays an important role in displacing diesel-based generation in some island communities. Apart from the mounting import bill, the region’s increasing dependence on imported energy raises significant energy security concerns.
The road ahead for Southeast Asia is not set in stone

The projections in our main scenario show that Southeast Asia is on track to achieve some key energy policy goals, including the difficult task of bringing universal electricity access and greater diversification of the energy mix. Yet they also highlight major potential risks. Despite the respite afforded by lower prices on oil import bills, energy security remains high on the agenda as the impact of lower upstream spending works its way into regional supply, while imports continue to grow. Concerns about air pollution in several of the region’s largest cities amplify as urban populations and demand for mobility increase. Strong growth in fossil-fuel consumption leads to a 75% increase in energy-related CO₂ emissions.

Policy choices can help mitigate these risks, and our new Sustainable Development Scenario describes an alternative pathway for the region that meets global sustainable development goals as well as putting the world on a trajectory consistent with the objectives of the Paris Agreement. In this new scenario, Southeast Asia’s energy demand is 16% lower in 2040 than in the central scenario, helped by a broader adoption of more stringent efficiency standards. The reduced demand and increased use of renewables (around 20 percentage points higher as a share of primary energy demand versus our main scenario) helps reduce reliance on imported oil and gas, and by 2040, the import bill is lower by almost $180 billion. The transition in the Sustainable Development Scenario has profound impacts on greenhouse-gas and air pollutant emissions, with energy-related CO₂ emissions 50% lower than in our main scenario.

Rising energy needs and changing supply-demand dynamics are creating tough challenges for Southeast Asia’s policy-makers, but the energy transition is also opening up new affordable policy and technology options. Energy-efficient and low-carbon technologies offer a way to pursue multiple objectives of energy security, affordability and environmental goals. The rapidly declining cost of wind and solar PV provides an opportunity to help meet growing electricity demand in a cost-effective and sustainable manner, while also helping spur local manufacturing industries. Malaysia is already the world’s third-largest producer of photovoltaic cells, while investment in Thailand’s solar manufacturing industry is increasing PV output for global markets.

Our scenarios highlight three avenues that require particular attention from policymakers: investment, efficiency and regional co-operation and integration:

- **Adequate energy investment**: Southeast Asia’s cumulative energy investment requirement (in energy supply and efficiency) to 2040 is estimated at $2.7 trillion in our main scenario. It is slightly higher in the Sustainable Development Scenario at $2.9 trillion, although greater attention to energy efficiency in this scenario reduces the call for new supply infrastructure. In either case, mobilising investment on this scale will require significant participation from the private sector and international financial institutions. Attracting investment will be contingent on the incentives available to investors, which may be dampened by the presence of electricity price
controls or fossil-fuel consumption subsidies, or terms that are unfavourable compared with other investment opportunities worldwide. There is also a strategic choice to be made regarding the direction of investment flows. Realising the Sustainable Development Scenario requires a major shift towards low-carbon options and efficiency, with the savings in energy consumption and the lower fossil-fuel import bill more than offsetting the increased investment.

- **More efficient energy use**: Efficiency policies in place or under consideration today can curtail energy demand in end-use sectors in Southeast Asia by 10% by 2040, but this far from exhausts the potential gains. For instance, the limited adoption of fuel-economy standards for passenger vehicles means that average fuel economy in the region is projected to be 20% worse than the global average in 2040 in our main scenario. With growing economies and expanded road infrastructure, freight activity more than doubles by 2040 and fuel consumption by trucks (less than 15% of road transport fuel use today) accounts for around 40% of transport energy demand growth to 2040. Rising electricity demand means that reform of electricity subsidies, which are prevalent in some countries in Southeast Asia, becomes imperative in order to prevent wasteful consumption, incentivise investments in efficiency and avoid a drain on fiscal resources. National budgets would face a cumulative electricity subsidy bill of more than $350 billion over the period to 2040 if they fail to achieve the subsidy reforms anticipated in our main scenario.

- **More integrated gas and electricity markets**: Better interconnection of natural gas supply networks, underpinned by harmonised regulation towards flexible and transparent markets, can enhance gas security in the region. In the power sector, realising the long-planned regional grid would make large-scale renewables-based projects more viable. It would also provide benefits to the power system as a whole, aiding the integration of rising shares of wind and solar power.
Chapter 1

Energy in Southeast Asia today

A rising force in global energy

Highlights

- Southeast Asia is increasingly influential on the global energy stage. The ten member countries of the Association of Southeast Asian Nations (ASEAN) collectively are the world’s seventh-largest economy and the fifth-largest destination for foreign investment in 2016. Strong economic growth has fuelled a 70% increase in energy demand since 2000, and the region now accounts for 5% of total global demand.

- There are major differences in energy use patterns across Southeast Asia, with Indonesia accounting for over 35% of the region’s total energy demand. Overall, fossil fuels supply around three-quarters of the region’s energy mix, with oil taking the largest share (34%), followed by gas (22%) and then coal (17%). Use of solid biomass for cooking is widespread, but accounts for a decreasing share of primary energy use. Hydropower has grown rapidly and the deployment of solar PV and wind is also starting to pick up, albeit from a low base in most countries.

- The potential for renewable energy is abundant and widely distributed, but fossil fuels are concentrated in a few countries, with Indonesia, Malaysia and Viet Nam having the largest resources. Southeast Asia’s oil production has been in decline for over a decade and stood at 2.5 mb/d in 2016. The region also accounts for 6% of global gas output and 7% of worldwide coal production. Southeast Asia is a net exporter of energy, as exports of coal, natural gas and bioenergy (mainly biofuels) more than offset net imports of oil in energy-equivalent terms.

- Many ASEAN countries are taking concerted steps to address energy security and environmental concerns. Reform efforts and lower international fuel prices have cut the cost of fossil-fuel consumption subsidies by more than half over the last five years, to $17 billion in 2015. Government action has underpinned a two-thirds reduction in the number of people lacking access to electricity since 2000, to 65 million. Policy attention in many countries aims to improve energy efficiency and to speed the deployment of renewables, to address pressing problems with local pollution and emissions.

- Future energy trends in Southeast Asia will be largely determined by the interplay of government policies and key energy, economic, environmental and demographic indicators. We assume that the region’s economy triples in size by 2040, by which time it is comparable to that of China’s today, while its population increases by 20% to over 760 million. The respite afforded to countries by the fall in the price of oil since 2014 ebbs as the price rises gradually in our main scenario, accompanied by more modest increases in the anticipated prices for natural gas and coal.
1.1 Introduction

Southeast Asia Energy Outlook, a World Energy Outlook Special Report, has been published every other year since 2013. It provides in-depth analyses of the energy demand and supply prospects of the countries that make up the Association of Southeast Asian Nations (ASEAN). Ten countries are members of ASEAN – Brunei Darussalam, Cambodia, Indonesia, Lao People’s Democratic Republic (PDR), Malaysia, Myanmar, Philippines, Singapore, Thailand and Viet Nam – which are at different stages in their economic development, but which are all experiencing rapid economic and demographic change. Individually and collectively, the countries of Southeast Asia are increasingly influential on the global stage. The region’s economy has grown robustly, at an average of 5.2% per year since 2000, and has increasingly attracted foreign direct investment, averaging $120 billion per year over the last five years, a record comparable to China (around $130 billion) and significantly higher than India (around $35 billion). Southeast Asia has been experiencing rapid urbanisation and population growth, and its estimated 640 million inhabitants in 2016 represented around 9% of the world total. Its burgeoning economy and population has resulted in a significant increase in primary energy demand, which has grown by around 70% since 2000.

Figure 1.1 - Changes in total primary energy demand per capita in Southeast Asia

Energy demand in Southeast Asia has grown rapidly since 2000, although regional averages mask a wide range of country circumstances

Note: PPP = purchasing power parity; toe = tonnes of oil equivalent.

Trends at the regional level mask wide disparities in circumstances and energy trends across the member countries of ASEAN (see section 1.3.1). Taken together, average per-capita energy demand in Southeast Asia grew by around 20% over the past decade and has now reached around half of the world average, suggesting great scope for future growth in
energy demand. However, the range is significant: some ASEAN members, albeit those with relatively small populations such as Singapore and Brunei Darussalam, have per-capita energy demand that is more than twice the world average, while that of Myanmar is just one-fifth of the world average (Figure 1.1). The region has considerable fossil and renewable energy resources, but around 65 million people still lack access to electricity.

This report provides updated analyses of a region experiencing vibrant economic and demographic change. It describes a changing energy landscape and examines how policies in place and under consideration might continue to re-shape this landscape over the period to 2040. Although it looks to the future, this outlook does not make predictions, but instead provides a framework within which to assess Southeast Asia’s own policy choices and the direction that they imply for the region’s energy system. Some of the trends described will be welcome; but others may raise concerns about their implications for energy security, economic development or environmental sustainability. We hope that this analysis will help policy-makers, industry, investors and other stakeholders address the myriad opportunities and challenges that lie ahead.

1.2 Key energy trends in Southeast Asia

1.2.1 Energy demand

Primary energy demand

Primary energy demand in Southeast Asia grew by around 70% between 2000 and 2016, to around 640 million tonnes of oil equivalent (Mtoe), while its gross domestic product (GDP) more than doubled over the same period. Rising incomes, urbanisation, expanded access to energy and growing populations all contributed to strong energy demand growth. Fossil fuels dominate the primary energy mix, accounting for almost 75% of the total in 2016 (Figure 1.2). Among ASEAN members, Indonesia has the highest energy demand, accounting for over 35% of the region’s total, followed by Thailand.

Oil continues to be the dominant source of energy, though its share of total primary energy demand has declined by around six percentage points, to 34%, since 2000. Oil demand grew by around 40% over this period, as increasing wealth and relatively weak public transport infrastructure translated into an almost doubling of the number of passenger vehicles to 56 vehicles per 1,000 people in 2016. Nonetheless, this level of ownership is still less than half of the world average, signalling the potential for further growth. Demand for mobility, which today is heavily correlated with consumption of oil products, is likely to remain one of the main underlying drivers of energy demand growth.

Coal demand has more than tripled since 2000, with an annual average growth rate of 8.8%. In 2016, coal demand of around 110 Mtoe accounted for 17% of the total primary energy demand, of which the largest portion was for power generation. Abundant coal resources in the Southeast Asia region, as well as its relatively low cost, have underpinned the rise in coal demand, alongside the policy imperatives to meet rising demand for electricity and extend access to electricity to the millions of people that lack it. Natural gas consumption
also grew rapidly, almost doubling since 2000, with use in power generation accounting for around 60% and industrial demand accounting for the bulk of the rest.

Solid biomass plays a major role in Southeast Asia’s primary energy mix, accounting for 20% of total demand in 2016. A variety of biomass, such as fuelwood, charcoal and agricultural waste is used as a source of energy, mainly in the residential sector, where it is relied on by around 250 million people as a source of heat for cooking. Though still high, the share of bioenergy in the mix has been in decline (it was about 26% in 2000); this reflects the ongoing shift towards modern energy such as electricity (for lighting) and liquefied petroleum gas (LPG) (for cooking).

Among the modern sources of renewable energy, hydropower has grown rapidly with expanded use in Cambodia, Myanmar and Lao PDR. So far, non-hydro renewables have played only a relatively limited role in the energy mix. To address environmental concerns, as well as to make better use of abundant renewable resources, many countries in Southeast Asia have plans to expand the use of wind and solar power (and geothermal in some areas). Currently there is no nuclear power capacity in the region, though there are plans in some countries to introduce it to meet growing electricity demand.

**Figure 1.2**

Evolution of primary energy demand in Southeast Asia

<table>
<thead>
<tr>
<th>Year</th>
<th>Coal</th>
<th>Oil</th>
<th>Gas</th>
<th>Bioenergy</th>
<th>Other renewables</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>26%</td>
<td>8%</td>
<td>19%</td>
<td>6%</td>
<td>20%</td>
</tr>
<tr>
<td>2016</td>
<td>18%</td>
<td>34%</td>
<td>22%</td>
<td>6%</td>
<td>20%</td>
</tr>
</tbody>
</table>

Primary energy demand has increased by around 70% since 2000, with coal accounting for the largest share of the growth.

**Sectoral demand**

Industry has increased its energy use by almost 70% since 2000 and it is the largest consumer among the energy end-use sectors (Figure 1.3). Rapid economic development has spurred demand in a range of energy-intensive industries including steel, petrochemicals, paper, cement and aluminium. Energy demand in each of the subsectors of

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1 Industry energy demand includes blast furnace, coke ovens and petrochemical feedstocks.
iron and steel, chemicals and cement has doubled over the period, while energy demand in paper production has grown by more than half. Energy demand for aluminium production has increased almost five-fold, albeit from a low base. Growth in industrial energy demand since 2000 was met primarily by coal, gas and electricity. Demand for electricity more than doubled. Demand for oil for energy purposes decreased by 8%, but oil demand for petrochemical feedstocks more than doubled, leading to total oil demand in industry increasing by around 40%.

Among end-use sectors, energy demand in transport grew most rapidly, almost doubling between 2000 and 2016. The region’s passenger vehicle stock has more than doubled since 2000, to around 36 million. These vehicles are dominantly fuelled by oil, while natural gas and biofuels constitute around 6% of transport energy demand, collectively, reflecting efforts made by some Southeast Asian countries such as Thailand, Malaysia, and Indonesia to increase the use of alternative fuels. Electric vehicles have yet to feature prominently in the region: the total electric vehicle stock is estimated at around 7 000 as of 2016, including two/three-wheelers, much lower than the level of other regional groupings such as the European Union (over 5 million).

Figure 1.3  Energy demand by fuel and sector in Southeast Asia

Industry has led energy demand growth among the end-use sectors since 2000, overtaking buildings to become the largest end-use consumer

Note: Bioenergy in the buildings sector includes the demand for traditional biomass, which accounted for around 70 Mtoe in 2000 and around 90 Mtoe in 2016.

Bioenergy is the dominant fuel in the buildings sector, meeting around 60% of energy demand. Lack of access to clean cooking facilities means that various biomass sources, including firewood, charcoal and agricultural wastes are still prominent in the mix. Since 2000, a 180% increase in electricity consumption (the fastest growing energy source in

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buildings over the period) has helped slow the growth in biomass use, doubling the share of electricity in the buildings energy mix. The growth in electricity demand reflects government policy to extend electricity access in a number of countries, particularly Indonesia, but also the impact of urbanisation and improved living standards. Despite efforts to provide universal access, an estimated 65 million people remain without electricity across Southeast Asia; filling this gap is a major policy priority, examined in detail in Chapter 3. In the buildings sector, oil consumption is mostly in the form of LPG, an important facilitator to access clean cooking for households.

1.2.2 Electricity

Electricity demand and supply

Rapid economic and population growth pushed up electricity demand in Southeast Asia at an annual average rate of 6.1% since 2000, twice the world average. The demand roughly tripled over this period so per-capita electricity consumption grew robustly, with consumption in some ASEAN members such as Cambodia, Indonesia, Myanmar and Viet Nam more than doubling, albeit from a low base in Cambodia and Myanmar (Figure 1.4). Electricity has been the fastest growing energy source in the region since 2000, but its share in total final energy consumption remains relatively low at 16% in 2016 (compared with the world average of 19%). Electricity demand in industry, the largest end-user, accounted for 40% of the growth between 2000 and 2016. Electricity demand in the residential sector, the second-largest electricity consuming sector, grew rapidly at an average annual growth rate of 7.5%, underpinned by increasing ownership of appliances (household ownership of refrigerators has increased from around 40% in 2000 to around 60% in 2016) and by increasing energy access.

Figure 1.4 Average annual growth in per-capita electricity consumption in Southeast Asia, 2000-2015

Growth in per-capita electricity consumption was well above the global average in most Southeast Asian countries, driven by strong economic growth
Installed power generation capacity in Southeast Asia has more than doubled since 2000, to around 240 gigawatts (GW) in 2016. Net capacity additions over the period were primarily coal- and gas-fired power plants, each accounting for around 40% of the increase. There are some signs that the rapid rise in coal-fired capacity, which more than tripled since 2000, is running out of steam: final investment decisions taken on new coal plants in Southeast Asia (except Indonesia) fell in 2016 for a third year in a row (Figure 1.5). Such decisions can fluctuate from year-to-year for various reasons, including the availability of personnel to build plants, so are not entirely reliable as an indicator of future trends. Nonetheless, the recent slowdown is symptomatic of the challenges facing the large-scale deployment of new coal-fired power plants, including the need to address environmental concerns and to secure financing.

Renewables-based power generation capacity has tripled since 2000, to 56 GW in 2016, led by a 25 GW expansion of hydropower. Non-hydro renewables accounted for 6.5% of total installed electricity capacity in 2016, of which bioenergy and geothermal capacity made up around 70%. Reflecting policy efforts to deploy renewables, solar and wind capacity increased by more than ten-fold over the past five years, albeit from a low base. Despite the increase in electricity capacity, a shortage of electricity supply remains a significant issue for some Southeast Asian countries. For example, according to the World Bank Enterprise Survey, 95% of manufacturing firms in Myanmar experience electricity outages, a level far in excess of the global average of around 60% (World Bank, 2017).

In line with the increase in capacity, power generation in Southeast Asia also more than doubled between 2000 and 2016 (Figure 1.6). Fossil fuels continue to dominate the
generation mix with their more than 80% share remaining unchanged over the period. However, the shares of the various fuels have changed significantly, with coal-fired generation growing at an annual average rate of 9.8% and increasing its share in the mix to around one-third in 2016, from one-fifth in 2000. In an effort to mitigate some of the environmental concerns associated with coal-fired generation, some countries led by Indonesia, Thailand and the Philippines are prioritising more efficient coal-fired power generation in new construction, such as supercritical plant technology.

**Figure 1.6** Power generation mix in Southeast Asia

Electricity generation has more than doubled since 2000, with coal taking a rising share

Note: TWh = terawatt-hours.

Natural gas also remains a key input for power generation, accounting for around 40% since 2000. Individual countries have seen more dramatic changes, sometimes bucking the regional trend. For example, in Malaysia, the share of gas in the power mix decreased from 67% in 2005 to 47% in 2015, led by policies to switch to coal in response to declining domestic gas production. The share of gas in Viet Nam’s power generation mix also declined, from 42% in 2005 to 33% in 2015, as the share of coal increased from 23% to 30%. On the other hand, in Indonesia, the share of gas increased to 26% in 2015 from 15% in 2005, as the country took advantage of domestic gas production to meet rising demand. In Myanmar, a steep increase in the share of gas-fired power generation, from 15% in 2005 to 39% in 2015, reflects a push to take advantage of its abundant domestic resources.

Oil has gradually been replaced by gas and coal in power generation, and has seen its share in the power mix fall from about 20% in 2000 to just 4% in 2016. This trend of less oil in power generation holds in many of the ASEAN members’ economies, as in other parts of the world, but diesel continues to play an important role in electricity supply in many remote islands and settlements (see Chapter 3).
Among renewables, hydro was the biggest contributor to power generation, more than doubling the capacity since 2000, to 14% in 2016. While a significant amount of the region’s hydropower resources remain untapped, particularly in Cambodia, Lao PDR and Myanmar, these are increasingly being developed to meet local demand and for export. Hydropower dominates the power mix in Cambodia and Myanmar, with a share of around 50% and 60% in 2015, respectively. The four countries in the Lower Mekong Basin, namely Lao PDR, Thailand, Cambodia and Myanmar, have significant hydropower potential of more than 110 GW (ACE, 2017), but the development of large-scale projects raises a plethora of social and environmental questions that could stymie expansion.

Power generation from other renewable sources also has been increasing, with variations from country to country linked to policy choices and resource availability. As of 2015, the Philippines and Indonesia had the world’s second- and third-largest geothermal power generation. In Malaysia and Thailand, bioenergy constitutes a major source of non-hydro generation. Many countries in Southeast Asia plan to increase the use of renewables to take advantage of their abundant resources and to address growing local air pollution and environmental concerns, and have already introduced various support measures. Five ASEAN members (Indonesia, Malaysia, Thailand, Philippines and Viet Nam) have introduced feed-in tariffs to incentivise investment in renewables. Such measures have helped solar photovoltaic (PV) capacity in Thailand more than triple since 2013, to 2.8 GW in 2016.

Today nuclear power does not feature in Southeast Asia’s energy mix, though a number of countries are considering it as an option. Thailand includes 2 GW of nuclear power capacity by 2036 in its national power development plan. Viet Nam also makes provision for its introduction by 2030 in its power development plan (though the plan is currently suspended). Malaysia and Indonesia recognise nuclear power as an energy option in their national plans, though there is no quantitative target or specific plan to introduce it. Malaysia, Thailand, Indonesia, Philippines and Viet Nam have been engaged in nuclear power capacity-building activities such as raising public awareness and ensuring safety in co-operation with the International Atomic Energy Agency.

Countries across Southeast Asia, including Malaysia, Indonesia, Thailand and Viet Nam, have taken steps to increase private sector participation in the power sector, including by facilitating entry of independent power producers (IPPs), with the use of power purchasing agreements. This is a departure from the long-held model of concentrating on large national power companies. Use of power generation from IPPs complements that from state-owned power generation companies and contributes to enhancing reliability of electricity supply, which is one of the key elements to attract industries and foster economic development. In 2016 in Thailand, for example, IPPs account for around 36% of electricity generation capacity (EPPO, 2016). In addition, small power producers (SPPs), which are distributed power generators using renewables or cogeneration technologies, certified by the government of Thailand, can sell the electricity directly to industrial customers and play a significant role in boosting reliability of supply (Box 1.1).
In many Southeast Asian countries, manufacturing industries play a prominent role in attracting foreign direct investment and boosting economic growth. Between 2000 and 2015, total manufacturing value added in the region almost doubled, to around $550 billion, a pace faster than the global average (World Bank, 2016), with many Southeast Asian countries having a share of manufacturing value added in GDP of more than 20%. Growth in the region’s automotive sector is notable, with production more than doubling to over 4 million vehicles between 2006 and 2016 (ASEAN Automotive Federation, 2017). Thailand, with the largest share of manufacturing value added per GDP of 27% in 2015, is the largest automobile producer among the ASEAN member countries and has attracted many global industries including automobile assemblers and parts manufacturers. The electronics industry is also flourishing, with many multinational companies having manufacturing bases in Southeast Asia. Thailand alone has 2,300 electric appliance assembly companies (ASEAN, 2017).

Reliable, affordable electricity supply is a key element to attract foreign direct investment and manufacturing industries to the region. Rising electricity demand, coupled with the lack of sufficient financial resources to ensure adequate power infrastructure, can provoke unplanned electricity outages that disrupt operations and create losses for manufacturing industries. These concerns apply in many of the Southeast Asian economies (Figure 1.7). Electricity loss in transmission and distribution is higher than the global average of 8.9% in Indonesia, Myanmar and the Philippines, leaving room for electricity cost reduction by refurbishing existing and building new networks.

Distributed power generation can play a substantial role in ensuring reliable electricity supply to industry. It allows industries to bypass the national grids, as well as reinforcing those grids when electricity surplus to needs is supplied to the network. Some Southeast Asian countries offer programmes to promote the use of distributed power generation facilities to cope with potential supply deficiencies. For example, in Thailand, the Small Power Producer Programme (SPP) guarantees the purchase of power supplied from distributed generation by cogeneration technologies or non-fossil fuel resources with capacity up to 90 megawatts (MW). Owners can sell electricity directly to industry. The programme has proven successful in reinforcing the national electricity system, with power generation capacity in the SPP programme accounting for 15% (6.3 GW) of total installed capacity in 2016 (EPPO, 2016). Natural gas cogeneration facilities accounted for around 70% of the capacity in the SPP programme in 2016 (EGAT, 2016). Much of this capacity is situated in Thailand’s industrial zones, where foreign manufacturing companies are concentrated, to provide reliable electricity supply and heat under the SPP programme. The SPP also promotes the efficient use of energy and contributes to the deployment of low-carbon energy technologies. Renewables-based power generation in the SPP mainly use biomass such as bagasse and sugarcane.
Thailand’s experience with the SPP programme provides a useful reference to the many other Southeast Asian countries with financial constraints that limit their ability to keep pace with increasing electricity demand. Such an approach requires effective regulatory frameworks that allow the private sector to sell electricity directly to industrial customers. In Indonesia, the government plans to set up 13 industrial parks outside of Java to foster industrial development, of which ten are located in provinces where diesel-fired plants are the dominant source of power supplemented with only a small amount of renewables, such as mini-hydro and biomass. The promotion of distributed power using renewables or gas cogeneration can offer multiple benefits: they would allow Indonesia to tap abundant energy resource and efficiency potentials; reduce electricity cost by replacing costly diesel generation and bring the co-benefit of improved air quality; and would reinforce the national grid by providing a supply of reliable electricity. The development of industrial zones in remote areas outside of Java can benefit local people by helping to improve the economic viability of electricity access projects, bringing electricity earlier to remote areas.

**Figure 1.7** Firms experiencing power outages and transmission and distribution losses in selected Southeast Asian countries

The degree of private participation in power generation varies among Southeast Asian countries depending on the allowable competition in its power market structure. In Indonesia, around 20% of power generation capacity currently comes from IPPs, with their role expected to expand under the General Plan for National Electricity to 2034. Viet Nam also intends to increase the role of the private sector in electricity supply and has prepared

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the necessary regulatory framework to allow IPPs to provide electricity to EVN, the national electricity utility. On the other hand, Singapore does not have a national power generation company.

Transmission and distribution (T&D) networks have also been expanding rapidly in Southeast Asia, increasing by around 70% since 2000 to around 3.6 million kilometres (km) today. This rate of expansion is twice the world average. However, many parts of the network need to be modernised to reduce T&D losses, which averaged 8% across the region in 2016, compared with 7% in the OECD and 9% globally. Losses vary by country, from 17% in Myanmar to 6% in Thailand, with rates in more than half of the ten ASEAN members exceeding the average of Organisation of Economic Development and Co-operation (OECD) countries.

1.2.3 Production and trade

Southeast Asia’s energy resources are varied and abundant (Figure 1.8). The region is a significant net energy exporter; coal, natural gas and bioenergy (mainly biofuels) exports more than offset net imports of oil in energy-equivalent terms. Bioenergy refers to the energy content in solid, liquid and gaseous products derived from biomass feedstocks and biogas. This includes biofuels for transport and products (e.g. wood chips, pellets and black liquor) to produce electricity and heat. Municipal solid waste and industrial waste are also included.

Figure 1.8 Total energy production in Southeast Asia by source

Coal accounts for around 40% of Southeast Asia’s primary energy production and underpins the region’s role as a net energy exporter.
Oil

Southeast Asia’s oil production has fallen from 2.9 million barrels per day (mb/d) in 2003 to 2.5 mb/d in 2016. This trend is due to Indonesia, the region’s largest producer, where production has fallen by almost 40% since 2000, as investment lagged behind what is needed to stem declines from existing fields. Although Indonesian production trended higher in 2016 (increasing to around 880 thousand barrels per day (kb/d), the first year-on-year increase in six years) due to new output from the Banyu Urip field, in general the country is a mature oil producer where it is proving difficult to discover and develop resources, especially in today’s lower price environment. Proven reserves in Indonesia, i.e. the amount of oil that is discovered and ready to produce, has also fallen, from 5.1 billion barrels in 2001 to 3.3 billion barrels by end-2016. The decline in output in Indonesia, coupled with a strong increase in demand, means that it has been a net importer of oil since 2004, with net imports of around 700 kb/d in 2016.

Malaysia, Southeast Asia’s second-largest oil producer (and the only country in the region apart from Brunei Darussalam that remains a net oil exporter) has successfully maintained output at around 700 kb/d over the period since 2000. It has been less successful, however, at booking new reserves, which have fallen by 20% since 2000, to 3.6 billion barrels by end-2016 (implying a reserves to production ratio of a little over 14 years). Oil production in Thailand grew more than in any other country in the region since 2000, by around 270 kb/d, but this was not enough to offset increasing demand. Overall, Southeast Asia’s net import requirement increased five-fold between 2000 and 2015, to 3.5 mb/d.

While Southeast Asia is a mature oil-producing region, there is still potential to boost output, as there remain relatively unexplored areas that are thought to hold significant resources, particularly in deepwater. However, in some parts of the region, efforts to increase production are constrained by challenging legal and resource ownership issues, infrastructure constraints and the difficulties caused by the sector-wide decrease in capital expenditure in the current market conditions.

Southeast Asia has gone from being self-sufficient in oil products in 2000 to being a net importer of 1.3 mb/d in 2016 (including bunker fuel). This is the result of a combination of strong demand growth of 2.4 mb/d, coupled with only a modest increase in refinery capacity of 0.2 mb/d. Oil product demand stood at 6 mb/d in 2016, increasing more than 60% since 2000, primarily on increasing demand for gasoline. Many projects have been proposed to expand the region’s refining capacity from the current level of 4.8 mb/d, but a range of investment bottlenecks mean that few have led to a final investment decision.

Lagging capacity additions is not the only challenge that Southeast Asia’s refining sector faces. Globally, there is a trend towards more stringent fuel quality specifications,

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4 The World Energy Outlook methodology typically excludes bunkers from regional demand analysis, as they do not count as domestic demand. However, Southeast Asia has a high share of bunkers in its total demand relative to other regions due to its significant marine and air transportation hubs. Therefore, an estimate of future bunker demand was added to our demand projections.
especially regarding sulfur content. The Euro V (and more stringent Euro VI) standards are increasingly being adopted across the globe and some Asian countries such as China and India introduced specifications similar to the Euro standards. However, most existing oil refineries in Southeast Asia have relatively limited upgrading and desulfurisation capacity. The desulfurisation capacity of the region’s refining capacity relative to its primary distillation capacity is currently around 40%, lower than the global average of 51%. The upgrading capacity ratio is also low, at around 29%, well below the global average of 49%. While diesel and gasoline sulfur standards are relatively lax compared with other parts of the world, some countries in Southeast Asia are tightening their standards. Singapore, for example, adopted the Euro V-equivalent diesel specifications in 2014, which requires sulfur content of below 10 parts per million (ppm) and Malaysia plans to adopt Euro V standard by 2020.

Natural gas

Indonesia and Malaysia are Southeast Asia’s main players in natural gas, accounting for around 70% of the region’s 8.1 trillion cubic metres (tcm) of proven reserves and two-thirds of its 220 billion cubic metres (bcm) of production in 2016. Both countries are also major exporters of gas, primarily in the form of liquefied natural gas (LNG), along with two other, smaller gas exporters, Myanmar and Brunei Darussalam. Thailand and Singapore are the region’s main gas importers, with imports of 16 bcm and 12 bcm respectively in 2016 (Figure 1.9). The Philippines and Viet Nam are currently self-sufficient in gas, but they will soon start importing LNG as their demand increases at a quicker pace than domestic production. The Philippines has plans for a regasification facility that it expects to complete by 2020, and Viet Nam has two in advanced planning stages with first gas scheduled to be received around 2020. Singapore is also expanding its existing LNG importing facility and is seeking to become a major LNG trading hub (as are Shanghai and Tokyo). Singapore’s relatively small import needs raise questions about how quickly the hub would reach sufficient liquidity to operate efficiently, but it is nonetheless well placed to bring Asian LNG buyers and sellers together and has taken a major step forward with the creation of an LNG price index (the “SLiNG”) (see Spotlight in Chapter 3).

The increasing development of LNG regasification terminals in Southeast Asia is linked to the limited intra-regional pipeline infrastructure and a desire for flexibility in gas procurement. Although there are ambitious plans to develop an ASEAN natural gas grid, current pipeline connections are quite limited: gas trade by pipeline in the broader region consists of Indonesia and Malaysia exporting gas to Singapore, and Myanmar exporting gas to Thailand and China (See Chapter 2).

5 The upgrading capacity ratio refers to the ratio of conversion capacity such as coking, visbreaking, hydrocracking, residue hydrocracking, fluid catalytic cracking and residue fluid catalytic cracking relative to atmospheric distillation capacity.

6 Although exports are smaller in volume terms than in Indonesia and Malaysia, Myanmar and Brunei Darussalam actually export a larger share of their total production. In 2015, Myanmar exported some 90% of its production with Thailand and China being the main outlets. Brunei Darussalam currently ships some two-thirds of its production abroad.
Southeast Asia remains a net exporter of natural gas, but growth in domestic demand is outpacing that of production

Southeast Asia’s gas market development has been held back by lack of infrastructure, slow progress in market reform and sluggish production growth. Myanmar is a case in point: despite a relative abundance of gas resources, delays in ramping up production, together with long-term contracts that require it to sell the vast majority of its output to China and Thailand (the contracts expire around 2030), has left the domestic market short of gas. Domestic consumers have turned to more costly fuel oil – according to the World Bank, more than 75% of companies in Myanmar own a generator (World Bank, 2015a) – or more polluting coal (over 5 GW of coal-fired power plant are being planned) to meet their energy needs. There was a programme to convert gasoline vehicles to use natural gas (in Yangon and Mandalay), but a shortage of natural gas effectively stalled the initiative. Most of the country’s offshore shelf is completely unexplored (with only 3 out of 17 identified basins thoroughly explored) and only 3 of its 14 onshore basins have been explored. Furthermore, a lack of comprehensive and accessible geological data increases investment risk and limits investor interest.

Indonesia faces a similar set of problems. Reform of wholesale natural gas pricing and gas allocation mechanisms, including the long-term goal of moving the market towards netback parity with LNG export prices, would help to provide reliable pricing signals for investment, as well as supporting more efficient use of gas. Reform of the regulatory framework, which is viewed as complicated and unclear, could also stimulate investment in the country’s conventional and sizeable unconventional gas resources, notably coalbed methane. The investment climate would also benefit from an expansion of infrastructure to connect demand centres (especially Java and Sumatra) and the geographically dispersed gas production regions. Pipelines, floating storage regasification units for LNG, and even small-
scale LNG supply for smaller demand centres on outer islands (e.g. to displace costly and polluting diesel generators) could all be part of the solution. The gas transmission sector currently suffers from a number of problems: a lack of integrated long-term planning; extensive lead times for infrastructure planning, construction and commission; a lack of co-ordination between different stakeholders; and physical bottlenecks.

The examples of Myanmar and Indonesia highlight that a co-ordinated set of policy decisions to develop or expand infrastructure and foster gas production growth would be vital for natural gas to make further inroads in Southeast Asia’s energy system. This would include better interconnections of the various gas markets through pipeline links or via LNG trade and co-operation on energy security issues. The planned Trans ASEAN Gas Pipeline project (TAGP) and the establishment of Singapore as a gas hub would be notable steps in this direction.

**Coal**

Coal is the most abundant fossil fuel in Southeast Asia, with around 31 billion tonnes of reserves as of end-2015. Commensurate with its resources, the region is also a large producer, and mined around 400 million tonnes of coal equivalent (Mtce) in 2016. Indonesia is by far the biggest coal producer in the region and the only net exporter. In 2016, Indonesia produced 350 Mtce, of which 290 Mtce was exported, making it one of the world’s largest exporters of steam coal. Indonesian coal production is concentrated on the island of Kalimantan with some production also taking place in Sumatra (Figure 1.10). Costs of coal production vary in Indonesia. Companies with access to low-cost coal (typically shallow seams and access to inland transport via a system of navigable rivers) have very competitive costs whereas smaller producers increasingly have difficulties to make ends meet.

Boom years for Indonesia’s coal industry between 2003 and 2013, saw export growth rates of over 15% per year. Yet overcapacity in the international coal market has hit Indonesia hard. While rivals like Australia, Russia and South Africa have benefitted from a devaluation of their local currencies against the US dollar, this effect did not help Indonesian coal companies as the vast majority of their costs (fuel, explosives, machinery, etc.) are incurred in US dollars. This has significantly weakened their competitive position vis-à-vis other exporters. Moreover, with coal readily available on the international market, producers of low quality coal, as is the case in Indonesia, see demand weakening as consumers can easily procure coal with higher energy content. The cost advantage of Indonesian coal, compared to Australian coal, has diminished over the last couple of years. Many smaller, high-cost producers had to leave the market as they were running at a loss (or were shut down as Indonesian authorities moved to curtail illegal mining activity). Yet, idled Indonesian coal mines are simple truck-and-shovel operations that can quickly be brought back online if prices are favourable. Indonesia thus has become kind of a swing-supplier in the international market.
Viet Nam is the second-largest coal producer in Southeast Asia, with output of some 30 Mtce in 2016. Most of its production is anthracite (a type of high rank coal) which, in the case of Viet Nam, has relatively high ash content, is not easily substituted and often requires a specific boiler configuration for use in coal-fired power plants. The state-owned mining company, Vinacomin, is responsible for nearly all the production and is one of the largest employers in the country (some 120,000 people are estimated to work in Viet Nam’s coal industry). Despite significant coal reserves of 3,400 million tonnes, Viet Nam’s coal production has stayed relatively flat over the last ten years and with stagnating production and soaring domestic demand its exports have been declining. In 2006, Viet Nam exported three-quarters of its output (mostly to China), but exports have been dropping steeply and 2015 marked the switch from it being a net exporter to a net importer of coal.

There are coal mining operations in several other countries in the region. Malaysia has a handful of mines in Sarawak on the island of Borneo that together produced just over 2 Mtce in 2016. Thailand’s current production of nearly 6 Mtce of lignite from the Lampang province in the north is used for power generation near the mines (the high sulfur content of the coal has, in the past, led to significant air pollution problems but now the plants are equipped with control technology). The Philippines produced more than 8 Mtce of mostly sub-bituminous coal in 2016 for domestic use and export, with most of it produced in a large open cast mine on Semirara Island.

Renewables

Renewable energy sources are abundant in Southeast Asia and remain an important and, in some regions, a dominant source of energy supply. The technical potential is large for
bioenergy (from feedstocks such as agricultural and forestry crops and residues, and animal and municipal solid waste). Hydro already plays an important role in power supply, generating 14% of the region’s electricity in 2016. Considerable untapped potential remains to expand hydro facilities (particularly in the Greater Mekong sub-region, namely Cambodia, Lao PDR, Myanmar, Thailand and Viet Nam), although increasing environmental and social challenges are making them more difficult to develop. China is actively investing in the development of hydropower projects in Southeast Asia, particularly in Cambodia, Lao PDR and Myanmar. Geothermal resources have been tapped and produced 2% of the region’s electricity in 2016, with Indonesia and Philippines being in the top-three in the world in terms of installed capacity. Yet the region’s geothermal resources are undeveloped relative to its potential. Wind and solar PV remain small in terms of overall generation, although their deployment is growing. Thailand, in particular, is rapidly installing solar PV capacity, driven by supportive policies. Solar PV has the potential to play a unique role in bringing electricity access to a portion of the 65 million people in the region whom lack access. For instance, solar PV used in an off-grid or diesel-hybrid system can bypass the need to make costly investments to connect remote regions and small islands to existing transmission or to build new networks (see Chapter 3 for a full discussion on the role of renewables in energy access).

Southeast Asia accounts for a vast majority of the world’s palm oil production and this industry is supported by biofuel mandates in several countries. Indonesia, the world’s largest producer of palm oil, increased its mandate in 2015 to require a 20% biodiesel (produced from palm oil) blend for transport, and a 30% mandate for diesel used in power generation. Malaysia recently announced plans to raise its “B7” mandate for blending 7% palm methyl ester for transport to 10%.

1.3 Factors affecting’s energy development in Southeast Asia

1.3.1 Economy and demographics

Collectively the Southeast Asian economies have grown by more than 125% since 2000, to reach $7.4 trillion in 2016 (year-2016 dollars in purchasing power parity [PPP] terms), making it one of the fastest growing regions in the world over the period. Within the group, the rates of growth and the overall size of the economies vary greatly, with per-capita income levels in the four poorest (Myanmar, Cambodia, Lao PDR and Viet Nam) standing at just one-fifth the regional average. However, over the last 15 years, these countries have grown at a significantly faster rate than their peers, signalling a modest convergence between ASEAN members (Figure 1.11).

A number of factors have contributed to this period of high, sustained growth. Southeast Asia saw one the largest improvements of any region in total factor productivity between 2000 and 2015 (2% per year), thanks in part to a general reorientation of economies from agriculture, towards higher value manufacturing and services. This reorientation has been
facilitated by a steep increase in foreign direct investment (FDI), which rose from around $21 billion in 2000 to over $120 billion in 2015 (in current terms), making the region the fourth-largest recipient of FDI in the world. In several countries, political and economic reform has been the key enabler for growth, not least in Myanmar, which in 2011 began a transition from military rule to civilian government, paving the way for an almost three-fold increase in FDI the next year.

**Figure 1.11** Average economic growth rate and per-capita income levels in Southeast Asian countries, 2000-2015

Many of the region’s poorest countries have also been its fastest growing

The single largest source of foreign investment in the region was other ASEAN members, making up almost one-fifth of the total, pointing to the importance of increased economic integration (ASEAN, 2016). The relationship between the region’s countries is also fundamental for trade, with exports rising more than three-fold since 2000, intra-ASEAN trade totalled around $540 billion in 2015, making trade between countries within the region more important than with any other external partner. Trade with China ($346 billion) has been rising steadily for over two decades, but particularly since 2005, when the ASEAN-China Free Trade Area agreement came into effect for the trade of goods. Major trading partners include: Japan ($238 billion); Europe ($228 billion); United States ($212 billion) and Korea ($122 billion), while trade with India ($59 billion) is increasingly important.

Taking into consideration other capital flows, mostly concerning aid and concessional loans, China is by some distance the region’s most important partner. Following a pledge of $20 billion in loans to the region for infrastructure development in 2014, China offered $11.5 billion in loans and credit to Myanmar, Lao PDR, Thailand, Cambodia and Viet Nam in 2016. It has also increasingly pursued bilateral trade, investment and aid relationships with these countries. Similarly, Japan and Korea play a significant role in financing development
in the region, with Japan in 2016 extending a 100 billion yen (nearly $1 billion) infrastructure loan to Myanmar and Korea in 2017 pledging a $420 million development loan to Cambodia to finance roads and other key infrastructure projects. Multilateral financing from a range of institutions plays a vital and growing role in energy infrastructure across the region.

The region’s demographic trends have also been integral to its economic growth. The working-age population has expanded from 63% on average in 2000, to around 67% in 2015, a slightly larger proportion than the world average at 66%. Furthermore, the movement of people to cities (the urbanisation rate increased from 38% to 48% over the same period) has translated into a gradual diversion of labour from low value-added agriculture towards manufacturing and services — the share of agriculture in GDP has fallen by 3.2 percentage points between 2000 and 2016.

1.3.2 Energy pricing and fossil-fuel subsidies

Fossil-fuel subsidies are prevalent in many parts of the world, including in Southeast Asia. Six countries – Brunei Darussalam, Indonesia, Malaysia, Myanmar, Thailand and Viet Nam – subsidise the use of fossil fuels and electricity prices. Efforts to phase out subsidies in the region date back decades. These received a boost by the decline in oil prices since mid-2014, with Indonesia, Thailand and Malaysia taking the opportunity of lower international prices to accelerate reforms. IEA analysis estimates fossil-fuel subsidies in Southeast Asia at around $17 billion in 2015, a fall of 57% since 2014 (Figure 1.12). Around half of the total stems from electricity ($9 billion) and almost all of the rest from oil ($8 billion). Reflecting policy efforts to reduce subsidies in the transport sector, fossil-fuel subsidies in Southeast Asia are now concentrated in the residential sector, which accounted for more than half of the total in 2015. Among fuels used in the residential sector, subsidies for LPG and electricity dominate.

Fossil-fuel consumption subsidies artificially lower end-user prices to below international market levels and lower consumer electricity prices to below the full cost of supply by subsidising the prices of fossil fuels used to generate power. The rationale for providing fossil-fuel subsidies has typically been linked to various social and economic objectives, for example, to reduce energy poverty, ensure energy access and redistribute national wealth stemming from the exploitation of natural resources. In practice, however, subsidies, if not efficiently targeted, often disproportionately benefit wealthier segments of society, who consume more of the subsidised products. They also deprive states from valuable revenue that is often needed for infrastructure investment. Fossil-fuel subsidies often encourage wasteful use of energy and discourage investment in energy efficiency and low-carbon

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7 For more information on fossil-fuel subsidies in Asia, see “Tracking Fossil-Fuel Subsidies in APEC Economies” (IEA, 2017).
8 For more detailed information on our methodology to estimate subsidies, see [www.worldenergyoutlook.org/resources/energysubsidies/methodology/](http://www.worldenergyoutlook.org/resources/energysubsidies/methodology/).
technologies thereby increasing energy-related carbon-dioxide (CO₂) emissions. Artificially low electricity prices can also discourage private investment in the power sector, as they hamper the ability of private investors to recoup their investment cost and make necessary returns.

**Figure 1.12 Fossil-fuel subsidies in Southeast Asia**

The value of fossil-fuel consumption subsidies is falling in Southeast Asia, thanks to policy efforts and lower international oil prices.

**Recent policy developments in reforming fossil-fuel subsidies**

Rising energy demand has made fossil-fuel subsidy reform a key issue for many governments in Southeast Asia, despite the associated political difficulties. Rising energy demand, which for many countries in the region means increased reliance on imported energy, can lead to rising costs to sustain the subsidies that are usually borne by governments. In Indonesia, the government abolished subsidies for gasoline in 2015 and fixed subsidies for diesel at Indonesian rupiah (IDR) 500/litre (about $0.04) in 2016. Prices are now reviewed every three months based on a formula reflecting international oil prices and the cost of supply. This adjustment mechanism was designed to allow Pertamina, the national oil company, to manage the difference between the oil product prices and the one calculated by the formula. The reforms saved the government around IDR 120 trillion ($9 billion) in 2015, which has been redirected to infrastructure development and social programmes. However, since September 2016, gasoline prices have remained stable at IDR 6 450/litre ($0.49, RON 88), lower than the prices calculated by the formula, implying the existence of a subsidy. The cost of the subsidies is currently borne by Pertamina as the government budget for 2016 and 2017 does not explicitly include allowances for subsidies for gasoline. LPG subsidies constitute the bulk of the remaining oil subsidies in Indonesia, while those for kerosene have declined significantly. LPG is particularly important for the poorer segments of society, especially those without access to clean cooking facilities in
remote areas. The current LPG scheme does not subsidise consumers directly but instead targets 3-kilogramme (kg) LPG cylinders sold in the market and has led to the gas being diverted to commercial use. To avoid such diversion, the government is considering reforming subsidies so that only eligible and targeted consumers receive a cash subsidy directly, rather than subsidising LPG suppliers (MEMR, 2017a). Various challenges need to be overcome for successful implementation, including effective system design to identify and transfer subsidies to eligible consumers, communication campaigns to the public to raise awareness and transparent pricing mechanisms for those who are not eligible for subsidies (GSI, 2016).

Indonesia is also reforming electricity subsidies. As recently as 2012, all of Indonesia’s 37 categories of electricity consumer were subsidised. Electricity tariffs for some consumers, including industrial and residential users, have been gradually increased since 2013 and eligibility criteria for subsidies have been tightened. As of 2016, almost 80% of the total number of households receiving subsidies were in the 450 Volt-ampere (VA) and 900-VA category, the two classes with the lowest level of consumption among six residential customer classes. Government studies found that only around 4 million out of 23 million customers in the 900-VA customer class meet the income threshold to be eligible for subsidies. Since January 2017, subsidies for the 900-VA customer class are being progressively reduced. This saw the electricity price for 900-Va customers more than double, from IND 586 ($0.04) per kilowatt-hour (kWh) in December 2016 to IND 1352 ($0.1)/kWh in May 2017, and since then prices have been revised every two months. This is expected to reduce electricity subsidies substantially, leading to the share of subsidised customers declining from 79% in 2016 to 46% (MEMR, 2017b). Nonetheless, 24 customer classes, including industry and commercial consumers, continue to receive subsidies for electricity.

In Malaysia, continuous efforts have been made to phase out subsidies and in December 2014, subsidies for gasoline and diesel were eliminated. Prices are now set monthly based on movements in international markets, while residential LPG remains subsidised. Malaysia is also working towards phasing out electricity subsidies. Currently the government indirectly subsidises electricity by regulating the price of natural gas, a primary source of electricity generation. In January 2014, a fuel cost pass-through mechanism was introduced, which adjusted electricity prices every six months to reflect changes in fuel and supply costs. The government continues to reduce the subsidy, and it increased the price of natural gas to power producers in both 2015 and 2016.

Myanmar provides subsidies to natural gas as an input to electricity generation. In the 2016 fiscal year, average electricity supply cost was around Myanmar Kyat (MMK) 94/kWh (about $0.07/kWh), of which around 24% was subsidised by the government (Ministry of Electricity and Energy, Republic of the Union of Myanmar, 2017). The total electricity subsidy was estimated to be around MMK 300 billion (around $230 million) in 2015, or around 2% of the national budget. In transport, only compressed natural gas (CNG) for
vehicles is subsidised. Myanmar recognises the need to reform fossil-fuel subsidies and has established a review of energy pricing and subsidies in its National Energy Plan 2015 (ADB, 2016). Thailand has also made progress in reforming fossil-fuel subsidies. The Oil Plan 2015-2036 stipulates the intent to reform prices of subsidised fuel such as CNG and LPG to reflect the cost of supply. After a gradual increase in CNG prices in 2014 and 2015, the prices of CNG were floated to follow international fuel prices in 2016. A reform in LPG pricing in 2017 reflects the changes in international oil prices, while the policy to provide subsidies to low-income households continues.

In Viet Nam, gasoline and diesel prices are not fully deregulated. The Petroleum Price Stabilisation Fund is used to reduce the price fluctuation stemming from changes in international oil prices. Electricity tariffs are also subsidised and despite some reform, they do not reflect cost-recovery level (ADB, 2015), though the subsidy is implicit rather than direct fiscal transfers. The national master plan for electricity development towards 2020 aims to increase prices gradually to allow power utilities, including Viet Nam’s dominant national power company, EVN, to recoup the cost of supply. In 2017, the government eased the pricing regulation for EVN, allowing it to change electricity prices by 3-5% without the government’s approval, but any rise above 5% requires approval and no clear path to price liberalisation has been formulated. Retail electricity prices were raised in 2015, but they remain relatively low in the Southeast Asia region.

In Brunei Darussalam, the value of fossil-fuel subsidies is among the lowest in the region, but on a per-capita basis, it is the highest, at around $360 per capita in 2015. Subsidies are provided to oil products and electricity, with the bulk going to gasoline and diesel. The electricity tariff structure was revised upwards in 2012. In Thailand, the government ended untargeted LPG subsidies in 2014 and floated CNG prices in 2016. The only subsidies remaining in Thailand are for LPG for low income households and small business owners.

The value of fossil-fuel subsidies can fluctuate from year-to-year for a number of reasons, including changes in international energy prices, changes in energy consumption, pricing reforms, inflation and currency exchange rates. IEA decomposition analysis identifies the relative contribution of each of these factors to the $13 billion decline in the value of subsidies in Southeast Asia between 2010 and 2015. Had fuel and end-user prices remained constant over the period, the increase in energy consumption between 2010 and 2015 would have increased the value of subsidies by around $5 billion, corresponding to around 15% of the value of subsidies in 2010. However, pricing reforms and falling fuel prices between 2010 and 2015 more than offset the increase, decreasing subsidies by around $5 billion and $13 billion, respectively (Figure 1.13).

Although prices of transport oil products in Indonesia and Malaysia now fluctuate based on prices in international markets, they remain regulated and are not completely liberalised. This leaves the door open for subsidies to be re-introduced if international prices rise, particularly if there is political and public pressure to alleviate the impact of price hikes. The rationale for this discretionary approach is that the governments reserve the right to act to
protect vulnerable consumers, but the risk of a failure to sustain the reforms could be substantial if retail prices do not respond to movements in international fuel prices (IEA, 2017). Another challenge in reforming subsidies in Southeast Asia lies in the residential sector, in which subsidies to electricity and LPG are significant. These energy carriers are crucial to providing access to energy, especially for the poor. As seen in Indonesia and Malaysia, subsidised LPG is often diverted to commercial purposes, leaving room to consider more targeted provision of subsidies. As electricity consumption is growing rapidly in the region, reforming electricity subsidies, including the gradual phase-out of subsidies and better targeting for the vulnerable groups, will be crucial. Various examples of sound reform exist across the world, which can provide valuable lessons to aid policy design.

**Figure 1.13** Contributing factors to the change in the value of fossil-fuel subsidies in Southeast Asia, 2010 – 2015

Lower international energy prices made the biggest contribution to the reduction in fossil-fuel subsidies in Southeast Asia, but pricing reforms also played a role.

### 1.3.3 Access to modern energy

Access to modern energy is essential for people’s quality of life and welfare and Southeast Asian countries have made significant progress in expanding access to modern energy in recent years. Although our estimate shows that around 65 million people, roughly 10% of Southeast Asia’s population, still lacked access to electricity in 2016, the share of people with electricity access has improved by almost 30 percentage points since 2000, thanks to various government efforts (Table 1.1). Across the region, the electrification rate has increased from 62% in 2000 to 90% in 2016, as Malaysia, Thailand and Viet Nam achieved almost complete access to electricity, while other countries, such as Indonesia and

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9 The global outlook for energy access is presented in the newly-released *WEO Special Report: Energy Access Outlook: from Poverty to Prosperity*, which can be accessed for free at: [www.iea.org/energyaccess](http://www.iea.org/energyaccess).
Philippines, have also been significantly improving access levels. Grid extensions have provided an effective means to extend access to electricity, but in Indonesia and the Philippines – both countries made up of thousands of islands – extending the grid is often costly and distributed power generation, including renewables-based generation technologies, can offer a more effective way of providing access (see Chapter 3). Currently, diesel power is one of the major sources for electrification in islands in these countries, but Indonesia is exploring options to take advantage of solar potential via a programme to electrify 1,000 islands with 225 MW of solar or solar-diesel hybrid systems (PLN, 2017). In Cambodia and Myanmar, roughly two-thirds of the population still lack access to electricity. However, both countries have started implementing measures with ambitious targets to 2030: 100% of households in Myanmar and at least 70% in Cambodia. Myanmar has promoted rural electrification programmes in co-operation with international financial institutions, such as the World Bank, which has financed $400 million for projects in the period to 2021 (World Bank, 2015b). Cambodia has pursued programmes for rural grid connection since 2013 by offering interest free loans for private electricity suppliers and poor households.

Table 1.1  Access to modern energy services in Southeast Asia

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<tr>
<td></td>
<td>Million</td>
<td>Share (%)</td>
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<tr>
<td>Brunei Darussalam</td>
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<tr>
<td>Cambodia</td>
<td>6</td>
<td>40%</td>
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<tr>
<td>Indonesia</td>
<td>23</td>
<td>9%</td>
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<tr>
<td>Lao PDR</td>
<td>&lt;1</td>
<td>9%</td>
</tr>
<tr>
<td>Malaysia</td>
<td>&lt;1</td>
<td>1%</td>
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<tr>
<td>Myanmar</td>
<td>22</td>
<td>41%</td>
</tr>
<tr>
<td>Philippines</td>
<td>11</td>
<td>10%</td>
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<tr>
<td>Singapore</td>
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<tr>
<td>Thailand</td>
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</tr>
<tr>
<td>Viet Nam</td>
<td>2</td>
<td>2%</td>
</tr>
<tr>
<td>Total ASEAN</td>
<td>65</td>
<td>10%</td>
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Note: Estimates based on IEA energy access database and World Health Organization (WHO) household energy database.

In addition to improving access to electricity, challenges also exist in Southeast Asia to provide access to clean cooking facilities, with around 250 million people relying on biomass for cooking in 2015, accounting for around 40% of the total population in the region. Solid biomass is used mostly in rural regions across Southeast Asia. The use of biomass in unimproved cookstoves in households represents a serious health risk, with around 270,000 premature deaths in the region in 2015 attributed to poor indoor air quality.
1.3.4 Social and environmental aspects

Water

Energy development and climate change have important impacts on water resources in Southeast Asia, most prominently in the countries of the Lower Mekong River Basin spanning Cambodia, Myanmar, Viet Nam, and Lao PDR. Much of the population around the river system depend on it for drinking water, fishing, transport, irrigation, and food, with around 85% of the rural population making their living directly from the various resources within the basin.

Hydropower resources on the Mekong River are significant, with over 32 GW of capacity installed (predominantly in the upper Mekong where China has built seven dams on the Lancang River and has plans for 20 more), and a further 30 GW of potential as yet undeveloped in the lower Mekong region. Upstream dams, combined with El Niño-linked weather patterns, have taken a toll on the Mekong River Basin, with water levels at their lowest since records began 100 years ago. In 2015 and 2016, drought hit a number of countries, including Cambodia, where 18 of 25 provinces reported water shortages, affecting an estimated 93 500 rural households, and Viet Nam, where two million people were thought to have lost access to drinking water. This stress, coupled with the high numbers of people directly reliant on the river for their livelihoods, makes large-scale projects controversial. In an effort to ensure responsible development, Thailand, Cambodia, Lao PDR and Viet Nam signed the “Mekong Agreement” in 1995, which stipulates that all countries must approve major projects on the lower Mekong River. This treaty has not been able to allay fully concerns over potential transboundary impacts of dams. Concerns over the Xayaburi dam led to Cambodia and Viet Nam asking for a delay of the project.

Land

Land use, energy production and greenhouse-gas emissions (GHG) are closely interconnected in Southeast Asia, due in part to the region being responsible for over 80% of the world’s palm oil production, prominently used as a biofuel. Palm oil is Indonesia’s second-largest export product (after coal) and employs around 3.7 million people there and a further 860 000 people in Malaysia. It is considered particularly important for rural economic development. A third of allowances for new palm oil plantations in Indonesia and Malaysia – by some distance the world’s largest two producers – are situated on peat-rich primary forests. This land type absorbs carbon at a rate of 1 450 tonnes per hectare, raising concerns that the emissions associated with the growth of palms is greater than the amount offset by the subsequent substitution of hydrocarbons with the biofuel. Recognising the importance of a sustainable palm oil industry, in 2015 Indonesia

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10 Several countries have a biofuels mandate, with Indonesia’s latest, released in March 2015, increasing mandatory biodiesel blending to 20% for transportation and industrial uses, and to 30% for electricity generation.

11 Land use, land-use change and forestry (LULUCF), and peat and forest fires account for 63% of total greenhouse-gas emissions in Indonesia.
introduced a nationwide certification process for smallholder farms, responsible for around 40% of the country’s production, which helps establish more environment-friendly methods that also increase productivity. Malaysia announced a similar certification scheme in 2015, which is to be mandatory by 2019. Prioritising sustainability in the palm oil industry could have benefits beyond the environment. In 2017, the European Union recommended a ban on biofuels made from vegetable oils by 2020 as a response to their perceived contribution to deforestation.

Local air pollution

Rapid economic and population growth since 2000, coupled with increasing urbanisation has led to a strong rise in energy demand across the region, met primarily by fossil fuels. Yet, despite growth in supply, around 10% of the population still has no access to electricity and almost 40% have no access to clean cookstoves, relying instead, on the use of fuelwood and charcoal for cooking. The combination of rapid economic and energy demand growth, with increasing urbanisation and reliance on the traditional use of biomass presents a serious threat in terms of air pollution. Air quality standards are in place in several countries in the region. However, while some of the standards comply with the World Health Organization (WHO) interim targets, enforcement action is limited and concentration limits are frequently exceeded.

Combustion of coal for power generation and industrial processes is the largest source of energy-related sulfur dioxide (SO$_2$) emissions in Southeast Asia today, accounting for more than half of the total 2.3 Mt of SO$_2$ emissions. Around 40% of the region’s SO$_2$ emissions from coal-fired power generation occur in Indonesia alone. Energy-related nitrous oxides (NO$_x$) emissions were almost 4.9 Mt in 2015, of which around 75% were from oil combustion, primarily in the transport sector. The number of private cars in the region has more than doubled since 2000, reflecting income growth, although two/three-wheelers and public buses remain important sources of mobility and, hence, urban NO$_x$ emissions. Fine particulate matter (PM$_{2.5}$) emissions from the energy sector are very high, at 2.6 Mt in 2015, mostly from the residential sector. More than 90% of the emissions from households arise from the use of fuelwood and charcoal for cooking and heating. The consequent human and environmental burden of air pollution in the region is considerable.

Climate change

Southeast Asia is considered to be among the most vulnerable regions to the effects of climate change. Its coastal regions are particularly at risk. In Indonesia, 42 million people live less than 3 km from the sea in areas that are less than 10 metres above sea level. About 80% of natural disasters are “hydro-meteorological” events and these are expected to grow in number and severity with the effects of climate change. Average temperatures have been rising at around 0.14 degrees Celsius (°C) – 0.20 °C per decade since 1960, while the average rainfall on wet days has increase by 22 millimetres per decade (Hijioka et al., 2014).
Power generation accounts for the largest share of Southeast Asia’s energy-related CO₂ emissions, having grown by more than 150% since 2000. This increase is slightly less than the overall increase in generation however, reflecting a marginal improvement in the CO₂ intensity of power generation partly explained by the shift from oil towards gas-fired generation. Despite the recent improvement, the carbon intensity of the region’s power sector remains around one-fifth higher than the world average, in part because renewables make up a smaller share of generation (18%) than the world average (24%).

Non energy-related emissions are significant across Southeast Asia and this is reflected in a number of the Nationally Determine Contributions that formed the Paris Agreement in 2015. Lao PDR, for example, pledged to increase its forest cover to 70% of its total land area by 2020, while Viet Nam, Cambodia and Lao PDR all committed to increase efforts to protect their forests and promote reforestation. A number of the region’s countries act as greenhouse-gas sinks, by virtue of their forest coverage.

Box 1.2 ➢ Growing needs for climate-resilient energy infrastructure

Southeast Asia is particularly vulnerable to climatic impacts, with extreme weather events, high temperatures and extreme precipitation patterns posing a range of risks to energy infrastructure, supply and demand. Climate change is expected to exacerbate these threats.

- Increasing water stress caused by changing hydrological patterns have direct repercussions for hydropower generation, which makes up important shares of electricity generation, notably those in the Lower Mekong Basin region (Lao PDR, Myanmar, Viet Nam, Cambodia and Thailand). The 2016 drought in the Mekong delta, which along with climate change was attributed to the El Niño phenomenon and increased dam construction upstream, resulted in the lowest water levels in Viet Nam in almost a century and negatively affected hydropower production across the region. Thermal power generation, particularly coal, is also highly dependent on the availability of water for steam cooling. Rising water constraints can increase cooling costs for power plants and may require adoption of alternative cooling technologies or improved water management practices.

- Certain Southeast Asian countries face acute risks from rising frequency and magnitude of extreme weather events, which can cause extensive damage to infrastructure and disrupt energy supply that fuels essential services across the economy. A notable case was Typhoon Haiyan in 2013, which in the Philippines caused widespread power loss, damage to electricity grids and other energy infrastructure, and an oil spill. Infrastructure located near coastlines and rivers, such as oil refineries, tanker ports and LNG terminals, as well as pipelines face compounded risks from sea level rise and increased flood risk. Sea level rise is projected to be 10-15% greater in Southeast Asia compared to the global average, increasing over 1 metre from current levels in certain cities by the end of the century (World Bank, 2013).
Rising temperatures reduce the efficiency of electricity transmission and distribution lines, as well as that of thermal processes in power plants. Projected warmer temperatures, including more frequent and intense heat waves, will increase cooling and energy demand during the summer months. The 2016 heat wave in Thailand broke national energy consumption records and prompted the Electricity Generating Authority of Thailand (EGAT), the national power utility, to call for curbs in consumption.

Increasing resilience to such impacts requires a range of organisational, policy and financial measures to be taken. These include improving the quality and availability of downscaled climate data, increased organisational capacity for risk assessment and emergency preparedness and response, strengthened technical standards for infrastructure, and a supportive framework for financing both asset preparedness as well as post-disruption recovery. The projected increases in energy and infrastructure investments in Southeast Asia create a unique opportunity to build resilience into the energy system while ensuring it meets other objectives such as energy access, energy security and decarbonisation.

1.3.5 Investment

Investment in energy supply in Southeast Asia has averaged around $50 billion per year since 2000. Investment in oil and gas made up around more than half of the total, but was still insufficient to reverse a decline in oil output or to replenish oil production with new reserves through exploration; remaining technically recoverable resources have fallen by more than 15% since 2000. Investment in the natural gas sector has seen the region’s gas production increase by around 40% since 2000 (Figure 1.14). Around two-thirds of the total coal supply investment since 2000 was in Indonesia, which accounted for $1.4 billion of the $2.2 billion per year spent over the period. This represents a five-fold increase in investments over the average of the 1990s, enabling a commensurate increase in production.

Around $365 billion in investment has been made in the power sector across Southeast Asia since 2000, a little over half ($195 billion) of which went towards grid expansion and improvement. While the region saw the third-highest investment in coal-fired generation over the period (after China and India), it invested more in renewables since 2000 than in coal, with the $69 billion in renewables investment making it the single largest tranche of investment in generation across the region (compared with $66 billion for coal and $35 billion for gas).

Both the private and public sectors have a played prominent role in meeting Southeast Asia’s investment needs. Large international oil companies are active across the region, including in Myanmar, Malaysia, Thailand, Indonesia and Brunei Darussalam. A growing amount of investment has come from publicly owned energy companies making investments offshore. One example is Ratchaburi Electricity and PPT (Thailand), which
made a joint investment of $400 million in an LNG terminal in Myanmar in 2015. Another is the CH. Karnchang Public Company’s agreement with Lao PDR for the development of the Xayburi hydroelectric project, which is underpinned by a power purchase agreement with the Electricity Generating Authority of Thailand.

**Figure 1.14**  
Energy supply investment by type in Southeast Asia

Power sector investments are growing increasingly important in the overall supply investment picture

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1.4  
**Projecting future developments**

The evolution of energy demand and supply in Southeast Asia will be determined by the interplay of a number of factors, such as government policies, demographic change, urbanisation, economic trends including shifts in the structure of economic activity, energy pricing and technological developments.

1.4.1  
**Defining the scenarios**

The projections in our *Southeast Asia Energy Outlook 2017* (the results of which are set out in Chapter 2) look out to 2040 and are derived from the overall methodological approach used in the *World Energy Outlook-2017 (WEO-2017).* The central scenario in this *Outlook* is the **New Policies Scenario.** It takes into account existing policies and measures as well as announced policy intentions in the ten countries of the ASEAN. It therefore incorporates both existing progress and, to varying degrees, achievement of the pledges contained in the Nationally Determined Contributions ratified in the Paris Climate Agreement. Where

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12 Chapter 1 of WEO-2017, which describes the scope of the analytical work and the underlying assumptions and price trajectories used, is available at: www.worldenergyoutlook.org (as from 14 November 2017).
policy intentions are not backed by clearly defined implementing measures, then our assessment of possible regulatory, market, infrastructure and financing constraints determines how far and how fast these intentions are met.

We also refer to two additional scenarios modelled in WEO-2017. The Current Policies Scenario depicts a path for Southeast Asian countries shorn of all policy intentions that, as of mid-2017, had yet to be expressed in specific implementing measures. No allowance is made for changes in policies or measures beyond this point, regardless of announced intentions. The Current Policies Scenario can therefore be considered as the “default setting” for the region’s energy system, with little or no change compared with what has already been agreed and settled. Its results provide a benchmark against which the impact of “new” policies can be measured.

The Sustainable Development Scenario, a new feature of this year’s WEO, is a scenario that meets the key energy-related goals of the United Nations Sustainable Development Agenda. It describes a world in which countries take urgent action on climate change, in line with the Paris Agreement, while also achieving universal access to modern energy by 2030 and a dramatic decline in the emissions that cause poor air quality.

The projections for all three scenarios are derived from the IEA’s World Energy Model (WEM). The WEM is a large-scale simulation model designed to replicate how energy markets function, that consists of three main modules: (i) final energy consumption; (ii) energy transformation; and (iii) oil, natural gas, coal and renewable supply. Assumptions based on analysis of the latest developments in energy markets, the broader economy and energy and climate policy, are used as inputs to the WEM, together with huge quantities of historical data on economic and energy variables. These data were obtained from a wide variety of sources.

1.4.2 Key assumptions

Economic growth

Southeast Asia is a major pillar of economic growth in Asia. The combined GDP of the ten ASEAN member countries has increased by around 125% since 2000. Huge wealth disparities exist both among and within countries in the region: Singapore and Brunei Darussalam rank among the wealthiest countries in the world in terms of GDP per capita, while Cambodia, Lao PDR, Myanmar and Viet Nam are at the other extreme. There are also significant social, cultural and institutional differences across the region.

The energy projections in this Southeast Asia Outlook are highly sensitive to underlying assumptions about economic growth — the principal driver of demand for energy services in most countries. Our GDP growth assumptions have been based primarily on

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13 The Sustainable Energy Scenario supplants the 450 Scenario, which had been used in previous World Energy Outlook publications.
International Monetary Fund projections, with some adjustments to reflect information available from regional, national and other sources. We assume that Southeast Asia’s GDP (expressed in real PPP terms) grows by 4.5% per year on average over the period 2016 to 2040, compared with 5.2% between 2000 and 2016. Growth slows from 5.1% per year in the period to 2020 to 4.3% per year after 2020, as the region matures and population growth declines. By 2040, the size of the economy almost triples, to reach $21 trillion (year-2016 dollars, PPP terms). Average per-capita income rises from $11 600 to almost $27 600.

Energy prices

Our assumptions about international fossil-fuel prices reflect our analysis of the price levels that would be needed to stimulate sufficient investment in supply to meet projected demand over the period. They are used to derive average retail prices in end-use sectors, and in power generation and other transformation sectors. These end-use prices take into account local market conditions, including taxes, excise duties, as well as any subsidies. The rates of value-added taxes and excise duties on fuels are assumed to remain unchanged, except where future tax changes have been adopted or are planned.

In the New Policies Scenario, the average IEA crude oil import price – a proxy for international oil prices – rises from today’s levels to more than $80/barrel (in real-2016 dollars) by the mid-2020s, with continued gradual increases thereafter. The price of natural gas imports to the region is assumed to rise to almost $14 per Million British thermal units (MBtu) by 2025. Having fallen precipitously since 2013 to $45/tonne in 2016, average Indonesian steam coal export prices recover slowly, reaching around $63/tonne by 2040 (adjusted to 6 000 kilocalories per kilometre). As they do at present, many Southeast Asia countries are expected to continue to use lower cost and lower calorific-value coal for their electricity needs.

Demographics

Demographic change affects both the level and pattern of energy use, directly and through its impact on economic growth and development. Our assumed rates of population growth are based on the medium-variant of the latest UN projections (UNPD, 2015). Southeast Asia’s population was estimated at almost 640 million in 2016. We assume Southeast Asia’s population increases to over 760 million in 2040, 0.7% per year on average. The region’s “demographic dividend”, which has been integral to its economic growth in the last decades, remains in play, as the working-age population as a share of the total stays at around 67%, higher than regional and global standards.

Urbanisation is another crucial demographic factor that ultimately impacts energy demand. The proportion of people living in cities has grown by almost ten percentage points, to 48% since 2000, and we assume further growth to 60% by 2040. This implies a 50% increase in the number of people living in cities, to nearly 460 million, while the rural population decreases by around 10%.
Growth in energy demand is correlated closely with growth in per-capita income, although the relationship has decoupled in a number of advanced countries and may be weaker in the future than expected in economies that are emerging today if they evolve with smart urban planning, efficient transport systems and energy-efficient buildings. Nonetheless, rising incomes will continue to lead to increased demand for goods that require energy to use and to produce, such as cars, refrigerators and air conditioners.

**Policies**

Many Southeast Asian countries are seeking to rebalance their energy mix, responding to their own resource availability, energy security and environmental concerns. A wide range of policy developments have been made recently, notably those in the nationally determined commitments underpinned by the Paris Agreement, and some key energy targets that are summarised in Table 1.2. In support of Singapore’s target to reduce energy intensity by 35% by 2030, it introduced energy efficiency standards and labelling for lamps in 2015. The Philippines recently introduced an Energy Efficiency Roadmap 2014-30, with a target of reducing energy intensity by 40% by 2030 compared with 2005 levels. The action plan includes a wide range of measures, such as setting building energy efficiency codes and introducing standards and labelling systems for appliances.

Targets for renewable energy have been reinforced in some Southeast Asian countries. In 2016, Viet Nam made upward adjustment to its non-hydro renewable capacity target in its power development plan, from 9.4% to 21% of total installed capacity in 2030, and decreased the share of coal-fired capacity from 52% to 43% in 2030. Thailand is set to use 30% of final energy consumption from renewable energy sources by 2036. To pursue these goals, feed-in tariffs (FiTs) have been widely adopted in the region and these continue to be updated. After introducing FiTs for wind, solid waste, small hydro and biomass, Viet Nam established a FiT for solar PV in 2017. Indonesia extensively modified its renewable purchasing policy in early 2017.\(^\text{14}\) New policies are promoting electric vehicles (EVs). Thailand aims to spur the development of an EV manufacturing industry, building on its existing automobile manufacturing base, through incentives such as tax exemptions. Malaysia has set a target of 100 000 EVs on the road by 2020 and 125 000 charging stations nationwide.

\(^\text{14}\) In 2015, Indonesia increased its biofuels mandate (effective in 2016) to 20% for diesel used in transport, industry and commercial enterprises, and 30% for diesel used in power generation.
<table>
<thead>
<tr>
<th>Country</th>
<th>Sector</th>
<th>Policies and targets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brunei Darussalam</td>
<td>Efficiency</td>
<td>Reduce total energy consumption by 63% from BAU levels by 2035.</td>
</tr>
<tr>
<td></td>
<td>Renewables</td>
<td>Achieve 10% of electricity generation from renewables by 2035.</td>
</tr>
<tr>
<td></td>
<td>Climate change</td>
<td>Reduce CO₂ emissions from morning peak-hour vehicle use by 40% from BAU level by 2035.</td>
</tr>
<tr>
<td>Cambodia</td>
<td>Electrification</td>
<td>Universal electrification for all villages by 2020 and 70% electrification for households by 2030.</td>
</tr>
<tr>
<td></td>
<td>Renewables</td>
<td>Increase capacity of hydropower to 2 241 MW by 2020.</td>
</tr>
<tr>
<td></td>
<td>Climate change</td>
<td>Reduce GHG emissions 27% from baseline emissions by 2030 with international support.</td>
</tr>
<tr>
<td>Indonesia</td>
<td>Electrification</td>
<td>Achieve electrification ratio of 99.7% by 2025.</td>
</tr>
<tr>
<td></td>
<td>Efficiency</td>
<td>Reduce energy intensity by 1% per year to 2025.</td>
</tr>
<tr>
<td></td>
<td>New and renewable energy*</td>
<td>Increase share of new and renewable energy in primary energy supply to reach 23% by 2025 and 31% by 2050.</td>
</tr>
<tr>
<td></td>
<td>Climate change</td>
<td>Reduce GHG emissions 26% and 29% from BAU level by 2020 and by 2030, respectively, and 41% by 2020 with international support.</td>
</tr>
<tr>
<td>Lao PDR</td>
<td>Electrification</td>
<td>Achieve electrification rate of 98% by 2025.</td>
</tr>
<tr>
<td></td>
<td>Efficiency</td>
<td>Reduce final energy consumption from BAU level by 10%.</td>
</tr>
<tr>
<td></td>
<td>Renewables</td>
<td>Achieve 30% share of renewables in primary energy supply by 2025.</td>
</tr>
<tr>
<td>Malaysia</td>
<td>Efficiency</td>
<td>Promote energy efficiency in the industry, buildings and domestic sectors with methods of standard setting, labelling, energy audits and building design.</td>
</tr>
<tr>
<td></td>
<td>Renewables</td>
<td>Increase capacity of renewables to 2 080 MW by 2020 and 4 000 MW by 2030.</td>
</tr>
<tr>
<td></td>
<td>Transport</td>
<td>Introduce 100 000 electric vehicles by 2020 with 125 000 charging stations.</td>
</tr>
<tr>
<td></td>
<td>Climate change</td>
<td>Reduce GHG intensity of GDP by 35% by 2030 from 2005 level, increase to 45% reduction with enhanced international support.</td>
</tr>
<tr>
<td>Myanmar</td>
<td>Electrification</td>
<td>Achieve total electrification rate of 100% by 2030.</td>
</tr>
<tr>
<td></td>
<td>Efficiency</td>
<td>Reduce primary energy demand by 8% by 2030 from 2005 level.</td>
</tr>
<tr>
<td>Philippines</td>
<td>Electrification</td>
<td>Achieve 100% electrification by 2022.</td>
</tr>
<tr>
<td></td>
<td>Efficiency</td>
<td>Reduce 40% energy intensity by 2030 from 2010 level. Decrease energy consumption by 1.6% per year against baseline forecasts by 2030.</td>
</tr>
<tr>
<td></td>
<td>Renewables</td>
<td>Triple the installed capacity of renewables-based power generation from 2010 level to 15 GW by 2030.</td>
</tr>
<tr>
<td></td>
<td>Climate change</td>
<td>Reduce GHG emissions by 70% from BAU level by 2030 with the condition of international support.</td>
</tr>
<tr>
<td>Singapore</td>
<td>Efficiency</td>
<td>Improve energy intensity by 36% by 2030 from 2005 levels.</td>
</tr>
<tr>
<td></td>
<td>Renewables</td>
<td>Increase solar PV capacity to 350 MW by 2020.</td>
</tr>
<tr>
<td></td>
<td>Climate change</td>
<td>Reduce GHG emissions by 16% below BAU level by 2020, stabilise emissions with the aim of peaking around 2030.</td>
</tr>
<tr>
<td>Thailand</td>
<td>Efficiency</td>
<td>Reduce energy intensity by 30% by 2036 from 2010 level.</td>
</tr>
<tr>
<td></td>
<td>Renewables</td>
<td>Increase share of renewables in final energy consumption to 30% by 2030.</td>
</tr>
</tbody>
</table>
2036; increase share of renewables-based power generation capacity to 20.11%, and share of renewables in transport fuel consumption to 25.04% by 2036.

<table>
<thead>
<tr>
<th>Transport</th>
<th>Increase to 1.2 million EVs and 690 charging stations by 2036.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuclear</td>
<td>Install nuclear power plants of 2 GW by 2036.</td>
</tr>
<tr>
<td>Climate change</td>
<td>Reduce GHG emissions by 20% from BAU level by 2030, increase to 25% with enhanced international support.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Viet Nam</th>
<th>Electrician</th>
<th>Ensure most rural households have access to electricity by 2020.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Efficiency</td>
<td>Increase commercial electricity savings to more than 10% of total power consumption by 2020 relative to BAU.</td>
</tr>
<tr>
<td></td>
<td>Renewables</td>
<td>Increase the share of non-hydro renewables-based power generation capacity to 12.5% by 2025 and 21% by 2030.</td>
</tr>
<tr>
<td></td>
<td>Climate change</td>
<td>Reduce GHG emissions from BAU level by 8% by 2030 and by 25% with international support.</td>
</tr>
</tbody>
</table>

*New energy includes nuclear, hydrogen, coalbed methane, liquefied coal and gasified coal. Traditional use of biomass is excluded.

Notes:  BAU = business-as-usual; GHG = greenhouse gases.
Southeast Asia’s energy prospects to 2040
Does the future have to look like the past?

Highlights

• Energy demand in Southeast Asia continues to grow robustly in the New Policies Scenario, by two-thirds to 2040, underpinned by a growing economy, demographic changes and improved access to energy. Oil remains the largest fuel in the region’s energy mix, but coal is projected to be the largest source of growth, mainly due to increased use for electricity generation. Natural gas demand also rises, by around 60% to 2040, as its use increases for power and industry. Hydropower and non-hydro renewables grow rapidly, their rise in primary energy offset by the decreased use of solid biomass as a fuel in the residential sector.

• Rising electricity demand means that power generation more than doubles to 2040, at a pace twice the global average. Modern coal-fired generation and renewables account for two-thirds of the large expansion in installed capacity, which reaches 565 GW by 2040. Coal- and gas-fired plants remain the largest sources of power, but the share of all renewable sources together increases to 30% of the generation mix. Rising electricity consumption makes reforms to electricity pricing an imperative for the long-term health of the power sector: without reforms, the cumulative electricity subsidy bill could reach more than $350 billion to 2040.

• New initiatives to improve efficiency help to constrain growth in end-use energy consumption by around 10% over the period to 2040. However, there is still ample untapped potential for further efficiency gains. A growing manufacturing base means that industrial energy consumption almost doubles by 2040. In the residential sector, rising household incomes and higher ownership of appliances results in a near-tripling of electricity use. In transport, around 30 million passenger cars are added to the fleet by 2040, but limited adoption of fuel-economy standards results in fuel economy in the region being 20% worse than the global average in 2040.

• The balance between rising demand and stagnant or falling production turns Southeast Asia into a significant net importer of energy by 2040. As many oil fields mature, oil production declines by 30% by 2040, resulting in net imports more than doubling, to 6.9 mb/d. Despite maintaining gas production at current levels, a strong increase in demand leads to the region becoming a net gas importer by the mid-2020s. Coal production declines slightly, to around 375 Mtce, reflecting policy decisions in Indonesia to limit production. While Indonesia remains a significant coal exporter, the region as a whole relies on imports by 2040.
2.1 Overview of scenario outcomes

In the New Policies Scenario, our main scenario, which reflects today’s configuration of enacted and announced energy policies, Southeast Asia continues to experience robust growth in primary energy demand, which increases by two-thirds to more than 1 000 million tonnes of oil equivalent (toe) in 2040 (Figure 2.1). A growing population and rising incomes, as well as strong economic growth and increased electricity access are all important factors in propelling energy demand higher. However, the pace of energy demand growth for the next 25 years, which averages around 2.1% per year, is about half that of the past 25 years, reflecting both a partial structural realignment of the economy in favour of less energy-intensive sources of growth as well as policies promoting the more efficient use of energy. By 2040, the region’s economy almost triples in size, growing at a far faster rate than energy demand, implying a welcome loosening of the links between energy and economic growth. Energy intensity, measured as the amount of energy required to produce a unit of gross domestic product (GDP), decreases by around 40% by 2040 compared with today (at an annual average rate of 2%, equivalent to the average reduction seen worldwide). In the New Policies Scenario, Southeast Asia meets and exceeds the targets set out in the Association of Southeast Asian Nations Plan of Action for Energy Cooperation 2016-2025 (APAEC), to reduce energy intensity by 30% by 2025 compared with 2005 levels (ACE, 2015).

Figure 2.1 Primary energy demand in Southeast Asia in the New Policies Scenario

Southeast Asia calls on all fuels and technologies to meet demand growth: oil remains the largest source of energy, while coal use almost triples to 2040

Note: Mtoe = million tonnes of oil equivalent.

1 See section 1.4.1 in Chapter 1 for a description of the scenarios.
Among the fuels, coal retains a powerful position in the energy mix and accounts for almost 40% of the growth in primary energy demand between 2016 and 2040 primarily due to its growing use in electricity generation. However, oil remains the largest source of energy in Southeast Asia and consumption grows by 40% over the period to 2040. This is the slowest pace of growth among the fossil fuels, but it is still relatively robust compared with trends in many other parts of the world. Natural gas consumption also increases strongly, by 60% to 2040, mainly due to its increased use in industry and power generation. As examined in more detail later in this chapter, the extent of the projected rise in coal and oil consumption gives rise to significant environmental and public health concerns, as well as rising import bills and, in the case of oil, potential energy security issues.

The overall share of renewables in the region’s energy mix slightly decreases to 24% in 2040 (from 26% in 2016). This mostly reflects the continued switch away from solid biomass in the residential sector, and belies the important dynamic of a tripling in the use of other renewables (including hydropower, wind and solar photovoltaic) over the period to 2040. Both of these trends – the reduction in reliance on solid biomass as a traditional cooking and heating fuel and the rise in modern energy technologies – are positive from the perspective of Southeast Asia’s sustainable development. Yet, as explored in more detail later in this Outlook, there is ample potential for both to be accelerated further. Policies to promote the use of renewable energy in the region, coupled with the falling costs of solar photovoltaic (PV) and wind, lead to the overall share of renewables (excluding traditional biomass) increasing slightly from 13% in 2016 to 15% in 2025, but this falls well short of the aspirational goal of 23% stated in the APAEC.

### Table 2.1  Key energy indicators for Southeast Asia by scenario

<table>
<thead>
<tr>
<th></th>
<th>New Policies Scenario</th>
<th>Current Policies Scenario</th>
<th>Sustainable Development Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2016</td>
<td>2025</td>
<td>2040</td>
</tr>
<tr>
<td>Primary energy demand (Mtoe)</td>
<td>643</td>
<td>806</td>
<td>1062</td>
</tr>
<tr>
<td>Share of fossil fuels (%)</td>
<td>74%</td>
<td>76%</td>
<td>76%</td>
</tr>
<tr>
<td>Final consumption (Mtoe)</td>
<td>453</td>
<td>560</td>
<td>714</td>
</tr>
<tr>
<td>Electricity demand (TWh)</td>
<td>837</td>
<td>1 214</td>
<td>1 997</td>
</tr>
<tr>
<td>Energy intensity of GDP (2016=100)</td>
<td>100</td>
<td>81</td>
<td>59</td>
</tr>
<tr>
<td>Carbon intensity of power (2016=100)</td>
<td>100</td>
<td>94</td>
<td>83</td>
</tr>
</tbody>
</table>

Note: TWh = terawatt-hour; Mtoe = million tonnes of oil equivalent.

Final energy consumption in Southeast Asia grows by around 60% to 2040 in the New Policies Scenario (Table 2.1). Growth is strongest in industry, where energy consumption doubles. Among the fuels, electricity accounts for the largest share of the growth, driven by rising demand in industry and the residential sector. To keep pace with rising electricity demand, Southeast Asian countries need to bolster electricity supply infrastructure. In the
New Policies Scenario, total installed power generation capacity more than doubles, reaching around 565 gigawatts (GW) by 2040. Thanks to policy developments to incentivise the use of renewables, around 50% of the net capacity increase comes from low-carbon sources. This leads to a significantly reduced carbon intensity of power generation, which decreases by 17% by 2040. In the Sustainable Development Scenario, the share of fossil fuels in the primary energy mix declines to 60% by 2040 (this share remains constant in the New Policies Scenario) and the energy system, including all end-use sectors and the power sector, is put on a pathway towards deep decarbonisation (Box 2.1).

**Box 2.1 Exploring a deeper transformation of the Southeast Asian energy system**

The *World Energy Outlook* (WEO) is a multi-scenario analysis, and in addition to the Current Policies and New Policies scenarios (the latter being the focus for much of our analysis), another alternative path is presented in the Sustainable Development Scenario. This new scenario, introduced in WEO-2017, posits a rapid and radical transformation of the global energy system in a way that is consistent with three major goals. First, to reduce energy-related CO₂ emissions to 2040 in a way that is consistent with the Paris Agreement, including an early global peak followed by a rapid decline. Second, to reduce dramatically the energy-related emissions of other pollutants linked to poor air quality. Third, to ensure universal access to energy by 2030. A transformation in line with these three targets is challenging and would require profound additional efforts in across all regions, not least Southeast Asia.

**Figure 2.2 Primary energy mix in Southeast Asia by scenario, 2040**

*In the Sustainable Development Scenario, the rise in energy demand is slowed by efficiency policies and the energy mix shifts to more low-carbon sources.*

Note: NPS = New Policies Scenario; SDS = Sustainable Development Scenario.
In the Sustainable Development Scenario, carbon-dioxide (CO₂) emissions peak in the next ten years and reach 1.2 gigatonnes (Gt) in 2040, around 6% below the level of 2016. Total primary energy demand increases by around 40% by 2040, but at an annual growth rate around 35% slower than in the New Policies Scenario, thanks to the more stringent and broader adoption of efficiency policies. The primary energy mix is much more decarbonised than in the New Policies Scenario, with the share of renewables reaching around 40% by 2040 (Figure 2.2).

In the power sector, the share of renewables-based generation reaches almost 65%, more than half of which is generated by solar PV, geothermal and wind. Among fossil fuels, coal, a major source of power in the New Policies Scenario, plays a significantly diminished role, with a share of less than 10% in 2040. In addition, around 8% of coal-fired power generation capacity is fitted with carbon capture and storage (CCS) capabilities. Natural gas is the largest source of power over the Outlook period in the Sustainable Development Scenario, providing a flexible option to accommodate a larger share of renewables-based power generation.

In the transport sector, oil continues to play a dominant role, but the sector’s energy use is more diversified, aided by tighter CO₂ emission and fuel-economy standards. Biofuels, gas and electricity reach shares of 12%, 7% and 5% respectively in transport. Consequently, in the Sustainable Development Scenario, the number of electric vehicles, including plug-in hybrids vehicles, reaches 12 million in 2040, roughly 20% of the total passenger vehicle stock. In the buildings and industry sectors, increased use of electricity and more stringent efficiency policies, such as the use of energy management systems and energy audits, help to lower CO₂ emissions.

2.2 A closer look at the New Policies Scenario

2.2.1 Outlook for the power sector

Electricity demand

Electricity demand in Southeast Asia continues its trend of rapid growth in the New Policies Scenario, more than doubling, to around 2 000 terawatt-hours (TWh) by 2040 (Figure 2.3). The rate of growth, at an annual average of 3.7%, is roughly twice as fast as the world average. Per-capita electricity demand also doubles to 2040, but remains around 30% below the global average in 2040.

The largest contribution to the growth in electricity demand comes from the buildings sector (residential and services), where electricity demand more than doubles by 2040. Most of this is residential electricity demand, which grows at an annual average rate of 4.4%; by the late-2030s, this becomes the largest electricity-consuming sector, overtaking industry. Increased appliance ownership and demand for cooling are the main factors underpinning this growth, such that by 2040, they account for more than 70% of residential electricity demand. Industrial demand accounts for around 40% of electricity demand in
Southeast Asia today and more than doubles, to 725 TWh, in 2040. Reliable electricity supply constitutes one of the key elements to attracting manufacturing industries, and the deployment of power generation capacity by independent power producers to supplement that from state-owned power companies is expected to help increase reliability over the Outlook period.

**Figure 2.3**

Electricity demand by sector in Southeast Asia in the New Policies Scenario

<table>
<thead>
<tr>
<th>Sector</th>
<th>2010</th>
<th>2016</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
<th>2035</th>
<th>2040</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>500</td>
<td>1000</td>
<td>1500</td>
<td>2000</td>
<td>2500</td>
<td>3000</td>
<td>3500</td>
</tr>
<tr>
<td>Industry</td>
<td>500</td>
<td>1000</td>
<td>1500</td>
<td>2000</td>
<td>2500</td>
<td>3000</td>
<td>3500</td>
</tr>
<tr>
<td>Transport</td>
<td>500</td>
<td>1000</td>
<td>1500</td>
<td>2000</td>
<td>2500</td>
<td>3000</td>
<td>3500</td>
</tr>
<tr>
<td>Services</td>
<td>500</td>
<td>1000</td>
<td>1500</td>
<td>2000</td>
<td>2500</td>
<td>3000</td>
<td>3500</td>
</tr>
<tr>
<td>Agriculture</td>
<td>500</td>
<td>1000</td>
<td>1500</td>
<td>2000</td>
<td>2500</td>
<td>3000</td>
<td>3500</td>
</tr>
</tbody>
</table>

Residential electricity demand grows quickly in Southeast Asia, becoming the largest electricity consumer among end-use sectors by 2040.

Among energy-intensive industries, iron and steel production becomes the largest industrial consumer of electricity, rising at an average annual rate of 4% as production using electric arc furnaces increases to meet rising steel demand in many sectors such as infrastructure development and construction. It is non energy-intensive industries, including the automotive sector and electronics industries, which contribute to the bulk of the increase in industrial electricity demand, accounting for 70% of industry electricity demand in 2040.

In Indonesia, electricity demand triples over the period and accounts for one-third of electricity demand in Southeast Asia in 2040. Electricity demand in the buildings sector leads the growth, tripling by 2040. Electricity consumption for appliances and cooling equipment grows rapidly, with the household ownership rate of air conditioners almost doubling to 17% and that of refrigerators reaching around 90% in 2040.

**Electricity supply**

To meet rising electricity demand in Southeast Asia, installed generation capacity more than doubles, to around 565 GW in 2040 (Figure 2.4). The major increase comes from Indonesia, whose capacity almost triples, to around 180 GW. Renewables-based power generation capacity makes the largest overall contribution to growth, rising to around
210 GW in 2040. By the end of the Outlook period, renewables account for around 40%, the largest share of installed capacity among power generation technologies. Solar PV and wind generation capacity increases the fastest, reaching a combined capacity of around 75 GW in 2040 from around 5 GW in 2016. This projection reflects the increasingly widespread policy efforts of various governments to incentivise renewables-based power generation technologies, including through feed-in tariffs, tax breaks and soft loans. Hydropower capacity also increases strongly, to around 105 GW in 2040, as a number of countries, including Lao People’s Democratic Republic (PDR), Cambodia and Myanmar take advantage of abundant untapped potential. Nuclear capacity is projected to be installed only later in the period, reflecting development plans in Thailand.

**Figure 2.4** Change in installed electricity generation capacity by type in Southeast Asia in the New Policies Scenario, 2016-2040

Taken together, renewables-based capacity takes the largest share of growth followed by coal and gas.

Coal-fired plants, whose capacity more than doubles to reach around 160 GW in 2040 make a large contribution to growth in Southeast Asia’s capacity. The increase in coal-fired generation reflects the relative affordability of this technology, based on the ample availability of coal resources in the region, even as costs for some renewable energy technologies continue to fall. Gas-fired power generation capacity almost doubles to around 180 GW by 2040, with almost half of the capacity increase coming from Indonesia, which adds about 40 GW (meaning that more gas-fired power plants are added than coal capacity in Indonesia). To ensure gas supply to power generators in Indonesia, in 2017, the government began regulating gas supply allocation and prices of natural gas for domestic power generators. These regulations set a maximum price for domestically produced gas and clarify the conditions for power generators to procure indigenous gas or imported liquefied natural gas (LNG). The government also plans to build a number of LNG receiving terminals for power generation, including nine floating storage and regasification units by 2030 to provide a source of electricity to remote islands (BPPT, 2016). Oil-fired power
generation capacity continues to be phased out in Southeast Asia, due to its high cost and because small diesel plants are replaced by electricity from other sources as the grid reaches remote areas and other decentralised options become viable (see Chapter 3).

The increased role for coal-fired power plants in our projections raises understandable questions regarding environmental impacts and efficiency. Currently, around 90% of coal-fired power plants in Southeast Asia use subcritical technologies, with an average power generation efficiency of around 33%. Some countries, notably Indonesia, the Philippines and Thailand, are prioritising the deployment of more efficient coal-fired power plants, with Indonesia setting a grid code for the use of efficient coal-fired power generation. In the New Policies Scenario, supercritical and ultra-supercritical plants with higher efficiency are gradually introduced, along with integrated coal gasification combined-cycle later in the projection period. Such efficient coal-fired power generation capacity accounts for around 70% of total new coal capacity additions between 2016 and 2040, such that in 2040 the more efficient plants are about a half of total installed coal capacity. However, challenges remain to expand coal-fired capacity, not least public opposition in some countries. Additional challenges involve financing the high upfront costs (when many international development banks are limiting lending to coal projects) and ensuring availability of skilled operators to achieve efficient output in plant operation.

**Figure 2.5**

Electricity generation by type in Southeast Asia in the New Policies Scenario

The power generation mix gradually diversifies, with the share of renewables reaching 30% by 2040

The efforts by governments across Southeast Asia to rebalance the generation fuel mix achieve some success in the New Policies Scenario (Figure 2.5). Electricity generation more than doubles to around 2 200 TWh in 2040. It continues to be dominated by fossil fuels though their share declines by twelve percentage points, to 70%, in 2040. Coal accounts for 44% of the increase in power generation between 2016 and 2040 to become the primary
fuel for power generation in the region, overtaking natural gas. Reflecting recent policy developments that favour renewables and the multiple challenges in building coal-fired plants, the contribution of coal in the power generation mix in 2040 is lower by almost ten percentage points at 40% than in our *Southeast Asia Energy Outlook-2015* (IEA, 2015).

Gas-fired power generation also increases, by around 60% by 2040, but its share of the total mix decreases to 28%, partly reflecting plans adopted by some governments, such as Malaysia, Thailand and Viet Nam, to reduce reliance on gas for power generation. Oil is the only source of power generation that declines, due to its high cost. Yet in remote areas, small diesel generators continue to play a role, albeit a diminishing one, in providing electricity.

Reflecting the upward adjustment favouring renewables in some countries’ power development plans as well as policy support such as feed-in tariffs widely adopted in the region, the share of renewables in the power generation mix increases to around 30% in 2040. The rising share of renewables-based generation is driven by hydro, whose generation almost triples by 2040, to around 350 TWh. Non-hydro renewables-based power generation also grows rapidly, accounting for 14% of the total power generation in 2040. Solar PV and wind power generation grows especially quickly, at an annual average rate of around 15% between 2016 and 2040. Geothermal power generation almost triples by 2040, reflecting its substantial potential in some parts of Southeast Asia and supportive government policies, particularly in Indonesia and the Philippines.

**Electricity subsidies**

Southeast Asian countries provide a range of subsidies for consumers, including by setting lower input prices and providing tax exemptions for fuels used in power generation, and setting end-user prices below the cost of supply with the gap met by the treasury, state-owned utility or other customer categories. Many countries also subsidise electricity for low-income households with lifeline rates. Types of subsidies vary among countries. For example, in the Philippines, subsidies are provided through a cross-subsidy scheme in areas where the private sector is not able to provide electricity at an affordable cost.

Many Southeast Asian countries have undertaken pricing reforms on oil products used in transport (see section 1.3.2 in Chapter 1). Rapid increases in residential electricity demand have raised awareness of the need to reform the subsidies, but political sensitivity and public reaction to rising electricity prices has often hampered sustained and consistent subsidy reforms in the region.

As discussed in Chapter 1, many Southeast Asian countries – including Indonesia, Malaysia, Thailand, and Viet Nam – have made progress in gradually removing electricity subsidies. However, there have been cases in the region, as well as in many other parts of the world, where subsidies have been reintroduced and the move towards complete removal of
subsidies has stalled or even reversed course. To consider the financial impact of such a reversal, we have analysed a case in which countries across the region do not continue reform on electricity subsidies. Assuming the same demand trajectory as in the New Policies Scenario, if the level of subsidies to total cost of electricity supply are kept constant, the electricity subsidy bill would amount to over $20 billion in 2040 (Figure 2.6). This is equal to 4% of total government revenue in Southeast Asia in 2015 and the cumulative subsidy bills to 2040 would rise to more than $350 billion.

Figure 2.6  Residential electricity subsidies in Southeast Asia without pricing reforms

To further promote subsidy reforms, some Southeast Asian countries that are members of multilateral groups, such as the Asia-Pacific Economic Cooperation (APEC) and the G20, can benefit from peer reviews that can help rationalise their subsidy schemes. There also are notable examples in Southeast Asia where subsidy reforms have been sustained. One instance is in the Philippines, which undertook subsidy reforms in the late 1990s, starting with the deregulation of prices for oil products. Despite political pressures to reinstate subsidies, the government has sustained the reforms. A public communication campaign led by the president and a special committee composed of relevant stakeholders analysed the need for subsidies and highlighted the importance of the reforms, which facilitated public consent for the subsidy reform.

2.2.2  End-use sectors

Overview

Reflecting economic development and demographic changes, final energy consumption in Southeast Asia grows by around 60% to 2040 in the New Policies Scenario, at an annual average rate of 1.9% (Table 2.2), around 70% faster than the world average. Among the
end-use sectors, industry grows the fastest, becoming the largest energy consumer in the early 2020s. Oil remains the largest energy source, its position upheld by an ongoing dominance in the transport sector, which accounts for around 60% of the oil consumed. Electricity is the largest contributor to demand growth between 2016 and 2040, as the robust economy and urbanisation increase electricity demand in the buildings and industry sectors. Bioenergy decreases its share in final consumption, from 25% to 13%, as more and more people gain access to modern energy, replacing traditional biomass.

**Table 2.2** Final energy consumption by sector in Southeast Asia in the New Policies Scenario

<table>
<thead>
<tr>
<th>Shares</th>
<th>2000</th>
<th>2016</th>
<th>2025</th>
<th>2030</th>
<th>2040</th>
<th>2016</th>
<th>2040</th>
<th>Change</th>
<th>CAAGR*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry</td>
<td>76</td>
<td>129</td>
<td>176</td>
<td>202</td>
<td>255</td>
<td>29%</td>
<td>36%</td>
<td>126</td>
<td>2.9%</td>
</tr>
<tr>
<td>Transport</td>
<td>61</td>
<td>123</td>
<td>157</td>
<td>170</td>
<td>186</td>
<td>27%</td>
<td>26%</td>
<td>63</td>
<td>1.7%</td>
</tr>
<tr>
<td>Buildings</td>
<td>108</td>
<td>149</td>
<td>161</td>
<td>170</td>
<td>193</td>
<td>33%</td>
<td>27%</td>
<td>45</td>
<td>1.1%</td>
</tr>
<tr>
<td>Other sectors**</td>
<td>30</td>
<td>52</td>
<td>68</td>
<td>72</td>
<td>79</td>
<td>11%</td>
<td>11%</td>
<td>27</td>
<td>1.8%</td>
</tr>
<tr>
<td>Total</td>
<td>276</td>
<td>453</td>
<td>560</td>
<td>614</td>
<td>714</td>
<td>100%</td>
<td>100%</td>
<td>261</td>
<td>1.9%</td>
</tr>
<tr>
<td>Industry, incl. transformation***</td>
<td>96</td>
<td>163</td>
<td>221</td>
<td>251</td>
<td>310</td>
<td>n.a.</td>
<td>n.a.</td>
<td>147</td>
<td>2.7%</td>
</tr>
</tbody>
</table>

*Compound average annual growth rate. ** Includes agriculture and non-energy use. *** Includes energy demand from blast furnaces and coke ovens (not part of final consumption), and petrochemical feedstocks. Note: n.a. = not applicable.

To address fast-rising energy demand, Southeast Asian countries are increasingly pursuing energy efficiency policies and have agreed on a collective efficiency target of reducing energy intensity by 30% by 2025 compared with 2005 level, in addition to national targets in some countries. A few countries, such as Philippines and Thailand, have gone further, adopting extensive energy efficiency policies under comprehensive national energy efficiency plans. However, across the region, the degree of implementation of efficiency policies varies significantly. For example, many appliances such as air conditioners, refrigerators, and television sets are covered by energy-efficient labelling schemes in Thailand and in Viet Nam, while other countries such as Cambodia, Lao PDR and Myanmar have not yet introduced efficiency labelling schemes. These countries often lack the institutional resources and capabilities necessary to implement efficiency policies, including data collection as a basis to measure consumption and save energy, as their resources are often directed towards other policy priorities, such as extending electricity access.

End-user energy demand\(^3\) would be around 10% higher in 2040 without efficiency improvements associated with the efficiency policies currently in place, as well as those announced as intended targets, compared with what is seen in the New Policies Scenario (Figure 2.7). The impact of efficiency savings grows over time, suggesting that earlier action bears more fruit in the future. Achieving these benefits involves efforts to collect reliable

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\(^3\) End-user energy demand here includes demand from blast furnaces and coke ovens, and petrochemical feedstocks for industry.
energy data, raise consumer awareness, effectively enforce standards, build institutional capacity and finance additional upfront cost for efficient equipment.

**Figure 2.7** Contribution of efficiency improvements in end-use energy consumption in Southeast Asia in the New Policies Scenario

![Graph showing energy demand and efficiency savings from 2016 to 2040](image)

**Without efficiency improvements, energy demand would be around 10% higher in 2040**

Note: The amount of energy efficiency savings reflects the cumulative effect of efficiency savings in all end-use sectors in the New Policies Scenario, based on a decomposition analysis of projected demand.

**Industry**

Industrial energy demand in Southeast Asia grows rapidly in the New Policies Scenario, almost doubling to 2040 to around 310 million tonnes of oil equivalent (Mtoe). This reflects the large and growing role manufacturing industries play in the region, buoyed by considerable foreign direct investments, which totalled around $30 billion in 2015. A number of industries, including automobile and electric appliance manufacturing, steel and chemicals production are playing a prominent role in economic growth.

Energy-intensive industries, including steel, chemicals, cement, paper and aluminium, account for roughly half of total industrial energy demand throughout the period to 2040. In all of these industries except steel, energy intensity (expressed as the amount of energy needed per tonne of output), continues to decline over the period. The steel industry in Southeast Asia is an exception because to date it largely employed electric arc furnaces using recycled steel. With demand rising for steel products for infrastructure, construction and other manufacturing industries, countries such as Indonesia and Viet Nam plan to build blast furnace technologies for primary steel production. Blast furnaces consume more energy per unit of production than electric arc furnaces, and therefore will contribute to the overall energy intensity in the steel industry increasing in the period to 2040.

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4 Energy demand in industry in this section also includes blast furnaces, coke ovens and petrochemical feedstocks.
Demand for natural gas in the industry sector more than doubles by 2040, accounting for around 30% of industrial energy consumption in 2040. Among the end-use sectors, industry has been by far the largest gas consumer and this trend continues, accounting for around 80% of end-user natural gas consumption in 2040. Demand for electricity in industry more than doubles, to around 730 TWh in 2040, gaining prominence in a wide range of areas such as automobiles and electric appliance manufacturing. In many Southeast Asian countries where manufacturing plays an important role in the economy, reliable electricity supply is a key factor to industrial development. Some countries such as Thailand take advantage of gas-fired cogeneration plants installed at industrial parks or factories to ensure reliable heat and electricity supply, and the government plans for cogeneration plants to account for about 11% of total new installed electrical capacity between 2015 and 2026. Coal consumption more than doubles to 2040, partly due to the increased use of blast furnaces in the steel industry, which accounts for one-third of the rise. Oil consumption also expands, particularly for petrochemical feedstocks. The share of oil in industrial energy consumption, however, declines from one-third in 2016 to one-quarter in 2040, reflecting a continued switch to natural gas from fuel oil.

The profile of energy demand in Southeast Asia changes due to shifts in industrial activity, fuel and technology switching and efficiency improvements. We conducted a decomposition analysis that illustrates the relative contributions of these factors to changes in energy demand. All else being equal, the rise in industrial activity would increase energy demand by around 130% in the period 2016 to 2040. However, in our projections, this growth is tempered by energy efficiency improvements that moderate the growth in industrial demand, enabling a saving of around 50 Mtoe in 2040 (Figure 2.8).

**Figure 2.8** Contributing factors to changes in industry energy demand in Southeast Asia in the New Policies Scenario

*Energy demand in industry rises rapidly, but efficiency improvements help moderate the growth*
Although energy efficiency can provide a powerful tool to enhance energy security and address environmental concerns at the same time, the effective implementation of policies often faces considerable challenges, including lack of resources and capabilities and insufficient enforcement. In many Southeast Asian countries, incentive programmes are being implemented to encourage industry to invest in energy-efficient equipment, but a regulatory approach, such as minimum energy performance standards to limit consumption is weak. For example, so far only Malaysia and Thailand implements minimum energy performance standards for electric motors, while Indonesia and Singapore have plans to introduce them near future. A broader adoption of minimum energy standards for electric motors (which consume more than half of the world’s electricity) can play an important role in moderating the growth in industrial energy consumption.

The majority of industrial energy efficiency programmes involve energy audits, an essential tool to understand energy use and efficiency potentials. The most well known is the ISO 50001 for energy management, which was developed through a collaborative process involving hundreds of experts from around the world over many years. Successful implementation of ISO 50001, or any audit programme, requires a process for training and maintaining the performance of qualified auditors through, for example, an accreditation programme. Raising awareness of the importance of efficiency and addressing the resource constraints are primary challenges for Southeast Asian countries. Only half of the ten Association of Southeast Asian Nations (ASEAN) members have so far introduced energy management systems in industry (ECCI, 2017). The infrastructure necessary for such an initiative is considerable, so sharing resources across the ASEAN members could be useful. A collective approach has been initiated under the ASEAN Plan of Action for Energy Cooperation to share best practice and policy experience and various multilateral efforts to co-operate to enhance capacity building, such as the APEC energy efficiency peer review scheme.

Energy audit programmes need to be packaged with reporting requirements, targeted information that helps industries understand how they can save energy and where they can get assistance. The more successful programmes also provide some form of incentive, for example access to preferential loans or tax exemptions. For instance, in Japan, mandatory reporting requirements and annual efficiency improvement requirements are bolstered by a tax incentive in the form of accelerated depreciation for efficient equipment. India’s Perform Achieve Trade Scheme is another successful example of a packaged approach to industrial energy efficiency that is relevant to Southeast Asia. This programme starts with an audit process to understand the specific site energy consumption from which targets are set across a specific industrial subsector with the best performing sites having the least to achieve and the worst ones having higher targets. Firms can comply with the targets by achieving energy savings, or if they over achieve they can sell credits, which can be purchased by under-achieving firms. The latest assessment of 427 firms shows that the original targets were surpassed with energy consumption reduced by 5.3% (IEA, 2016).
Transport

Southeast Asian countries continue to experience rapid growth in transport demand, with the number of passenger light-duty vehicles increasing by around 70% by 2040 in the New Policies Scenario, to around 62 million, a stock roughly equivalent to that of Japan today. Indonesia accounts for around 70% of the growth, as the passenger vehicle stock triples to around 28 million in 2040, accounting for 45% of the Southeast Asian total. Rising incomes, underpinned by economic growth and improvements in road infrastructure, push projected passenger vehicle ownership higher across the region, which increase by more than 40% to 81 per 1,000 habitants in 2040. This level of ownership remains far below that of the global average in 2040, which is around 220 per 1,000 habitants.

Against this backdrop, and with industrial output also increasing demand for freight, there is strong demand for transport fuels. Overall transport energy demand increases by 50% to 2040 and oil continues to meet around 90% of transport-related demand. Oil consumption for transport rises by around 1.1 million barrels per day (mb/d). Use of bioenergy as an alternative to oil increases gradually and accounts for around 5% of road transport demand by 2040. In 2040, there are about 4 million electric cars in a total passenger vehicle stock of 62 million, but electricity accounts for only 1% of transport energy demand. Some Southeast Asian countries have set targets for electric vehicles, notably Malaysia (100,000 electric cars, 2,000 electric buses and 125,000 charging stations by 2020) and Thailand (1.2 million passenger electric vehicles by 2036). Indonesia recently announced a plan to encourage the introduction of electric vehicles. The adoption of electric vehicles, however, is projected to grow slowly in the New Policies Scenario, as policy support to encourage consumer uptake and the necessary recharging infrastructure is still relatively weak.

The strong linkages between the services provided by road freight services and increased economic activity mean that the volume of goods transported by road freight (measured in tonne-kilometres) more than doubles from 2016 levels by 2040. This accounts for about 7% of the global growth in road freight activity. Consequently, energy demand for road freight increases by around 60% by 2040, accounting for around 50% of oil demand for road transport. Energy demand for passenger vehicles also rises strongly, by around 60% to 2040.

The number of two/three-wheelers continues to expand, accounting for three-quarters of the total vehicle stock and more than 20% of energy consumption in road transport in 2040. More and more of these vehicles raise concerns about traffic congestion and air pollution. Some countries in the region are taking policy actions. For example, Hanoi City, Viet Nam, plans to ban motorcycles by 2030 in an effort to alleviate traffic and air pollution problems. Motorcycles have been banned in some streets in Jakarta, Indonesia since 2014 and there are plans to expand the scope of the ban. In Thailand, the government intends to replace 22,000 old tuk-tuks (a popular three-wheel vehicle) with electric tuk-tuks, supported by funding from the Energy Conservation Promotion Fund (EPPO, 2017). China provides a good example in transforming from internal combustion engine models of motorcycles to electric ones, with over 200 million electric motorcycles in 2015 (IEA, 2017a).
Energy demand in aviation sees an annual growth rate of around 4% – twice the global average – to almost triple the demand in the 2016 to 2040 period. Increased economic activity and wealth in the region boosts demand for air travel. In addition, the collective efforts to promote the aviation industry contribute to the increase, such as through the ASEAN Single Market Initiative, which aims to increase the safe and secure movement of people, goods and services.

Southeast Asia continues to be dependent on oil imports, which increase to around 6.9 mb/d in 2040 in the New Policies Scenario. Action in the transport sector, the largest oil-consuming sector by far, can play a vital role in mitigating oil security risks and reducing import bills. Many governments in Southeast Asia have introduced measures to improve efficiency in the transport sector, such as by introducing tax incentives to purchase vehicles with higher efficiency, but currently only Viet Nam has established a fuel-economy standard. This standard is applicable only for cars with up to seven seats, but based on a prime minister’s directive issued in 2017, the coverage will be expanded to vehicles with up to nine seats. Singapore has a fuel labelling and an emissions scheme including CO₂ emission limits to provide rebates or impose surcharges on vehicles 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, the Philippines and Thailand currently are discussing plans to introduce fuel-economy standards. In the New Policies Scenario, the limited adoption of fuel-economy standards largely explains why this indicator in Southeast Asian countries lags behind the global trend, with average fuel economy of passenger vehicles in the region 20% lower than the global average in 2040 (Figure 2.9).

**Figure 2.9**  
Passenger light-duty vehicle stock and fuel economy in Southeast Asia in the New Policies Scenario

![Graph showing passenger light-duty vehicle stock and fuel economy in Southeast Asia in the New Policies Scenario.](image)

*The passenger light-duty vehicle stock expands to 62 million in 2040, but improvements in fuel economy lag behind the global trend.*

Note: PLDV = passenger light-duty vehicle.
More widespread adoption of mandatory fuel-economy standards for both freight and passenger vehicles can help Southeast Asian countries to mitigate a number of energy security and environmental concerns. Countries can take advantage of ongoing international co-operation to share best practices and information in shaping and implementing the policy. One of the approaches could be to work with the Global Fuel Economy Initiative on vehicle efficiency standards. This collaborative project, in which the International Energy Agency is a partner, helps dozens of countries around the world benefit from improved vehicle efficiency. As well as reducing oil consumption and thereby improving energy security, there are significant local air pollution benefits such as improved health and reduced costs to both the public and private purses due to ill health. Similarly, collaborative work on two/three-wheeler efficiency could be accelerated in Southeast Asia. Globally, there has been much less work done on efficiency of heavy-duty vehicles but a relevant global movement is starting and Southeast Asia could collaborate early on and help shape the process. The region can benefit from multilateral efforts to rein in rising oil demand of road freight, such as those in the Green Freight Asia Alliance where half the ASEAN countries are the members (IEA, 2017b). Seizing the most promising opportunities in this realm would require data sharing and collaboration across companies, with substantial hurdles to transforming the status quo of shipping and road freight operations.

As Southeast Asia is urbanising rapidly, consideration also needs to be given to improving public transport so that it is an attractive alternative to individual transport modes. Some countries in Southeast Asia are taking actions to alleviate urban traffic congestions by developing mass transit networks, e.g. Indonesia and Viet Nam. In Thailand, the Bangkok Mass Transport system is being built as a part of a broader transport infrastructure strategy to support a modal shift away from road to rail. It entails the expansion and improvement of a railway network, for which around 80% of the planned investment totalling around $67 billion will be spent by 2020 (APERC, 2015).

Buildings

Economic development and expanded access to modern energy has a major impact on quality of life and leads to steady increases of energy consumption across Southeast Asia in the residential sector. In addition to industry, the services sector is a leading source of the region’s economic growth such that its energy consumption more than doubles to around 50 Mtoe in 2040. Overall, energy demand in the buildings sector grows by about 30% to 2040. The increase is somewhat moderated by the fall in consumption of traditional biomass (a very inefficient form of consumption), whose share in the fuel mix in the residential sector decreases from 70% to around 40%. Improved infrastructure and rising incomes enable people to switch from the use of traditional biomass to electricity, natural gas and liquefied petroleum gas (LPG), and reduce the risks of indoor air pollution. Residential LPG consumption grows by around 30% by 2040.

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5 The buildings sector includes energy used in residential, commercial and institutional buildings, and non-specified other.
Electricity consumption in the residential sector almost triples by 2040, to around 760 TWh (Figure 2.10) with increased appliance ownership accounting for more than half of residential electricity consumption in 2040. In Cambodia, television ownership per household doubled between 2000 and 2015 to 67%, while in Viet Nam, the number reached 100% in 2014, up from 62% in 2000. In the New Policies Scenario, rising incomes extend these trends for a range of household appliances. Residential electricity demand is also on the upswing to power air conditioners, whose market is widening rapidly in many Southeast Asian countries, for instance it has tripled in the last five years in Viet Nam (JRAIA, 2017). Across the region, ownership of air conditioners spreads from 17% of households in 2016 to around 30% by 2040 and electricity demand to run them more than triples. Electricity demand per household continues to increase over the period to 2040 to around 3 300 kilowatt-hours (kWh) per year, a level approaching to the world average.

**Figure 2.10** Residential electricity demand by end-use in Southeast Asia in the New Policies Scenario

Electricity consumption almost triples by 2040, pushed higher by increased ownership of a range of appliances and air conditioners

Note: kWh = kilowatt-hour.

Robust growth in electricity consumption has made policy-makers in the region recognise the need to introduce or reinforce efficiency policies to moderate demand growth, especially for appliances. Many governments in the region have established minimum efficiency performance standards (MEPS) and labelling schemes for appliances, though their product coverage and efficiency thresholds of the standards and labelling vary. Thailand, which was the first ASEAN member country to introduce MEPS, has established standards for 26 appliances, while similar measures are still under development in countries such as Cambodia and Myanmar. Expanding product coverages for MEPS and efficiency labelling, together with frequent updates of the efficiency threshold, are expected to further promote energy savings. To this end, efforts among Southeast Asian
countries have already started. In 2015, Indonesia introduced a labelling program for air conditioners. In 2017, Viet Nam issued a prime minister’s directive to revise the efficiency labelling and MEPS to include items such as light-emitting diodes (LEDs) and water heaters.

Southeast Asian countries can benefit from international collaboration programmes on appliance efficiency. For example, the IEA 4E Technology Collaboration Programme (IEA-4E), which was established in 2008 helps ensure that similar energy performance standards apply in various markets in the world. Southeast Asian countries are in a position to emulate this experience and have taken the first steps through a programme known as ASEAN Shine where region-wide air-conditioner standards have been developed. While the programme is making progress, the agreed performance levels could be strengthened to move the market more expeditiously. Two problems with the air-conditioner standards are the ability of manufacturers to produce air conditioners to performance standards that vary across the region and a reluctance on the part of the manufacturers to be regulated for energy performance standards in their products. 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. There are many examples of where this approach has been successful. For example, the Thai air conditioning industry saw the opportunity of producing efficient equipment for an expanded market based on regional standards and became a major exporter. In India, a publicly owned energy service company, known as Energy Efficiency Services Limited, ran a series of bulk procurements for high quality LEDs under a prime minister’s initiative. This resulted in the price of procured LED bulbs decreasing to around one-quarter of the original price (Energy Efficiency Services Limited, 2016), leading to more than 100 million LED bulbs delivered across the country (EESL and IEA, 2017). Such examples illustrate the shared benefits that a well-designed programme can deliver to moderate energy demand while supplying an energy service, provide wider markets for the appliances and goods and also stimulate jobs in the manufacturing sector.

In the services sector, electricity accounts for around 80% of energy demand in 2040, of which lighting and appliances account for around 70%. Similar to households, the rising electricity demand in the services sector highlights the need for rigorous efficiency policies for appliances to moderate energy demand growth.

Policies, measures and practices dedicated to efficient energy consumption in buildings also need to be strengthened. Successful energy efficiency programmes for buildings take a packaged approach as the elements strengthen each other. The first element is building codes and whether they include MEPS for new buildings. Five of the ten ASEAN countries have either voluntary or mandatory building efficiency codes, but enforcement is insufficient. There is a vast market for new buildings in the region and as they last for decades, this is a critical area. Collaboration on regional standards can foster shared resources and knowledge, and widen markets for building materials and services. The second element is having a system to address existing buildings. One methodology rates buildings’ energy profiles with skilled and accredited assessors to regularly verify that
standards are maintained. Once the rating system is in place it can be used in a range of ways, for example to label buildings so that buyers or renters better understand what their operating costs will be. Ratings can be established for different building types such as offices, shopping centres, hospitals and schools. There is evidence that this approach can successfully drive improvements in the efficiency of buildings.

As with appliance standards, there is ample experience that can benefit the process to accelerate efficiency gains in the region’s buildings sector. For example, Australia’s building codes have been evolving to accommodate a variety of climates regimes, many of which are relevant to Southeast Asia. Australia’s experience could be informative to accelerate the process of establishing region-wide building codes, which have been under discussion among ASEAN members for some time. The assessment tool for commercial buildings in Australia is known as NABERS and it is used to label buildings in the Commercial Buildings Disclosure Programme (CBD). CBD is an integral part of the Green Lease Programme that clearly lays out the responsibilities of property owners and tenants in terms of energy efficiency. Government office buildings have to be of certain performance levels according to the NABERS scheme and this applies both to government-owned and rented space. Australia’s experience and packaged approach is not unique, but it is particularly relevant to Southeast Asia in terms of proximity and climate.

In most countries going through rapid urbanisation, like many of the Southeast Asian countries, energy demand for municipal energy services also rises rapidly and as new systems are being put in place this is an ideal time to make energy-efficient choices rather than locking in less efficient systems with excessive operating costs, potentially for decades. Street lighting, water treatment and distribution systems, and sewage treatment are all major costs for municipal government budgets and areas where design choices can have long-term implications for energy consumption. Efficient systems can yield major savings using efficient components such as lightings, high efficiency pumps paired with variable speed drives where appropriate, and automated control systems to match variable demand. There are also energy efficiency opportunities in specific types of building often managed by local authorities such as schools and hospitals.

Collaboration among the Southeast Asian governments to develop benchmarks related to energy aspects of public services can provide useful lessons and accelerate efficiency gains. For instance, there is a wealth of experience in technical and financing issues related to street lighting. So rather than devising new specifications, established standards for similar climatic conditions could be adopted to accelerate the process in Southeast Asia. India’s experience with Energy Efficiency Services Limited could be adapted for street lighting and other equipment needed for municipal services such as motors, pumps and control systems. The public sector should lead by example and require all levels of government to procure cost-effective high efficiency systems when using public money. This approach has successfully driven markets to produce more efficient goods in many parts of the world. A well-known example is Energy Star, initiated as a voluntary labelling programme in the United States; it is an international standard for energy-efficient consumer products.
2.3  Outlook by fuel in the New Policies Scenario

Southeast Asia’s energy supply and demand dynamics change measurably in the New Policies Scenario to 2040. Decreasing production output of oil and the strong increase in demand for all fossil fuels means that Southeast Asia, long accustomed to being a considerable net exporter of energy, turns into a prominent net importer, with the oil import requirement growing strongly (Table 2.3). Our price trajectories for fossil fuels in this scenario play a major role in shaping these trends: since our Southeast Asia Energy Outlook in 2015, the global price trajectories for oil and natural gas in the New Policies Scenario have been revised downwards. This has added some impetus to demand trends in the region, while complicating the prospects for new supply projects, particularly over the period to 2025.6

Table 2.3  Energy production and primary energy demand by fuel in Southeast Asia in the New Policies Scenario

<table>
<thead>
<tr>
<th></th>
<th>Unit</th>
<th>2000</th>
<th>2016</th>
<th>2025</th>
<th>2030</th>
<th>2040</th>
<th>Delta</th>
<th>CAAGR*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil production</td>
<td>Mtoe</td>
<td>140</td>
<td>118</td>
<td>100</td>
<td>94</td>
<td>79</td>
<td>-39</td>
<td>-1.7%</td>
</tr>
<tr>
<td></td>
<td>mb/d</td>
<td>2.9</td>
<td>2.5</td>
<td>2.1</td>
<td>2.0</td>
<td>1.7</td>
<td>-0.8</td>
<td>-1.6%</td>
</tr>
<tr>
<td>Oil demand</td>
<td>Mtoe</td>
<td>156</td>
<td>220</td>
<td>270</td>
<td>288</td>
<td>308</td>
<td>49</td>
<td>1.4%</td>
</tr>
<tr>
<td></td>
<td>mb/d</td>
<td>3.1</td>
<td>4.7</td>
<td>5.8</td>
<td>6.2</td>
<td>6.6</td>
<td>1.8</td>
<td>1.4%</td>
</tr>
<tr>
<td>Natural gas production</td>
<td>Mtoe</td>
<td>135</td>
<td>188</td>
<td>167</td>
<td>172</td>
<td>185</td>
<td>-4</td>
<td>-0.1%</td>
</tr>
<tr>
<td></td>
<td>bcm</td>
<td>159</td>
<td>223</td>
<td>198</td>
<td>204</td>
<td>217</td>
<td>-6</td>
<td>-0.1%</td>
</tr>
<tr>
<td>Natural gas demand</td>
<td>Mtoe</td>
<td>74</td>
<td>141</td>
<td>162</td>
<td>180</td>
<td>225</td>
<td>84</td>
<td>2.0%</td>
</tr>
<tr>
<td></td>
<td>bcm</td>
<td>88</td>
<td>170</td>
<td>195</td>
<td>216</td>
<td>269</td>
<td>99</td>
<td>1.9%</td>
</tr>
<tr>
<td>Coal production</td>
<td>Mtoe</td>
<td>58</td>
<td>278</td>
<td>276</td>
<td>263</td>
<td>262</td>
<td>-16</td>
<td>-0.2%</td>
</tr>
<tr>
<td></td>
<td>Mtce</td>
<td>83</td>
<td>397</td>
<td>394</td>
<td>376</td>
<td>375</td>
<td>-23</td>
<td>-0.2%</td>
</tr>
<tr>
<td>Coal demand</td>
<td>Mtoe</td>
<td>32</td>
<td>112</td>
<td>176</td>
<td>208</td>
<td>271</td>
<td>159</td>
<td>3.7%</td>
</tr>
<tr>
<td></td>
<td>Mtce</td>
<td>45</td>
<td>161</td>
<td>252</td>
<td>297</td>
<td>387</td>
<td>227</td>
<td>3.7%</td>
</tr>
<tr>
<td>Nuclear</td>
<td>Mtoe</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>4</td>
<td>n.a.</td>
</tr>
<tr>
<td>Renewables</td>
<td>Mtoe</td>
<td>123</td>
<td>169</td>
<td>197</td>
<td>217</td>
<td>253</td>
<td>85</td>
<td>1.7%</td>
</tr>
<tr>
<td>Hydropower</td>
<td>Mtoe</td>
<td>4</td>
<td>11</td>
<td>17</td>
<td>23</td>
<td>30</td>
<td>19</td>
<td>4.4%</td>
</tr>
<tr>
<td>Bioenergy</td>
<td>Mtoe</td>
<td>101</td>
<td>129</td>
<td>132</td>
<td>132</td>
<td>136</td>
<td>6</td>
<td>0.2%</td>
</tr>
<tr>
<td>Other renewables</td>
<td>Mtoe</td>
<td>18</td>
<td>28</td>
<td>49</td>
<td>62</td>
<td>88</td>
<td>59</td>
<td>4.8%</td>
</tr>
<tr>
<td>Total production</td>
<td>Mtoe</td>
<td>456</td>
<td>753</td>
<td>741</td>
<td>746</td>
<td>783</td>
<td>30</td>
<td>0.2%</td>
</tr>
<tr>
<td>Total demand**</td>
<td>Mtoe</td>
<td>414</td>
<td>708</td>
<td>890</td>
<td>988</td>
<td>1186</td>
<td>478</td>
<td>2.2%</td>
</tr>
<tr>
<td>Net trade</td>
<td>Mtoe</td>
<td>43</td>
<td>45</td>
<td>-149</td>
<td>-242</td>
<td>-403</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>Share of net trade</td>
<td>9%</td>
<td>6%</td>
<td>-17%</td>
<td>-24%</td>
<td>-34%</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
</tbody>
</table>

* CAAGR = compound average annual growth rate. ** Takes into account demand for bunker fuels (international marine and aviation). For nuclear and renewables, supply is equal to demand. Notes: mb/d = million barrels per day; bcm = billion cubic metres; Mtce = million tonnes of coal equivalent; Mtoe = million tonnes of oil equivalent. Excludes bunkers.

The share of renewables in the primary energy mix decreases slightly, to 24%, despite a significant increase in the use of wind and solar power, with the decline reflecting mostly changes in the use of biomass, which currently accounts for around one-fifth of primary energy demand. In the New Policies Scenario, the role of biomass shifts in several ways; it declines in residential use and is replaced by electricity, and natural gas and LPG, while biomass use for power generation increases, suggesting a more efficient use of bioenergy (including through the combustion of biofuels).

### 2.3.1 Oil

**Resources and production**

Southeast Asia’s oil production declines in the period to 2040 as decreasing production in Indonesia, Malaysia and Thailand are not fully offset by rises in Brunei Darussalam and the Philippines. By 2040, total oil production falls to 1.7 mb/d, a 30% drop on today’s level (Figure 2.11).

**Figure 2.11** Oil production in Southeast Asia in the New Policies Scenario

Indonesia, currently Southeast Asia’s biggest oil producer, had proven reserves of 3.3 billion barrels at end-2016. Of the 880 kb/d in production in 2016, over 90% came from the Sumatra, Java and East Kalimantan basins, the most widely explored in the country (Table 2.4). Declines in the onshore Duri and Minas fields and lack of sizeable new prospects (an issue compounded by a drop in activity in recent years due to the relatively low oil price environment) have seen oil production fall by around half since its peak in 1991. In our projections, Indonesia’s oil output is projected to continue to fall, reaching about 510 kb/d in 2040, as new sources of production, enhanced oil recovery (EOR) projects and the assumed start of coal-to-liquids production are able to slow, but not fully offset, continued decline.
New developments in Indonesia are limited in the short and medium term. The Cepu Block in East and Central Java, containing 720 million barrels of recoverable liquids, is Indonesia’s most recent major development. Peak production at the Banyu Urip and Kedung Keris fields on the block, operated by Pertamina, the national oil company, and ExxonMobil, was originally planned at 165 kb/d, but this was surpassed in 2016 by around 20 kb/d, with the operators now planning to boost production further to 205 kb/d. The performance of the Cepu Block fields helped offset, to some extent, the decline in other fields and allowed Indonesia to register its first year-on-year increase in oil production in six years. The modest pipeline of projects in the medium term, including the Jambaran and Tiung Biru fields, focus on the Cepu block, but East Natuna, a gas project in the South China Sea (if development goes ahead, see next section), could be a significant source of natural gas liquids (NGLs), while East Indonesia includes large frontier areas that are relatively unexplored and may contain significant potential. Uncertainty over the development of East Natuna stems from the extremely high carbon-dioxide content of the field.

Table 2.4  Oil resources by country, end-2016 (billion barrels)

<table>
<thead>
<tr>
<th>Country</th>
<th>Proven reserves</th>
<th>Remaining technically recoverable resources</th>
<th>Technically recoverable resources</th>
<th>Remaining as share of technically recoverable resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brunei Darussalam</td>
<td>1.1</td>
<td>5.0</td>
<td>8.9</td>
<td>56%</td>
</tr>
<tr>
<td>Indonesia</td>
<td>3.3</td>
<td>38.2</td>
<td>63.7</td>
<td>60%</td>
</tr>
<tr>
<td>Malaysia</td>
<td>3.6</td>
<td>15.3</td>
<td>24.2</td>
<td>63%</td>
</tr>
<tr>
<td>Philippines</td>
<td>0.1</td>
<td>1.5</td>
<td>1.7</td>
<td>90%</td>
</tr>
<tr>
<td>Thailand</td>
<td>0.4</td>
<td>2.9</td>
<td>5.4</td>
<td>53%</td>
</tr>
<tr>
<td>Viet Nam</td>
<td>4.4</td>
<td>10.9</td>
<td>13.6</td>
<td>80%</td>
</tr>
<tr>
<td>Rest of Southeast Asia</td>
<td>0.1</td>
<td>4.8</td>
<td>5.5</td>
<td>88%</td>
</tr>
<tr>
<td><strong>Total Southeast Asia</strong></td>
<td><strong>13.1</strong></td>
<td><strong>78.7</strong></td>
<td><strong>123</strong></td>
<td><strong>64%</strong></td>
</tr>
</tbody>
</table>

Notes: Proven reserves are usually defined as discovered volumes having a 90% probability that they can be extracted profitably. Technically recoverable resources comprise cumulative production, proven reserves, reserves growth (the projected increase in reserves in known fields) and as yet undiscovered resources that are judged likely to be ultimately producible using current technology. Remaining technically recoverable resources are equal to the technically recoverable resources less cumulative production.

Sources: IEA databases and analysis; BGR (2016); OGI (2016); USGS (2012a, 2012b); BP (2017); US DOE/EIA/ARI (2013, 2014).

Slowing Indonesia’s decline in oil output will require the execution of more complex, expensive projects, including EOR. Chevron employs EOR to slow decline in both the Minas and Duri fields, for example, with the steam injection project in the Duri field being one of the largest in the world. An enabling environment is crucial to incentivise EOR investments, which could be strengthened by, for instance, agreeing a variation on a production sharing contract that assigns a portion of the secondary recovery to the investing party, while keeping primary production in the hands of Pertamina. In early 2017, Indonesia introduced a “Gross Split Production Sharing Contract”, which it hopes will attract investment into the upstream oil sector by simplifying the calculation of permitted recoverable costs (that have
been a source of dispute in the past), and to better incentivise private sector participation by allowing a greater share of gross oil production.

Malaysia’s proven oil reserves are similar in size to Indonesia’s, at 3.6 billion barrels, and are located predominately in the waters off Peninsular Malaysia, as well as Sarawak and Sabah. Malaysia is the second-largest oil producer in Southeast Asia, with output of 700 kb/d in 2016, down from its peak of 830 kb/d in 2003. Significant discoveries during the period 2002-2005 have led to the development of a number of large projects. These include the Gomusut-Kakap field, which began producing in late 2014 with an annual peak production of around 148 kb/d (meaning it is responsible for around a one-fifth of Malaysia’s total oil production), and the Malikai field, which also came into production in 2014 at a rate of 60 kb/d. These projects have allowed Malaysia recently to turn around its trajectory of decline, with production showing three years of successive year-on-year increases.

Malaysia’s oil sector faces two distinct challenges going forward. The first is that half of Malaysia’s remaining recoverable oil resources are in fields smaller than 100 million barrels, requiring an approach to planning for their production that is different from the model that has served it well in the past. In recognition of this issue, the government introduced in 2013 a range of tax and duty waivers designed to attract investment in marginal fields. The second challenge relates to stemming the decline in the large, mature fields that have been the cornerstone of Malaysia’s production for decades. This includes the potential for use of EOR to extend the life and increasing the recovery factor of the fields. Falling output at Tapis and nearby fields prompted ExxonMobil and Petronas to undertake a large-scale EOR project there, while Petronas has worked with several partners on EOR development for fields in the Baram Delta and North Sabah. Further EOR potential is relatively low, given that only a small number of reservoirs in Malaysia are suitable for such techniques however, in certain areas, including the K5 field, high CO₂ content offers the potential for miscible flooding using CO₂.

Tackling both challenges is complicated in the short to medium term by the low oil price environment. This has already impeded efforts to stimulate exploration and production by awarding “risk service contracts”, such as those for the Berantai and Balai fields offered in 2011, which were designed to incentivise investment by providing a performance-based fee and favourable fiscal terms to develop and operate marginal fields. Both these contracts were terminated in 2016 due to the more challenging price environment.

Malaysia’s oil supply is projected to remain broadly level to the mid-2020s before slowly falling to around 490 kb/d in 2040. The recent success of the ramp up of oil production from deepwater projects in offshore Sabah and the start of EOR projects have had some success in reversing declines recently, but will not be enough to stem declining oil output in the longer term.

Thailand has proven reserves of around 400 million barrels, concentrated mostly in the Gulf of Thailand, and produces around 460 kb/d, of which around 60% was NGLs. Onshore
production is marginal and comes notably from the mature Sikrit field. Production has grown almost two-and-a-half-fold since 2000, but new prospects are limited, and Thailand’s oil production has likely already reached its high water mark. It is projected to fall slowly to 2020, reaching 435 kb/d, but then more rapidly as Thailand’s limited resource base is depleted.

Viet Nam has significant proven reserves of 4.4 billion barrels, larger than those of Indonesia and Malaysia. However, production of around 310 kb/d is not commensurate with the size of the resource base, despite concerted efforts to bring new fields into production. This is because the largest producing fields, namely Bach Ho, Rong and Rong SE, are all in decline. Relatively energetic efforts to develop new fields have been hindered in recent years by the low oil price environment: while nine areas were explored in 2013 and 2014, this number dropped to just three in 2015. The most promising areas for exploration are the Cuu Long, Nam Con Son and Malay basins, located offshore southern Viet Nam. Several new projects that have come on stream have allowed overall production to remain relatively stable for over a decade, but these will likely be unable to stave off falling oil production over the long term. Viet Nam’s oil output is projected to decrease to around 270 kb/d in 2020 and remain at around this level to 2040.

**Demand, refining and trade**

Oil demand in Southeast Asia is expected to grow robustly over the period to 2040, propelled by an increase in demand for mobility. The addition of 26 million cars and 1.6 million trucks to the vehicle stock means that transport alone accounts for over 60% of the increase in oil demand over this period, which rises from 4.7 mb/d in 2016 to nearly 6.6 mb/d. Much of the rest of the increase is attributed to rising demand for petrochemical feedstocks. Meeting this additional demand has implications not just on the level of import of crude, but also on refining.

In 2000, Southeast Asia had sufficient refining capacity to serve oil product demand in the region. However, modest capacity additions over the last 15 years have not kept pace with the rapid growth in demand, which has changed the picture significantly. In 2016, oil product demand (including bunkers) in Southeast Asia amounted to 6 mb/d while refining capacity stood at 4.8 mb/d, making the region a large net product importer (Table 2.5). Although many projects have been proposed to address this deficit, only a handful have reached final investment decision due to various bottlenecks.

In the near term, two expansion projects are likely to proceed in Indonesia, a 100 kb/d expansion of the Balikpapan refinery due to become operational by 2021, and Pertamina and Saudi Aramco’s investment in the Cilacap refinery’s expansion and upgrade. A third project, the Tuban refinery, is expected to become operational around 2023. Other

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7 WEO methodology typically excludes bunkers from regional demand analysis, as they do not count as domestic demand. However, Southeast Asia has a high share of bunkers in its total demand relative to other regions due to its significant marine and air transportation hubs. Therefore, an estimate of future bunker demand has been added to our demand projections.
greenfield projects face difficulties in attracting investment, an issue that is exacerbated by margins that are squeezed by regulated fuel prices (even though subsidies have been removed). However, the strong demand outlook means that there is an expectation for additional capacity to come online in the longer term, particularly if the investment climate improves.

Table 2.5  Oil demand by product in Southeast Asia in the New Policies Scenario (mb/d)

<table>
<thead>
<tr>
<th>Product</th>
<th>2016</th>
<th>2025</th>
<th>2030</th>
<th>2040</th>
<th>2016-2040 Delta</th>
<th>CAAGR*</th>
</tr>
</thead>
<tbody>
<tr>
<td>LPG/ethane</td>
<td>0.69</td>
<td>0.85</td>
<td>0.93</td>
<td>1.01</td>
<td>0.32</td>
<td>1.6%</td>
</tr>
<tr>
<td>Naphtha</td>
<td>0.49</td>
<td>0.65</td>
<td>0.67</td>
<td>0.72</td>
<td>0.23</td>
<td>1.6%</td>
</tr>
<tr>
<td>Gasoline</td>
<td>1.31</td>
<td>1.60</td>
<td>1.67</td>
<td>1.67</td>
<td>0.36</td>
<td>1.0%</td>
</tr>
<tr>
<td>Kerosene</td>
<td>0.50</td>
<td>0.74</td>
<td>0.92</td>
<td>1.33</td>
<td>0.83</td>
<td>4.2%</td>
</tr>
<tr>
<td>Diesel</td>
<td>1.54</td>
<td>2.04</td>
<td>2.03</td>
<td>2.19</td>
<td>0.65</td>
<td>1.5%</td>
</tr>
<tr>
<td>Fuel oil</td>
<td>1.04</td>
<td>0.88</td>
<td>1.08</td>
<td>1.18</td>
<td>0.14</td>
<td>0.5%</td>
</tr>
<tr>
<td>Total oil demand**</td>
<td>6.0</td>
<td>7.4</td>
<td>7.9</td>
<td>8.8</td>
<td>2.8</td>
<td>1.6%</td>
</tr>
</tbody>
</table>

* Compound average annual growth rate. ** Total includes international bunkers and other products such as asphalt, waxes and lubricants. Note: Each product demand includes demand for bunker fuels (international marine and aviation).

In February 2017, Saudi Aramco decided to invest $7 billion in Malaysia’s Refinery and Petrochemical Integrated Development (RAPID) project, which it hopes will position the country as a major product exporter in Southeast Asia. With a capacity of around 300 kb/d, the project is expected to produce high-specification gasoline and other products from around 2020. In Viet Nam, the 200 kb/d Nghi Son project is expected to come online during 2018, after a year of delays, while the expansion of the Dung Quat refinery is also in progress. With surging domestic demand, several expansion projects are being considered in Thailand, although most of these would take several years to materialise. Brunei Darussalam may add a 160 kb/d of distillation capacity. Similarly, Cambodia is building its first 40 kb/d refinery by establishing a joint venture between Cambodia Petrochemical Company and China’s Sino Great Wall International Engineering Company.

Given the region’s robust demand outlook, we project more capacity comes online in the longer term, increasing the region’s refining capacity to 7.7 mb/d, and throughput to 6.8 mb/d, by 2040. However, this level of capacity is still insufficient to meet growing demand, implying the region remains a net product importer with an import requirement of around 1.3 mb/d in 2040 (Table 2.6).

While Southeast Asia remains a net product importer, each oil product presents a different pattern in terms of trade balance. LPG and kerosene, which show the fastest growth, continue to be imported to meet rising demand. On the other hand, increasing refinery runs almost fully eliminate the need for gasoline and diesel imports. However, as China tries to export its surplus diesel to adjacent Asian markets, some diesel produced in the region is likely to be forced to find an export market. With the growing trend towards using
low sulfur transportation fuel, our projection is that desulfurisation capacity outpaces that of primary distillation capacity over the next decade in Southeast Asia. However, we cannot rule out the possibility of refiners failing to make adequate investments (in upgrading, hydro-treating or gasoline blenders) to comply with the tightening fuel specifications. This would mean that even though there is demand exceeding refining capacity, a considerable portion of this demand could be met by more sophisticated refineries in other regions, which could lead to a wider product deficit. This scenario would increase the risk of some older, less complex refineries suffering from reduced utilisation despite strong demand.

Table 2.6 - Southeast Asia refining capacity and refinery runs in the New Policies Scenario (mb/d)

<table>
<thead>
<tr>
<th></th>
<th>2016 Capacity</th>
<th>Net capacity additions to 2040</th>
<th>Refinery runs</th>
<th>Capacity at risk*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2016</td>
<td>2025</td>
<td>2040</td>
<td>2025</td>
</tr>
<tr>
<td>Southeast Asia</td>
<td>4.8</td>
<td>2.9</td>
<td>4.2</td>
<td>5.4</td>
</tr>
<tr>
<td>World</td>
<td>97.7</td>
<td>13.7</td>
<td>79.8</td>
<td>85.0</td>
</tr>
</tbody>
</table>

*Defined as the difference between refinery capacity, on one hand, and refinery runs, on the other, with the latter including a 14% allowance for downtime. This is always smaller than the spare capacity, which is the difference between total capacity and refinery runs.

Overall, total product imports stay relatively stable, at today’s level of 1.3 mb/d, as increases in demand are met by a commensurate increase in refinery capacity (Figure 2.12). However, the declining share of Indonesia in total imports from around a half today to less than 20% by 2040 reflects the growing import requirements of other Southeast Asian countries such as Thailand and the Philippines, which expand by almost 60%.

While Southeast Asia’s product import needs remain steady over time in our projections, its crude import needs increase. Net crude import requirements grow substantially, from 2.1 mb/d today to 5.5 mb/d by 2040. The recent plunge in oil prices and the increased competition for Asian market share in crude markets (allowing buyers to press for discounted prices) somewhat alleviated the pressures of the import bill. However, the eventual rebalancing of oil markets, higher prices and the region’s ever-increasing import needs imply that these dynamics are unlikely to play out over the longer term. A number of risks exist, not least the reliance on a small number of Middle East suppliers, while pressure on the Strait of Malacca intensifies due to the lack of viable alternatives.

With this in mind, some countries are adding storage capacity, which could help them respond to short-term disruptions, although these projects have been driven more by commercial motivations. Three of the top-ten largest tank farms under construction in the world are in Malaysia and several more projects are currently being planned in Indonesia, Singapore and Viet Nam (IEA, 2017c). A number of Middle Eastern national oil companies are eyeing investment opportunities in refineries in the region, which could help ensure a stable supply of crude oil to some extent. Nonetheless, all these are insufficient to allay fully energy security concerns.
Despite an envisaged increase in refinery capacity, Southeast Asia remains a net importer of oil products.

A low-carbon transition would point towards a different trajectory for Southeast Asia, including by reducing oil demand. In the Sustainable Development Scenario, stricter fuel-economy standards and the greater use of electric and natural gas vehicles, keeps oil use in transport virtually flat to 2040 (despite car ownership rising by almost half over the period). The reduced overall demand for oil has implications on the region’s crude import requirement, which is reduced by 1.9 mb/d, to 3.6 mb/d by 2040. Temporary relief provided by the period of low oil prices has been capitalised on in a number of countries, who have used the opportunity to reform existing fossil-fuel subsidies (see Chapter 1).

### 2.3.2 Coal

**Resources and production**

Coal production in Southeast Asia falls from 400 million tonnes of coal equivalent (Mtce) in 2016 to around 375 Mtce in 2040. This is accounted for entirely by changes in Indonesia, where the government has announced plans to cap coal production at 400 million tonnes (around 300 Mtce) from 2019 onwards. This policy shift serves as general guidance for our long-term production outlook but, in light of the fragmented Indonesian coal industry, which involves many small mines that are difficult to control, and the importance of coal mining for employment and fiscal revenues, we do not expect the target to be met strictly. Indonesian coal production drops to 340 Mtce in 2025 and reaches around 315 Mtce in 2040. The increase in regional demand means that net exports of the ASEAN group of countries dwindle over the Outlook period, and by 2040, the region is a net importer of...
coal. This contrasts starkly with the trend over the last 25 years that saw a very steep rise in net exports from the region. This shift towards regional consumption reflects both the natural increase in energy demand, but also targeted government policy: in its 2015-2019 medium-term development plan, the government of Indonesia included a domestic market obligation set at around one-third of its output.

Indonesian coal exports fall from just over 290 Mtce in 2016 to around 170 Mtce in 2040. Despite the drop in exports over the Outlook period, shipments to the international market remain important for Indonesian coal producers as they support local employment and bring (tax) revenues. Indonesia is expected to remain a swing supplier in the coal market (i.e. the country can quickly adjust its production to react to changes in international coal prices). India remains the primary market for Indonesian coal (geographic proximity and the low ash and sulfur content of Indonesian coal clearly plays in its favour) but Indonesia’s share in the Indian market declines as the country reduces its exposure to the international market. Various countries within the ASEAN group see their coal demand increasing strongly over the coming 25 years and Indonesia, due to its geography, will serve much of these growing import needs. With Indonesian exports declining, other coal exporters are ready to step in and fill the gap. Australia for instance increases its exports of coal by more than 15% in the coming 25 years, and Russia and South Africa are also well placed to capture market share from Indonesia.

Viet Nam sees its coal production rise modestly over the period but even a small increase in output hinges on the introduction of competition in the coal market, successful implementation of coal price reforms and productivity improvements. Viet Nam has just overtaken Thailand as the second-largest coal consumer in the region and, with demand expected to soar, is projected to become the region’s largest importer over the Outlook period.

**Demand**

Southeast Asia is, after India, the primary growth centre of coal demand in the world. Its coal consumption more than doubles to 390 Mtce in 2040. Coal demand growth in Southeast Asia is fundamentally a power generation story: consumption in power plants accounts for three-quarters of the additional coal use in the coming 25 years (Figure 2.13). Electricity demand grows by 3.7% per year to 2040 and the region’s power system planners need to mobilise all sources of power generation to keep pace. Coal maintains a strong foothold in the region’s projected consumption not only because it is markedly cheaper than natural gas, but also because coal projects are in many cases easier to pursue as they do not require the capital-intensive infrastructure associated with gas. On the other hand, coal projects face considerable public opposition that have delayed development efforts, for example, the Krabi plant in Thailand, the Inn Din plant in Myanmar and the Atimonan plant in the Philippines. The coal share in the region’s power mix increases from around 35% today to a little over 40% in 2040 while that of gas drops from nearly 45% to less than 30%.

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8 Intra-regional trade (from Indonesia to the rest of Southeast Asia) is not captured in the overall export number for the region, which only accounts for inter-regional exchanges.
Power generation accounts for 75% of coal demand growth in Southeast Asia to 2040

* Industry includes energy consumption in blast furnaces.

Some 100 GW of new coal-fired capacity is built in Southeast Asia over the Outlook period, bringing installed coal capacity to 160 GW in 2040 (40% of which is in Indonesia alone). Although around 25% of the new plants added to 2040 use subcritical technology, the bulk of the capacity additions rely on more efficient supercritical and ultra-supercritical technology. By 2040, around half of the coal fleet uses either supercritical or ultra-supercritical technology, helping to bring the fleet’s average efficiency up from 33% today to 38% in 2040 (Figure 2.14).

The strong increase in coal-fired power generation bears the risk of a significant increase in CO₂ and air pollutant emissions such as sulfur dioxide (SO₂) nitrous oxides (NOₓ) and fine particulate matter (PM2.5) over the Outlook period if not controlled by adequate regulation (see Chapter 3). The technology to mitigate air pollutant emissions from large coal combustion plants is readily available but use of this technology must be incentivised by regulation. Moreover, in terms of tackling SO₂ emissions, the region benefits from the prevalence of Indonesian coal which generally has low sulfur content. Therefore, in Southeast Asia, disconnecting air pollutant emissions growth from coal demand growth is primarily a policy challenge. All major coal-consuming countries in the region have emissions regulation standards for coal-fired plant in place but these vary in stringency. In light of the large amount of yet to be built coal capacity over the coming 25 years it is therefore crucial that policy-makers in Southeast Asia continue to raise the stringency of emission standards for new plants.

The use of coal in the Sustainable Development Scenario is vastly diminished, falling by around 30% in the period to 2040, as renewables eat into coal’s share of the power mix. As a result, by 2040, 70% less coal is used in the Sustainable Development Scenario than in the New Policies Scenario.
Figure 2.14 Installed coal-fired capacity by technology and average fleet efficiency in Southeast Asia in the New Policies Scenario

Coal-fired capacity more than doubles by 2040, but the addition of supercritical and advanced technologies leads to a significant increase in the fleet efficiency

2.3.3 Natural gas

Resources and production

Natural gas production in Southeast Asia fluctuates slightly over the Outlook period, but returns to its current level of around 220 billion cubic metres (bcm) by 2040 in the New Policies Scenario.

Indonesia remains the largest producer in the region with output growing from 77 bcm in 2016 to 90 bcm by 2040 – a downward revision of 45 bcm in 2040 compared with the previous Southeast Asia Energy Outlook (IEA, 2015). Currently some 40% of Indonesia’s production is geared towards exports, but the increase in supply over the period is not sufficient to offset domestic demand increases, and the country becomes a net importer of natural gas in the mid-2030s. With resources of almost 15 trillion cubic metres, a third of which are unconventional gas resources (mostly coalbed methane and shale gas), the country is not short of gas but developing large new projects such as East Natuna (Asia’s largest untapped gas field, located in the Natuna Sea off the coast of Western Kalimantan) becomes increasingly challenging. The project is expensive and technically difficult to realise, due to the high CO2 content of the gas, and the case for developing the field also is complicated by the ample availability of LNG on the international market. With these factors in mind, output from East Natuna is not included in this year’s supply projections – although the continued desire of the Indonesian authorities to encourage field development keeps this possibility open. Key contributions to Indonesia’s output growth come from the “Indonesia Deepwater Development” project (located off the coast of Eastern Kalimantan) and tapping of the country’s significant coalbed methane resources, mostly located in Eastern Kalimantan and Sumatra (Figure 2.15).
Domestic market obligations and gas tariffs that are lower than the fuel’s export value hamper the attractiveness of upstream investments in Indonesia. Preferential prices and priority access granted to some industries, for example, fertiliser production, have led to a rapid increase in demand, wasteful consumption and temporary gas shortages. Reform of the current regulatory framework, which is perceived as being complicated and unclear, is not only crucial for conventional gas development but also a prerequisite for the development of unconventional gas, notably for coalbed methane to resolve issues of overlap with coal exploitation rights. Our Outlook assumes an improvement of regulatory conditions for unconventional gas production over time, helping to propel output to 16 bcm in 2040 (around 17% of the country’s gas production by then).

Malaysia’s challenge is to offset declining output from its mature fields over the projection period. The government has taken measures to stimulate new upstream investment such as a reduction of the petroleum tax and other fiscal incentives. The first ever shipment of gas from a floating LNG plant was in 2017, from the Petronas’ Kanowit project, which could pave the way for monetisation of other stranded gas fields in Malaysia. Malaysian gas production likely reached its high water mark at 70 bcm in 2016, and is expected to go into
long-term decline. By 2040, Malaysian gas production drops to around 55 bcm, some 20% below 2016 levels. As a result, Malaysian LNG imports grow markedly over the next 25 years to meet domestic demand.

**Box 2.2 Unlocking Indonesia’s resources through carbon capture and storage**

CO₂ capture and storage (CCS) has been most successfully deployed where CO₂ capture has a manageable impact on the economics of projects, or where the captured CO₂ has a commercial value. Most projects to date have involved either or both CO₂ separated from natural gas during processing and use of the CO₂ for enhanced oil recovery. These two factors coincide in certain parts of Indonesia where CCS could enable increased oil and gas production while reducing the associated emissions.

CCS, coupled with the potential for CO₂ flood enhanced oil recovery in some Indonesian fields, could enable production from some of Indonesia’s high CO₂ content natural gas fields. Indonesia’s vast natural gas reserves are some of the most CO₂ rich in the world. The high concentrations of CO₂ have contributed to a number of large fields remaining undeveloped.

The East Natuna block in the Natuna field is potentially one of the largest fields in Southeast Asia, with 6.3 tcm of resources, yet remains undeveloped due in part to a CO₂ concentration of over 70%. The high CO₂ concentrations present a challenge to the economics of production as well as a technical challenge given the vast quantities of CO₂, which need to be captured, separated and reinjected into the field.

There are a number of fields in the vicinity of South Sumatra that could be candidates for tertiary recovery through CO₂ EOR. The potential for CO₂ EOR in the region is somewhat limited by the geography – low reservoir pressures in candidate fields mean the CO₂ would not mix with the oil making recovery less efficient. However, there is increasing interest in CO₂ EOR in Indonesia as, despite its relative inefficiency, it still provides a potential solution for increasing the recoverable proportion of original oil in place.

CCS has been employed in CO₂ rich fields elsewhere in the world. The Gorgon field in north-western Australia has a CO₂ concentration of around 14%, so CO₂ capture and storage were requirements for permitting the project. First gas was shipped from the field in March 2016 and CO₂ injection into a formation below the processing plant is expected to commence in late 2017.

Growth prospects for production in Myanmar are positive but significant challenges remain. Much of the country’s offshore acreage remains unexplored, infrastructure is ageing and, with the exception of the pipeline link to China, needs upgrading and expansion to handle larger production volumes. Despite regulatory issues, foreign companies have shown interest in Myanmar’s gas fields with Woodside Petroleum Ltd. having recently discovered a few offshore fields. The combination of promising reserves and increased
investment allows Myanmar to increase gas production to around 25 bcm by 2040. Thailand’s production faces long-term decline. New discoveries have been few and small in recent years, insufficient to counter the rapid drop in production from Thailand’s mature resource base. Moreover, delays in passing the new petroleum legislation have held back investment. We project Thailand’s gas production to drop to some 18 bcm in 2040, around 60% of today’s levels. The country thus is expected to become a significant importer of LNG to bridge the supply-demand gap.

**Demand**

Natural gas demand in Southeast Asia increases at a rate of 2% per year over the period to 2040, a marked slowdown from the more than 6% per year over the past 25 years. Nevertheless, gas demand continues to grow faster than production in the region, a trend that began a few years ago, and with this, net exports are gradually diminishing. By the mid-2020s the region as a whole turns into a net importer of gas (Figure 2.16). This has important implications for infrastructure development in the region over the next 25 years. Regasification terminals – onshore or floating – are growing rapidly in the region with four facilities currently under construction and some 20 terminals at various stages of planning. Various bilateral pipelines are in operation today, but an important task is integrating them into a harmonised regional pipeline network. The Trans-ASEAN Gas Pipeline project attempts to achieve this and could help bring important energy security benefits for the region and increase liquidity of gas trade. Yet, various commercial, technical and regulatory challenges remain, not least concerning the development of Indonesia’s East Natuna project, which would be an important source of new supply. Yet even without East Natuna, an integrated Southeast Asian pipeline network would bring flexibility and diversification of supply sources (see Chapter 3).

While gas demand in the power sector and in industry grew at similar rates in the past, this trend is set to change in the coming years. Gas burn in the power sector grows at 1.4% per year while industrial gas use grows at around 4% per year. Further demand growth is constrained in the power sector primarily because of the relatively high cost of gas compared with coal. Industry (especially the light industry branches) is thus the main growth engine in the region, accounting for 60% of the incremental gas demand in the period to 2040.

Based on our outlook for Asian gas and coal prices, it is markedly more expensive to build and run a gas-fired plant to generate baseload power than a coal plant. Thus, gas plants are largely confined to run in load-following operation (mid-merit) and to meet peak load in the region’s power systems. Various countries in Southeast Asia make progress in phasing out fossil-fuel subsidies over the **Outlook** period. While this is a welcome development, it also implies that in the absence of supportive policies like carbon pricing, the commercial case for gas weakens in power generation (several countries, including Indonesia, Viet Nam and Malaysia currently regulate the price of gas consumed in power generation). As a result, the share of natural gas in Southeast Asia’s power mix drops from nearly 45% today to just under 30% in 2040.
Transmission and distribution networks, and depending on the country, LNG import terminals, are capital intensive but a prerequisite for gas demand growth. The dilemma is that gas demand cannot grow without infrastructure but infrastructure development is only attractive for investors if there are good prospects for demand growth, a consideration of particular importance for Myanmar, Viet Nam and the Philippines. Large metropolitan areas with industrial zones are ideal to establish anchor consumers and develop a regional gas infrastructure; once a critical mass of demand is reached, the network can be further expanded to other parts of the country. Coastal areas are often particularly well suited as they allow for LNG imports, possibly starting with floating storage and regasification units technology that can gradually be scaled up allowing the infrastructure to grow commensurate with demand.

Southeast Asia has sizeable regasification terminal project plans, and makes progress on cross-border pipeline development over the Outlook period. However, infrastructure is costly and investments in the various gas supply chain components are pursued by different stakeholders, making co-ordination a critical element of successful project development. In our Outlook, difficulties to finance and build new infrastructure, alongside the commercial challenges to compete against coal and renewables, are potential constraints on gas market development. In the long term, gas loses out against coal in the region, the share of gas stays flat at around a fifth of primary energy demand in the period to 2040 while that of coal increases from 17% today to 26%.

Indonesia, by some distance the largest gas market in the region, sees its demand increase from 44 bcm in 2016 to nearly 100 bcm in 2040, with industry accounting for more than...
60% of the growth (Figure 2.17). The non energy-intensive industries are the primary engine of growth (expansion of gas distribution networks for small and medium enterprises is critical), followed by the chemical and petrochemical industry which relies on gas as a feedstock, for instance, for fertiliser production. There is significant downside risk to gas demand growth in the Indonesian industry: if gas remains unavailable, coal would be ready to step in, with negative environmental impacts.

**Figure 2.17**  
Natural gas balance in Indonesia in the New Policies Scenario

Rising domestic consumption more than offsets the growth in production, and Indonesia becomes a net importer of natural gas by 2035

Natural gas plays a slightly expanded role in the Sustainable Development Scenario, accounting for 22% of primary energy demand in 2040 (compared to 21% in the New Policies Scenario). It is the only fossil fuel whose use increases in power generation, while its use in transport increases almost four-fold in the period to 2040. Consumption in industry, the largest end-user of gas, grows less strongly than in the New Policies Scenario however, as electrification eats into the share of all fossil fuels.

### 2.3.4 Renewables

**Bioenergy**

Bioenergy currently accounts for around 25% of total final consumption, and despite some substitution with other fuels, is expected to retain a prominent share in the energy balance to 2040, by which time it accounts for 13% of final consumption. This general decrease belies several divergent dynamics between not only the end-use sectors, but also the types of bioenergy being consumed. Bioenergy use in buildings, which currently accounts for almost 80% of the total (as a result of firewood burned by around 250 million people currently without access to clean cooking facilities), falls by a third, despite a 30% increase
in energy demand overall. It is displaced, to a degree, by LPG — of the 74 million people who gain access to clean cooking over the period, 50 million do so through access to LPG cookstoves.

Bioenergy use in transport more than doubles in the period to 2040, as a result of increasing biofuel use in cars and trucks, supported by mandates already imposed in several countries. The push towards biofuels helps fulfil three imperatives: it supports important local palm crop industries, particularly in Indonesia, Malaysia and Thailand; it reduces dependency on imported petroleum products; it helps climate considerations, provided the palms from which the oil harvested are grown sustainably.

Industrial agriculture, particularly of sugar and palm oil, are conducive to producing power from biomass. Southeast Asia’s current biomass generation capacity of around 7.4 GW is expected to increase to almost 19 GW by 2040. While this is useful as an auto-generation scheme for businesses, it also helps to utilise palm oil mill effluent, which would otherwise produce a large amount of methane gas.

In the Sustainable Development Scenario, bioenergy use undergoes two fundamental changes. In the residential sector, its consumption falls by more than 90%, as use of solid biomass is eliminated in all but the most marginal communities. In the transport sector, its use increases more than four-fold, as biofuels are increasingly used.

**Solar**

Solar resources across the region range from around 1 400 kWh per square metre per year (kWh/m²/year), to 1 900/kWh/m²/year. In the New Policies Scenario, solar PV is the second-fastest growing technology in terms of installed generation capacity, increasing at around 11% per year (albeit from a low base). From 4.2 GW in 2016, solar PV capacity expands to more than 52 GW. Thailand currently accounts for most of the region’s installed capacity, and incentivises investment through a feed-in tariff (FiT) introduced in 2011. This is expected to increase in the coming years, with Thailand announcing a target of 30% for renewables in the energy mix by 2036 in its Alternative Energy Development Plan 2015-2036. Thailand also envisages robust growth in roof-top solar installations, targeting around 10 GW. Indonesia, which accounts for just under one-third of Southeast Asia’s solar PV capacity in 2040, also has ambitious plans, and in 2017 replaced its FiT incentives (introduced in 2013) with a new tariff system that is based on a reference to the cost of electricity production in a given region. Its aim is to encourage the deployment of renewables-based power outside of Java-Bali, in areas where the cost of production is relatively higher, due to the prevalence of oil-based generation. Indonesia hopes to reach 5 GW of renewables-based capacity by 2020. Viet Nam’s recently revised National Power Development Plan aims for 850 MW of capacity in 2020, rising to 12 GW by 2030. In mid-2017, Viet Nam introduced a FiT for utility-scale projects. The country has seen a recent uptick in activity, and so far in 2017, EVN, the state-owned utility, has announced plans for 350 MW of solar PV capacity due to come online in 2021, and Tata Solar announced a 100 MW plant at Binh Phuoc. Viet Nam also has plans to support distributed solar power,
and alongside the European Union’s Energy Initiative Partnership Dialogue Facility, is designing a net metering scheme to help stimulate investment. Malaysia hopes to reach 1 GW of capacity by 2020, but starts from less than 270 MW today.

One potential enabler of more rapid solar PV uptake is the close links many economies in Southeast Asia have with China, by far the world’s largest (and lowest cost) producer of photovoltaic cells, as well as to the Malaysian market, the world’s third-largest producer. Existing free trade agreements allow tariff-free access for Chinese manufacturers. Large producers of PV cells, including Yingli Solar (the world’s second-largest producer) and Trina Solar, have announced investments for factories to manufacture cells in Thailand for both domestic and export markets.

Falling costs worldwide, local air pollution concerns and the imperative of electricity access particularly in Indonesia and the Philippines means that the role of solar power could be far greater than that projected in the New Policies Scenario. In the Sustainable Development Scenario, where full access is assumed, solar PV capacity is three-times larger, reaching 160 GW in 2040.

**Wind**

Wind energy resources vary across the region, with the greatest potential thought to be in the Philippines, which has estimated technical potential of around 70 GW. Reflecting this, the government of the Philippines has set wind power targets in its National Renewable Energy Program, aiming to reach 2.3 GW of capacity by 2030. Progress since the plan was announced in 2011 would suggest that this target is modest. Since 2013, wind power capacity has increased from 33 MW to over 425 MW, with service contracts for projects potentially adding a further 1.2 GW of capacity registered with the Department of Energy. A key factor in the upswing in wind power activity in the Philippines has been the introduction of FiTs in 2013, which ensured priority grid connection and power purchases. Viet Nam’s wind resources, particularly along its 3,000 km of coastline, are also notable. Technical potential is estimated at around 27 GW, only a small fraction of which has been developed so far.

In the New Policies Scenario, wind power capacity increases from around 1 GW in 2016 to around 22 GW in 2040, making it the fastest growing of all power technologies. However, even with this increase, by 2040 it still only accounts for 4% of capacity and 2% of power generation. In the Sustainable Development Scenario, wind power plays a far more important role, its capacity reaching almost 100 GW by 2040.

**Hydropower**

Hydropower is by far the largest source of renewables-based power in Southeast Asia, accounting for more than 70% of renewables-based capacity and 17% of total generation capacity. There is a great deal of variation across countries, however, with hydropower accounting for more than 40% of total generation in Cambodia and nearly 100% in Lao PDR (its first thermal power plant at Hongsa began operation in 2015). Significant hydro
resources are untapped, with only around one-quarter of the Lower Mekong River Basin’s estimated hydropower potential of 30 GW developed.

Lao PDR is showing the most ambition towards the development of hydro resources among the countries in the Lower Mekong area, with plans to develop 24 GW of capacity and to make electricity exports its main source of revenue by 2025. Already, Lao PDR is a major exporter of electricity to Thailand, whose companies are involved in existing projects, including the Xayaburi dam (1.3 GW capacity), which is expected to be completed in 2017.

In the New Policies Scenario, hydropower capacity more than doubles, reaching 105 GW in 2040, as development of resources in the Lower Mekong Region is accelerated in a push to both meet domestic demand, but also for export, with electricity seen as a potentially important source of revenue. Hydropower is more widely deployed in the Sustainable Development Scenario, with capacity reaching around 130 GW by 2040.

**Geothermal**

Today Southeast Asia is home to one-quarter of the world’s geothermal generation capacity, with the Philippines (1.9 GW) and Indonesia (1.5 GW) ranked as the second- and third-largest producers. The high capacity factors (averaging above 70%, compared to 15-20% for solar PV and 25-30% for wind) and the ability of geothermal plants to provide low-carbon baseload electricity make them a potentially important source of sustainable energy in areas where geothermal resources are located.

The potential for geothermal for electricity generation is significant, estimated at around 4 GW in the Philippines and a further 29 GW in Indonesia. Indonesia has aggressively pursued policies to promote investment in geothermal. In 2003, it passed a “Geothermal Law” allowing operators to retain control of assets and mandating that all future fields be transparently and competitively tendered for development. This law was supplanted in 2014 by one that removed the “mining” designation from geothermal development, intending to help boost exploration by removing restrictions imposed on general mining within protected areas and forests. In 2004, the Ministry of Energy and Mineral Resources developed a “Blueprint for Geothermal Development” that outlined plans for 6 GW of capacity by 2020 and the General Plan of Energy set a target of 13.5 GW by 2040. In 2012, the ministry introduced a FiT, while the Ministry of Finance capitalised a $200 million fund intended to reduce the risk to investors seeking to develop geothermal resources. The Philippines, whose remaining resources are more modest, has plans to develop 1.2 GW of capacity by 2030, with the bulk happening before 2020.

In the New Policies Scenario, geothermal capacity increases more than three-fold, reaching around 11 GW in 2040, predominantly through developments in Indonesia and the Philippines. Further growth is constrained by the relatively high cost of geothermal development, the risks associated with resource exploration, as well as by competition with solar PV and coal to extend electricity access in both countries, where access remains a significant issue. In the Sustainable Development Scenario, geothermal generation capacity increases more rapidly, reaching 27 GW by 2040.
Addressing Southeast Asia’s energy priorities

How does the region square a circle?

**Highlights**

- Energy policy-makers face multiple challenges across Southeast Asia, not least the constant pressures on the energy system from robust economic and demographic growth. Extending access to electricity to the 65 million people currently without it remains a major priority, while ensuring affordable and secure energy and mitigating environmental impacts.

- All countries in Southeast Asia achieve universal electricity access by the early 2030s in the New Policies Scenario, a major achievement. This is achieved by deploying a range of technologies and approaches, with around 40% connected by extending the grid, one-third via mini-grids and the remainder via off-grid solutions. All fuels play a part, but renewables are particularly important in providing access in remote areas, providing a viable alternative to expensive diesel generators. The least-cost choice for access depends on a range of factors, including available resources, population density and the location of the existing grid.

- While policy efforts in many areas bear fruit, the New Policies Scenario also highlights some troubling trends for energy security and emissions. Increasing reliance on imported energy produces an import bill of more than $300 billion by 2040, mostly for oil. The demand patterns in this scenario also result in a 75% increase in energy-related CO₂ emissions, and continued public health impacts from poor air quality.

- Meeting Southeast Asia’s energy imperatives will require a major commitment of investment. In the New Policies Scenario, cumulative investment in energy supply infrastructure and energy efficiency is $2.7 trillion in the period to 2040. Around half of the investment on the supply side is for power generation and networks.

- The interconnection of energy networks and markets across Southeast Asia provides a key route towards a more resilient and secure energy system. Harmonising disparate regimes and intensifying efforts to increase energy interconnections could lead to more efficient and secure use of energy across the region.

- Putting the region’s energy system on a more sustainable path, as presented in a Sustainable Development Scenario, would require a slight increase in energy supply and efficiency investment to $2.9 trillion and a major shift in capital flows from oil, gas and coal production towards efficiency and the power sector. This path would reduce CO₂ emissions by around 50% compared with our main scenario, improve air quality and deliver a range of energy security and economic benefits. The increasing penetration of renewables, coupled with the more efficient use of energy overall, reduces dependence on imported oil and gas, leading to an import bill that is around $175 billion less than the New Policies Scenario in 2040.
3.1 Electricity access: the case of small islands and rural communities

The issue of electricity access in Southeast Asia has two main dimensions: the first is that 65 million people remain without access at all and the second is that millions more have access to sub-par connections, relying on costly and polluting diesel generators to provide power. Of those currently without access, more than 95% live in four countries: Indonesia (23 million), Philippines (11 million), Myanmar (22 million) and Cambodia (6 million).

The issue of electricity access has long been at the forefront of policy decisions across the region. A number of countries have made tangible gains through concerted government-backed plans to extend access. Between 2000 and 2016, more than 170 million people gained access to electricity in Southeast Asia, bringing the total electrification rate up by almost 30 percentage points, from 62% in 2000 to 90% in 2016 (Figure 3.1).

**Figure 3.1**  
Electricity access rates across Southeast Asia in the New Policies Scenario

Southeast Asia succeeds in achieving universal electricity access by the early-2030s in each of our scenarios. The region does this by deploying a variety of tools, with mini-grid and off-grid technologies accounting for more than half of additional access-related demand (Figure 3.2). Grid connections, however, are expected to remain crucial to meeting access objectives across Southeast Asia, not just in countries where current low access rates reflect underdevelopment, but also in Indonesia and the Philippines, where some islands are large enough and have sufficient population density to justify grid extensions. In reaching universal access, an additional 145 million people have access to electricity in 2030.1

1 This number includes all people who gain access, accounting for those to whom access is extended, as well as natural population growth.
In this section, we evaluate the various choices available to policy-makers in the four countries with the largest access issues: Indonesia, Philippines, Myanmar and Cambodia, and present the likely routes towards access taken by each given their unique circumstances. We do this by examining a range of factors, including relative costs of various technologies, resource availability, topography and population density to present a least-cost path towards electrification.

We pay particular attention to the cases of Papua and East Java in Indonesia, as each has an acute electricity access problem but under a very different set of circumstances. Papua is a sparsely populated, large and remote island, while East Java relatively is densely populated and close to more developed West Java and Bali. The different conditions present a useful proxy for other areas across the region, where access is related in some circumstances, such as Myanmar and Cambodia, to broader under development, and in others, notably the Philippines, to geographic isolation. We assess the government of Indonesia’s plans to promote electricity access in both regions, to explore the lessons they hold for other countries in Southeast Asia.

### 3.1.1 Indonesia

Ambitious government plans to extend electricity access have yielded fruit in Indonesia, where the number of people without access declined from around 100 million in 2000 to around 23 million in 2016 even with a population increase of almost one-quarter. Therefore, Indonesia alone was responsible for 55% of the net decrease in the number of people without access across Southeast Asia since 2000.

Those remaining without access in Indonesia are concentrated in a number of provinces, including East and Central Java, East Nusa Tenggara and Papua, where 2.110 of the
2,424 villages across the country that remain without any access are located. The circumstances in each differ significantly: East Java (where almost 4 million people do not have access to electricity) has more than 80-times as many people per square kilometre (km) as Papua (where 1.6 million people do not have access), and is relatively close to the most densely populated and developed urban centres in the country. This underscores that there is no uniform solution to meeting Indonesia’s energy access targets, and that a great deal of pragmatism and flexibility will be needed to meet its goal of universal access by 2024. In recognition, the plans introduced by the government of Indonesia are multi-dimensional; they include the extension of the existing grid, promoting micro-hydro and off-grid solar technologies as well as solar-diesel hybrid and isolated diesel generators. While the plans rely heavily on financing from the national utility, Perusahaan Listrik Negara (PLN), this is largely enabled by the presence of private participation in commercially viable projects in the country’s broad power sector, which gives some latitude to PLN to support projects that the government deems as having social benefits, rather than immediate commercial returns (Box 3.2).

Figure 3.3  Papua’s village electrification plan

At around 48%, the electrification rate in Papua is the lowest of any region in the country, 43 percentage points below the national average. The region is also unique due to its low population density: there are on average just ten people per square kilometre (km²) in Papua, compared to a national average of around 134/km² (Figure 3.3). The government’s plans to electrify the island are multi-faceted: as a matter of priority, it seeks to bring basic
electrification to unserved villages (mostly in the island’s mountainous interior) through off-grid solutions, while simultaneously working on providing the type of electricity infrastructure in the medium to long term that it hopes will stimulate broader economic development across Papua. Since 2011, 45 small-scale power plants, primarily solar photovoltaic (PV) and hydropower, have been built on the island, connecting an additional 7,000 households. The first element of the government’s plans represents a significant increase in ambition, including to electrify all remaining villages currently without access by 2019, before Papua hosts the National Sports Week in 2020, announcing projects to bring electricity to an additional 170,000 households in the next three years. On average, there are about 75 households in each of the villages to be electrified under this plan, and since virtually none of them is in proximity to a network, off-grid solutions are expected to be the quickest and least-cost method of achieving this part of the electrification plan.

The second element of the government’s plan for Papua includes building infrastructure to meet increasing electricity demand from recently connected consumers. It includes adding about 2.1 gigawatts (GW) of new capacity, mostly gas-fired plants (1.75 GW) to augment the 610 megawatts (MW) of current capacity. Additional generation capacity in Papua will be from hydropower of multiple sizes, geothermal and coal. The plan also includes extending around 2,500 kilometres (km) of high-voltage transmission lines (70 kilovolt (kV) to 150 kV) in Maluku and Papua. An important element of the strategy is to build mobile gas-fired and dual oil-gas plants, often linked to small-scale regasification hubs for shipments of liquefied natural gas (LNG). This allows Indonesia to utilise the gas from the Tangguh LNG facility in West Papua, thereby bypassing the need to build costly pipeline infrastructure for a limited and widely dispersed market (Figure 3.4). The levelised cost of electricity generated at such facilities is estimated at around $145-200 per megawatt-hour (MWh), around 75% less than the diesel alternative (Figure 3.5). In 2016, the Ministry of Energy and Mineral Resources also introduced new regulations that are designed to allow the private sector to gain access to “concession areas” in which they could act as an integrated utility company (providing generation, transmission and distribution). These networks are intended to rely heavily on renewables-based generation, and given that the relatively small markets are not anticipated themselves to provide sufficient returns, the government backs the scheme by ensuring a subsidy to bridge the difference between the marginal cost of supply and the electricity tariff charged.

The case of Papua reflects a degree of pragmatism that combines innovative on-grid solutions, with increasingly viable off-grid ones. However, if the long-term aim is to extend grid access to those first reached by off-grid technologies, it is important at the formative stages to design systems that would lead to the eventual integration of both systems, to avoid the risk of costly replicated investments.

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2 Tokyo Gas, supported by Japan’s Ministry of Economy, Trade and Industry, is currently assessing the commercial viability of small-scale LNG and power projects, and their efficacy in displacing existing fuel-oil power generation in islands in Indonesia and the Philippines.

3 We have presented a range in the levelised cost of electricity showing different fuel input prices and how these impact the overall cost.
Natural gas infrastructure has been identified as a central component in Indonesia’s energy access strategy.

Notes: LNG = liquefied natural gas; FSRU = floating storage and regasification units. “Virtual pipeline” refers to routes by which gas is delivered by ship, instead of using pipelines. Source: LNG Infrastructure Roadmap 2016-2030 (MEMR, 2016).
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**Figure 3.5** Comparative cost of electricity generation by technology in Indonesia and Southeast Asia

Notes: GT = gas turbine; CCGT = combined-cycle gas turbines. All values reflect regional averages, representing a range of project level costs. Values for fossil fuels account for regional differences in capital costs and fuel prices, but share common assumed capacity factors (15% for oil and gas GTs, 30% for small gas GTs and small diesel, and 60% for gas CCGTs and coal supercritical). Micro hydropower refers to small-scale installations under 0.3 kilowatts (kW). Solar PV utility refers to large-scale, ground-mounted installations; PV buildings refers to small-scale, roof-top solar PV installations and stand-alone solar PV refers to small-scale decentralised solar PV installations under 0.2 kW coupled with a battery. For distributed generation, a range of transport costs for fuels and project costs are represented: for small gas GTs, up to $4 per million British thermal units (MBtu) additional fuel delivery costs; for diesel generators, up to 100% additional fuel costs for delivery; and for stand-alone solar PV, up to double installation costs due to delivery costs to remote areas.

The situation in East Java differs significantly, with a population density more than 80-times that of Papua (more than seven-times that of the European Union), and its relative proximity to more developed areas in West Java and Bali. On average, each of the 225 villages recently electrified in East Java was only 13 km away from an existing grid, and often far larger (the average number of households per village is nearly 100 and several have over 1,000 households). These factors made it possible for grid extensions to form the
bulk of new electricity connections in the government’s recent efforts to ensure electricity connections to each of East Java’s villages, with fewer than ten villages connected to diesel-powered mini-grid systems (Figure 3.6). East Java’s village electrification initiative, however, highlights a significant challenge to household electrification: despite all villages in the region being successfully electrified, there remain around 4 million people in East Java that lack access to electricity. This is largely due to the cost associated with household connection (estimated at around $300 per household), which is prohibitive to many, and highlights the importance of considering full costs for policy-makers looking to tackle electricity access problems.

Our analysis of the size of each community and its distance from the existing grid, which we conducted to formulate a comparison of costs against a range of on-grid and off-grid solutions, shows that for the majority of people in East Java, on-grid solutions are the most cost effective regardless of whether coal or gas is used to generate the electricity. For the remainder, solar PV and other distributed generation technologies provide the least-cost option.

Figure 3.6  Villages recently electrified in East Java

Most villages in East Java were electrified through connections to the grid

Sources: Ministry of Energy and Mineral Resources, Indonesia; IEA analysis.

In this Outlook, Indonesia successfully deploys all the tools at its disposal to reach universal electricity access in the mid-2020s. The associated investment is around $5.6 billion to 2025, about 85% of which is for new generation and about 15% for extending the grid. Mini-grid and off-grid renewables-based generation play a fundamental role in extending access and over 35% of the new consumers are served from solar PV, hydropower, biomass
or wind power sources (Figure 3.7). This is particularly the case in places like Papua. Grid-based coal-fired power generation also makes a notable contribution, providing a relatively inexpensive solution in the more densely populated areas, though it could be limited by concerns about air pollution from placing coal-burning plants close to population centres. Small-scale gas-fired plants dotted along the coast of Papua are an interesting option as they can provide reliable baseload capacity and are less polluting than coal. Such plants could be supplied from domestic gas shipped in as LNG, thus avoiding the need for expensive pipelines.

![Figure 3.7](new-electricity-access-connections-by-technology-and-fuel-type-in-indonesia-2017-2025)

**Mini-grid and off-grid solutions account for more than 60% of connections made in the period to 2025**

3.1.2 The Philippines

The Philippines has made significant progress in delivering electricity access, extending access to 20 million since 2012, and boosting the household electrification rate to 91% in 2016. With around 5 million people gaining access per year, the Philippines is on track to meet the target of achieving universal electrification by 2022, as set out in the Philippine Development Plan 2017-2022. Thanks to the government’s effort, grid networks have been extended throughout the main islands, Luzon, Visayas and Mindanao (Figure 3.8). Universal access, however, remains challenging, particularly as the country has more than 7,000 islands. The problem is particularly acute in Mindanao, where around 60% of the households that are currently without access are located (NEA, 2016).

The National Power Corporation (NPC) is the main institution responsible for “missionary” electrification, which involves providing power generation in remote areas not connected to the grid and that cannot be served in an economically viable way. (The rest of the power sector was unbundled and privatised through the Electric Power Industry Reform Act of 2001). The government also allows private participation for rural electrification through
schemes such as the Qualified Third Party Program, in which private sector companies, accredited by the Department of Energy based on financial and technical criteria, can provide rural electrification. These companies can also take over the power generation assets of NPC, as the areas they serve develop markets that improve the economics of the plants.

**Figure 3.8**  
Access solutions by type in the Philippines and Myanmar

**Mini-grid and off-grid systems play a significant role in reaching the most remote consumers in the Philippines, while off-grid technologies prevail in Myanmar**

In the missionary electrification areas, electricity is served by the Small Power Utilities Group (SPUG) under the NPC. In 2015, SPUG had about 300 generating units with a total capacity of 185 MW (NPC, 2016). Small diesel generation units or power barges, with capacity ranging from less than 1 MW to 6 MW are predominantly used, accounting for around 80% of total installed electrical capacity in the SPUG area in 2015. The heavy reliance on diesel often causes blackouts and unplanned power outages. Moreover, due to the high cost of fuel and logistical support for diesel plants, together with customers’ unwillingness or inability to pay for the electricity service in rural areas, more than 80% of the plants in SPUG area generate electricity for less than 12 hours a day.
Due to the high cost of diesel power generation, the electricity price in the SPUG area is set at a price below actual cost, necessitating the NPC to rely on subsidies to cover the gap. The subsidies are funded by a surcharge paid by all other electricity consumers on a per-kWh basis. Improved access to electricity and associated subsidies have pushed the surcharge up four-times since 2003, to Philippine peso (PHP) 0.15/kWh ($0.003/kWh) in 2016. Together with other surcharges for electricity consumers for environmental charges for watershed rehabilitation and stranded contract cost for NPC, rising surcharges are a concern for domestic industries that have to cope with electricity prices that already are among the highest in Southeast Asia.

The heavy reliance on costly diesel power in the missionary area opens the possibility for the country to explore the use of solar PV and wind power generation. To diversify the sources of electricity, the government provides cash incentives, equivalent to about half of the surcharge, to power providers that use renewables in the SPUG area. This provides incentives for renewable energy developers, together with others stipulated in the Renewable Energy Act of 2008, such as accelerated depreciation and duty-free import of equipment. In addition to renewables, small-scale gas-fired plants fuelled by imported LNG (as in Indonesia) have the potential to support access initiatives in the islands of the Philippines. These units can provide reliable electricity supply at a lower cost than a diesel alternative and are less polluting. The Philippines National Oil Company is considering a natural gas infrastructure development plan with this objective in mind.

Geographically, Mindanao is one of the regions most afflicted with low access rates. It has around 11,000 sitios (minimum administrative units) that are unserved with electricity, accounting for half of the total unserved sitios in the Philippines. Mindanao is endowed with renewable resources, particularly hydropower, which accounted for 38% of the island’s total power generation in 2015. The Mindanao Development Authority received 290 renewable energy project applications totalling 3 GW as of 2015, of which hydro accounted for around 70% of the capacity, followed by solar PV at about 430 MW (Mindanao Development Authority, 2017). There is significant renewable energy potential, but oil-fired power generation still accounted for one-third of total power generation in Mindanao (compared with just 3-6% in Luzon and Visayas). Compounding this issue is the fact that the missionary electrification projects in Mindanao rely entirely on small diesel power plants or power barges run by bunker fuels. Given the high cost associated with the use of oil in power generation (as well as its impact on local pollution), the case for replacing oil with renewables is particularly strong in Mindanao.

Ramping up electricity supply capacity in a more cost effective and sustainable manner is a vital area of the Philippines Development Plan 2017 – 2022. This includes plans to achieve universal electricity access by 2022 by providing technical and financial support to electrify the remote areas that remain without supply. The government is accelerating electrification in Mindanao, both by on-grid and off-grid approaches, and by providing grants to electric co-operatives (major distribution units in the remote areas) to help fund their electrification projects. The European Union has provided financial support for
residential solar systems in off-grid areas. Apart from the paucity of generation, Mindanao also suffers from high grid system losses of around 13% in 2015, as well as from power supply constraints, with a reserve ratio of around 3%, much lower than Luzon (13%) and Visayas (12%).

The levelised cost of electricity (LCOE) analysis, which evaluates the relative delivered cost of electricity across a range of technologies for the Southeast Asian countries, suggests that there is considerable potential to lower the generation cost in remote areas by exploring a range of off-grid generation technology options to move away from diesel-fired generation (Figure 3.5). A dedicated site-by-site study is necessary to reflect diverse factors in remote areas in the Philippines, including potential customer base, installation cost, capacity rate, operational capability, available renewable resources and fuel prices.

Based on our analysis, the Philippines successfully attains universal access well ahead of 2030, effectively fulfilling the international commitments in the Sustainable Development Goal 7. A range of technologies and solutions are deployed, but grid-connected generation accounts for almost 90% of new connection to around 14 million additional consumers by 2030 (Figure 3.8). Off-grid and mini-grid technologies play a crucial role in remote areas, as wind and solar PV provide around 1.5 million people with electricity access. The associated investment totals around $14 billion, implying a cost of $1 000 per additional person gaining electricity access.

3.1.3 Cambodia

Cambodia’s electrification rate at 60% is the second-lowest among Southeast Asian countries. This percentage belies a stark dynamic: among the urban population, which is concentrated in Phnom Penh, 97% have access to electricity, while only 50% of the rural population have electricity access (around 30% of rural households rely on batteries for lighting). This underscores the issue of electrification as being synonymous with broader rural development. In order to accelerate electrification, Cambodia has set a target of achieving universal electrification to all villages by 2020 and for 70% of households nationwide to be connected to the grid by 2030.

Any entity looking to supply electricity must first obtain a licence from Cambodia’s Electricity Authority, which constitutes one the essential steps for electricity suppliers to extend access to electricity. As of 2015, around 70% of 14 000 villages were covered by areas where licences had been granted to electricity suppliers, (although this does not necessarily mean that all of the villages covered by the electricity suppliers are ready to supply electricity). The coverage of licenced electricity suppliers in provinces differs greatly, as those with relatively large populations tend to have a large share of villages covered by the licenced electricity suppliers (Figure 3.9). However, as of 2015, there were no provinces fully covered by the licenced suppliers; the highest coverage was about 95% in Phnom Penh and the lowest around 20% in Ratanakiri, a province in the northeast, underscoring the massive scale of effort needed to achieve universal access.
One of the key elements that hamper the extension of electricity access is the issue of affordability. In Cambodia, the tariff is determined based on the cost of electricity generated or purchased from independent power producers (IPPs) or neighbouring countries, plus distribution cost. To date, almost all installed capacity was built in Phnom Penh, which accounted for more than 90% of installed capacity in 2015, leaving rural areas to rely heavily on small diesel power generation and imports for electricity supply. This has led to high electricity tariffs, which the government has responded to by introducing a fuel cost adjustment mechanism to reflect changes in fuel costs, providing subsidies to small consumers with monthly consumption of less than 10 kilowatt-hours (kWh), used mainly for lighting. Nonetheless, the tariff to small consumers remains relatively high, at Cambodian riel (KHR) 480/kWh ($0.113/kWh), higher than the average residential tariff in Indonesia, Malaysia, Thailand and Vietnam (Electricity Authority of Cambodia, 2016). Electricity tariffs are relatively higher in the provinces with lower electrification rates, highlighting the need to improve affordability to further facilitate access to electricity. For example, in Kratie and Mondul Kiri provinces, which are only 44% and 22% covered by the electrical licences respectively, the electricity tariff was set in 2015 at KHR 1 050 ($0.25/kWh) (Electricity Authority of Cambodia, 2016), higher than the tariff in Phnom Penh which ranges from KHR 610 ($0.14/kWh) to KHR 820 ($0.19/kWh).

**Figure 3.9** Population and share of villages covered by licenced electricity suppliers in each province in Cambodia

![Graph showing population and share of villages covered by licenced electricity suppliers in each province in Cambodia.](image)

Cambodia is on its way to universal access, but there are still many provinces with low populations that are not served by electricity suppliers.

Sources: Electricity Authority of Cambodia (2016); National Institute of Statistics, Cambodia (2015); IEA analysis.

The large number of people that lack access to electricity are spread over a vast area, which coupled with high electricity tariffs, suggests that grid extensions are to play a prominent role in extending electricity access in a cost-effective manner in Cambodia (Figure 3.10). A
A grid network can distribute electricity to a broad area and integrate any fragmented small existing networks, which helps to spread the cost of electricity supply across broader areas and enhances security of supply.

**Figure 3.10 – Electricity access by type in Cambodia**

Cambodia deploys a variety of approaches to progress towards universal access. Cambodia plans to build 2.8 GW of power generation capacity, almost entirely hydropower and coal-fired plants by 2025, which can contribute to improve self-sufficiency of power supply (Electricité du Cambodge, 2016). The national grid, including 230 kV transmission lines, has been extended mainly in areas with relatively large populations to connect the urban areas in the south and northwest. This facilitated a three-fold increase in the number of consumers in just five years, from 672 000 in 2010 to 1.9 million in 2015 (Electricity Authority of Cambodia, 2016). It also supplemented power supply in urban areas via imports from Vietnam and Thailand. Other high-voltage transmission lines from the south to the northeast of the country are under construction, as part of the government’s initiative to build high-voltage networks to serve all provinces and cities by 2020. Savings can be achieved by reducing transmission and distribution losses, which in Cambodia are high at 13.5% (Electricity Authority of Cambodia, 2016). The country is endowed with non-
hydro renewable resources, with the average daily solar irradiation of 5 kilowatt-hours per square metre per day (kWh/m²/day) and wind speeds in the southwest and the coastal regions averaging 5 metres per second or greater (Ministry of Mines and Energy, 2016). However, the development of renewables-based power generation in Cambodia is in its infancy, with no established policy frameworks to encourage their development. Nonetheless, a financial agreement was reached in 2017 to introduce the first utility-scale solar PV installation, with a capacity of 10 MW, in co-operation with the Asian Development Bank (ADB, 2017).

In areas not served by the national grid, off-grid and mini-grid technologies are being used to provide electricity access, together with imports from neighbouring countries. In isolated areas, small diesel generators are predominant, serving around 22 000 consumers (Electricity Authority of Cambodia, 2016). These are costly, with an average retail price in 2015 of $0.68/kWh, compared with $0.13-0.25/kWh for customers connected to the grid.⁴ A Rural Electrification Fund (REF), established by the Ministry of Mines and Energy, provides assistance for infrastructure development and rural electrification through either interest-free loans or grants to cover a portion of the project costs. The programme has contributed to the expansion of transmission lines in rural areas, with more than 2 800 km of low- and medium-voltage lines constructed as of 2016. For consumers, the REF includes a “Power to the Poor” programme, which provides consumers with interest-free loans for in-house wiring and equipment, connection fees and deposits required by electricity suppliers. Financed with support from KfW (Germany’s development bank) and the government of Cambodia, since 2008, Power to the Poor spurred a significant uptake of solar home systems by providing a grant of $100 (roughly 50% of the cost of a 50 Watt system) and interest-free loans of around $90.⁵ Together with another financial support scheme for 5 Watt solar systems, it facilitated the installation of over 10 000 solar systems in homes in 2016. With limited financial capabilities in Cambodia, the role for development finance institutions, international donors and the private sector to support building power infrastructure is essential. So far, around 40% of Cambodia’s high-voltage transmission line projects have been financed by international donors, including the World Bank and the

⁴ Interview in 2017 with Mr. T. Sokhamal, Director of the Department of Tariff and Monitoring of Licensee’ Accounts, Electricity Authority Cambodia.

⁵ Interview in 2017 with Dr. L. Keosela, Director of Rural Electrification Fund.
Asian Development Bank. Around half of the 33 transmission system projects planned in the period to 2025 are to be financed by international donors, including China’s Export Import Credit Bank, France’s Development Agency and Japan’s International Cooperation Agency (Electricité Du Cambodge, 2016). For generation facilities, IPPs account for around 90% of total installed capacity. As the grid extends and the customer base expands, the economic viability of large power generation projects improves and the role of IPPs is expected to enlarge to meet increasing electricity demand (Spotlight). The ensuing reduction of electricity costs, stemming from the reduced reliance on small diesel generators and imports from neighbouring countries could have additional benefits, helping the country to leverage its relatively cheap labour costs to build new employment opportunities in industries and services.

Based on our analysis, Cambodia successfully attains universal access by the early 2030s. To do this at the lowest cost, it would need to rely heavily on-grid connections, which provide the least-cost choice for connections for all but 3% of the 7.6 million new connections in that timeframe. For those remaining without access, solar PV systems could help bring power to around 240,000 people by 2030. The associated investment totals $9 billion, implying a cost of $1,100 per additional person gaining electricity access.

Box 3.1 Community-oriented approaches to extend electricity access

Providing electricity access does not end with providing a physical connection to a grid or setting up generation facilities. Various factors need to be adequately considered to ensure the sustainability of electricity access, including its affordability to consumers, adequate financing mechanisms, capacity building for proper operation and maintenance and the socio-economic implications of using more electricity. Around the world, there are cases where power projects have ended up with installed plants becoming unavailable after a short period, due to inadequate attention to these elements (Ikejemba et al., 2017). Engagement of local communities in projects can help to avoid these pitfalls and enhance their sustainability.

Thailand has introduced a “Community-based Renewable Energy Program” to support projects initiated by local communities. It offers valuable insights into how to ensure project sustainability through the engagement of local communities (Chaichana, 2017). Through the programme, the Ministry of Energy, in co-ordination with Chiang Mai University, provides financial assistance to renewables-based power generation projects for small communities. The level of financing (ranging between 30-70% of the cost), is determined in large part by the degree of engagement of local communities. This is determined by assessing a range of factors, including the availability of local energy resources, community ownership of facilities and the financial commitments from local stakeholders such as farmers and industries.

Out of 285 proposals in 2013, twenty-six projects were selected. Eleven of them involved power production from agricultural waste and create income for local...
stakeholders by selling excess power to EGAT, Thailand’s national power company, via a feed-in tariff (FiT) scheme that sets favourable rates for small projects. The primary FiT rate applied for electricity from biomass-based generation capacity of less than 1 megawatt (MW) is Thai baht (THB) 5.84/kWh ($0.17), around 30% higher than the rate for power from larger than 3 MW capacity.

Such projects have a number of associated benefits. They effectively clear waste and the maintenance of the facilities creates employment opportunities in the local community. Financial commitments from local stakeholders increase the sense of project ownership, helping to ensure proper management. Creating such virtuous circles in the local community can enhance the viability of projects.

3.1.4 Myanmar

Myanmar has made significant progress in extending electricity access since 2000, when only 5% of the population had access, one of the lowest rates in the world. Efforts to electrify the country have gradually increased, with around 1.8 million people gaining access every year mostly through centralised, grid-based solutions, reflecting the fact that the low access rate was generalised (and not accounted for solely by remote communities). Despite this improvement, Myanmar’s electricity consumption on a per capita basis remains one of the lowest in the world, at around 260 kWh/year, about 10% of the global average. Nearly 22 million people remain without access to electricity. In absolute terms, this puts Myanmar behind only Indonesia for the number of people without access to electricity.

The government of Myanmar established a target of reaching universal access by 2030 in its National Electrification Plan. The majority of the additional 7.2 million households are to be connected through a grid, at an estimated cost of $6 billion, a rate of $800 per connection (World Bank, 2015). In the areas far from existing infrastructure and with low population density, as in Shan and Thaninthayri, off-grid and mini-grid access solutions are favourable with effective technology choices, and the World Bank is financing such projects to reach 500,000 households by 2021.

In the New Policies Scenario, Myanmar successfully attains universal access by the early 2030s. While grid connections are the least-cost solution for around 40% of the 24 million total new connections, Myanmar is the country among the Association of Southeast Asian Nations (ASEAN) members that could rely most heavily on renewables-based and off-grid options, particularly solar PV due to the abundance of the resource and the large number of people that live relatively far from the grid. Solar PV provides the least-cost connection to around 11.8 million people over the period. The associated investment totals almost $13 billion, implying a cost of around $525 per additional person gaining electricity access.
How can electricity access projects be financed?

To date, the majority of the investment for electricity access in Southeast Asia has taken a traditional grid extension approach. While this model will continue to play a central role in the near term, the high capital costs of grid investments, combined with limited public budgets and competing demands for development finance means that decentralised mini-grid or micro-grid solutions could offer earlier solutions through new business models to provide initial access.

Financing options for electricity access will vary depending on whether a centralised grid extension or decentralised approach is taken. Under a centralised model, where a state-owned utility is responsible for the investment, funding will likely come from a combination of public funds, the utility’s budget, grants (or development aid) or concessional funding from multilateral development banks, export credit agencies or development agencies. In many cases, initial electricity access via grid extensions will be driven by societal reasons and will not provide the cost recovery needed to attract private sector investment. This can put additional strain on state-owned utilities that may have competing budget needs. To address this issue, countries such as Thailand and Indonesia have turned to the private sector and IPPs to meet the increasing need for more generation capacity. Power purchase agreements are used to secure financing from a combination of debt and equity. In some cases, where project risks are deemed too high to be borne solely by the private sector, guarantee mechanisms provided by national governments or multilateral development banks have been used.

Under a decentralised approach to expanding access to electricity, financing options vary as the investment requirements are substantially lower and with the possibility of new actors entering the scene. Public funds from local governments or as transfers from the central government, funding from development banks and private funding (debt and equity) can be used. Fiscal measures can also be used to support energy investments.

In other regions such as South Asia and sub-Saharan Africa, new business models have unfolded for decentralised electricity access projects where investors focus on the delivery of services, e.g. lighting, cooling and cooking, versus solely on electricity supply. By bundling the cost of electricity together with the end-use equipment, consumers can access services quicker and may no longer need to save to purchase consumer goods. Instead, small and medium enterprises (SMEs) are entering the market as energy service providers who may be more adept at reaching isolated and rural systems than large state-owned utilities. Funding from multilateral and bilateral development institutions as well as social investors and philanthropic organisations can support the development of local SMEs while at the same time helping to fund electricity access projects (CEM, 2015).
The willingness of local villages and consumers to help fund or build electricity access projects can also speed the rate of electrification. In the Viet Nam, for example, at the peak of its rural electrification programme (1996-2000) household and local government contributions financed 59% of total investments versus 40% by EVN, the national power utility (ADB, 2011). Active involvement of rural communities in electrification projects in Viet Nam also helped to overcome right-of-way and land permitting issues that can delay developments.

In some circumstances, broadening the focus of electricity access projects beyond households to include energy for productive uses, and including such users in the focus of energy access policies and investments can create a stronger business case for investors and a greater impetus for policy-makers to improve access to electricity (IEA, 2017a).

3.1.5 The evolution of costs for access

The journey to universal electricity access across Southeast Asia is set to span many years, with the changing dynamics of the energy market in that time, including the cost of diesel, the rapidly falling cost of solar PV cells, and the growing viability and changing costs of batteries all needing to be taken into consideration when assessing strategies for electrification. While the relative cost of diesel-powered generators has already been shown to be higher than just about any alternative, the choice between pursuing on-grid, off-grid or mini-grid solutions and indeed dispatchable or variable renewables, is one where the elements change over time and requires close attention.

In the New Policies Scenario, the price of natural gas imported to Southeast Asia rises by around 40% in the period to early 2030 (when universal electricity access is reached across the region), to around $11/MBtu. This increase in cost is offset to a degree by increasing efficiency of the power plants used to burn it, such that the impact on the overall cost of electricity changes only slightly. The decreasing costs of PV cells have a much more profound impact: in the New Policies Scenario, these decrease measurably to 2030, with the potential of reducing the LCOE of solar PV in Southeast Asia from around $140/MWh today to around $75/MWh in 2030. The price of diesel increases by around half in the period to 2030, widening the already large gap in cost competitiveness between diesel generation and nearly all the alternatives. For policy-makers, the changing costs of fuels and technologies, as well as the environmental impact of their choices, will need to be taken into account. Southeast Asia has a number of approaches at its disposal to meet its energy access challenges, ranging from small-scale gas plants on islands fuelled with LNG and traditional coal baseload capacity to solar PV and small hydropower. To meet their

6 “Productive uses” refers to activities that create goods or services and enhance income potential or value. This includes income generation for agriculture, industry, mining and commercial activity, and through value creation in terms of education and health, services that can improve peoples’ livelihoods and their potential to capitalise on economic activity.
considerable, but attainable, ambitions of universal access in a relatively short period of time, countries in the region will need to effectively employ a mix of options that fit the specific conditions.

**Figure 3.11**  
Levelised cost of electricity for selected technologies in Indonesia and Southeast Asia in the New Policies Scenario, 2030

![Graph showing levelised cost of electricity for selected technologies in Indonesia and Southeast Asia in the New Policies Scenario, 2030.](image_url)

Rising costs of fossil fuels and falling costs for solar PV technology improve its competitiveness in various scales of application

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### 3.2 Implications of Southeast Asia’s energy development

Southeast Asia faces myriad energy challenges, a reflection of the fast-changing economies and demographics, the imperative of extending affordable and secure energy to the millions of people who lack access, plus the changing dynamics within the region as traditional net exporters rely ever more on increasing imports. In this section, the New Policies Scenario projections highlight a number of the challenges Southeast Asian countries may face. The focus is on energy security and environmental issues, and the investment necessary to meet growing energy demand while shifting to a more sustainable pathway. We also examine the prospects for increased interconnection as a means of meeting the shared challenges of countries across the region through better power and gas integration.

#### 3.2.1 Implications for energy security

Southeast Asia’s large oil, natural gas and coal resources have allowed the region to enjoy a long-term net energy export position, as evidenced in 2000 with exports values of more than $9 billion. Falling exports (due to both increasing domestic consumption and declining output of oil) and prices have taken a toll, with the trade balance moving to a large deficit of almost $20 billion in 2016. These dynamics are expected to increase in magnitude in the
period to 2040, as oil demand rises by around 40% and natural gas consumption by almost
60%. At the same time, oil production falls by one-third and gas production remains
virtually level. The interaction of these dynamics results in a dramatic shift in energy trade
balances. Southeast Asia is expected to register a net deficit in energy trade of over
$300 billion in 2040, equivalent to around 4% of the region’s gross domestic product (GDP)
(Figure 3.12).

**Figure 3.12**  Fossil-fuel trade balance in Southeast Asia in the
New Policies Scenario

Beyond the impact on trade balances, this large increase in imports raises energy security
concerns for countries across the region. On average, oil import dependency (the amount
of oil imported as a proportion of total demand) increases by 21 percentage points,
reaching 78% in 2040. The trend of Southeast Asia meeting its fast-increasing energy
demand through imports is expected to weigh significantly on policy-making over the
Outlook period. The current low oil price environment has been used by several
governments, including Indonesia, Thailand and Malaysia, to pass substantive reforms of
subsidies that have long been burdensome to the state. These measures alone dampen
demand growth, as energy is used more efficiently when its price properly reflects its full
cost. There are also policy developments in oil stockpiling to enhance energy security. In
2017, Viet Nam approved a master plan to develop an oil and oil product reserve system,
aiming to hold 90 days’ worth of net imports by 2020. Indonesia is considering measures to
strengthen fuel reserve regulation for the private sector. Several policy options remain
open to governments where changes would help alleviate the dual issues of energy security
and rising energy import bills. These include the possibility of a more efficient allocation of
capital for both supply- and demand-side energy investments and establishing closer
linkages across Southeast Asia to optimise management of energy systems.
3.2.2  Environmental implications

Local air pollution

Rising incomes, population and levels of energy access in Southeast Asia propel energy demand growth to 2040. Annual growth of 2.1% in energy demand exceeds the global average, although it is lower than in recent years due to slower economic and population growth, a switch away from the traditional use of biomass and energy efficiency gains. While all fuels contribute to meet energy demand growth, coal is the largest contributor, driven by strong demand in the power sector, where coal overtakes natural gas to dominate the electricity mix. In the New Policies Scenario, Indonesia alone accounts for over 40% of total energy demand growth and of the increase in coal use. The share of the population relying on the use of fuelwood and charcoal for cooking in the buildings sector falls from almost 40% today to around 25% in 2040; but there are still more than 200 million people relying on the traditional use of solid biomass for cooking by 2040.

The projected robust rise in energy demand entails strong growth in sulfur dioxide (SO$_2$) and nitrous oxides (NO$_x$) emissions. SO$_2$ emissions grow by 40% over current levels, to 5.1 million tonnes (Mt) in 2040, driven by rising coal use in power generation, which accounts for 60% of total SO$_2$ emissions growth. NO$_x$ emissions rise by more than 50%, to 8.3 Mt in 2040, with two-thirds of the total growth attributable to increased coal use in the power sector and rising oil use in transport (where car ownership goes up from around 55 cars per 1,000 inhabitants today to more than 80 per 1,000 inhabitants in 2040). Although NO$_x$ emissions from the industry and power sectors grow faster, the transport sector remains by far the largest source of NO$_x$ emissions in 2040, contributing more than half of the total. Driven by less use of traditional fuelwood and charcoal for cooking, emissions of fine particulate matter (PM$_{2.5}$) decline slowly to around 2.2 Mt in 2040, 14% below current levels, but households remain the largest source of PM$_{2.5}$ emissions. Pollutant emissions in Southeast Asia take a tremendous toll on health: ambient air pollution is linked with over 300,000 premature deaths in 2040, a 70% increase from current levels, while an equal number of premature deaths are associated with high levels of household air pollution.

Climate change

All ASEAN member countries have ratified the Nationally Determined Contributions they submitted to the Conference of Parties in advance of the Paris meeting in 2015. Commitments vary from increasing the share of renewables in the energy mix to increasing forest cover, and generally countries accepted that they have a role to play in the global effort to reduce greenhouse-gas (GHG) emissions.

The challenge in Southeast Asia is stark. The region, particularly its vast coastal areas and thousands of islands, is particularly vulnerable to the effects of climate change and rising
sea levels. The region’s growing economies need to be supplied with increasing amounts of energy, and its people, not least those currently without electricity, need to be supplied with affordable and secure energy. These imperatives underpin a continued role for thermal power generation, including coal-fired power plants, in the Southeast Asian energy system in the New Policies Scenario.

The power sector is the largest GHG emitter in Southeast Asia, and accounts for 55% of the increase in total carbon-dioxide (CO₂) emissions from the region to 2040 (Figure 3.13). In this period, the emissions intensity of power generation decreases by almost one-fifth. This reflects both the growing share of generation from low-carbon sources, from about 18% of generation today to around 30% in 2040, and the use of more efficient coal generation technology, particularly the use of supercritical and ultra-supercritical plants. Over the Outlook period, the rate of growth in GHG emissions across the region is surpassed by the rate of economic growth, delivering an almost 40% decrease in the carbon intensity of GDP.

**Figure 3.13** Energy-related CO₂ emissions in Southeast Asia in the New Policies Scenario

Southeast Asia has considerable opportunities to recast its energy sector to make it more sustainable (see section 3.2.4). The region achieves far greater decarbonisation in the Sustainable Development Scenario, while meeting its energy access targets and improving air pollution. CO₂ emissions drop slightly despite a three-fold increase in the size of the economy in the period to 2040 (reflecting a two-thirds decrease in the CO₂ emissions intensity of economic output).
3.2.3 Investing for a more secure energy system

Investment is vital in both energy supply and demand to mitigate security of supply concerns and to transition to a more sustainable energy system. On the supply side, ongoing investment is required in the upstream to slow declines in oil and gas production in established areas like Indonesia and Malaysia, as well as to increase output in nascent ones such as Thailand, Viet Nam and Myanmar. For the power sector, robust economic growth and reaching universal access to electricity necessitates a step increase in the level of investment. On the demand side, investment in efficiency across the end-use sectors has the potential to significantly alter the demand outlook. In the New Policies Scenario, total cumulative investment in energy supply infrastructure amounts to $2.1 trillion, of which the power sector accounts for over half. The annual average investment requirement of around $90 billion corresponds to around 3% of the region’s total GDP in 2016.

Table 3.1 Cumulative investment in energy supply in Southeast Asia in the New Policies Scenario (2016 $billion)

<table>
<thead>
<tr>
<th></th>
<th>2017-2025</th>
<th>2026-2040</th>
<th>2017-2040</th>
<th>Annual average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil</td>
<td>146</td>
<td>206</td>
<td>352</td>
<td>15</td>
</tr>
<tr>
<td>Gas</td>
<td>120</td>
<td>303</td>
<td>423</td>
<td>18</td>
</tr>
<tr>
<td>Coal</td>
<td>14</td>
<td>25</td>
<td>39</td>
<td>2</td>
</tr>
<tr>
<td>Power</td>
<td>387</td>
<td>855</td>
<td>1,242</td>
<td>52</td>
</tr>
<tr>
<td>Fossil fuel</td>
<td>82</td>
<td>149</td>
<td>231</td>
<td>10</td>
</tr>
<tr>
<td>Nuclear</td>
<td>-</td>
<td>9</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>Hydropower</td>
<td>46</td>
<td>99</td>
<td>145</td>
<td>6</td>
</tr>
<tr>
<td>Bioenergy</td>
<td>11</td>
<td>21</td>
<td>32</td>
<td>1</td>
</tr>
<tr>
<td>Wind</td>
<td>9</td>
<td>34</td>
<td>44</td>
<td>2</td>
</tr>
<tr>
<td>Geothermal</td>
<td>7</td>
<td>10</td>
<td>17</td>
<td>1</td>
</tr>
<tr>
<td>Solar PV</td>
<td>26</td>
<td>62</td>
<td>88</td>
<td>4</td>
</tr>
<tr>
<td>T&amp;D</td>
<td>207</td>
<td>470</td>
<td>677</td>
<td>28</td>
</tr>
<tr>
<td>Biofuels</td>
<td>7</td>
<td>18</td>
<td>25</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total energy supply</strong></td>
<td><strong>674</strong></td>
<td><strong>1,407</strong></td>
<td><strong>2,081</strong></td>
<td><strong>87</strong></td>
</tr>
</tbody>
</table>

Note: T&D = transmission and distribution.

Investment in fossil-fuel production and related infrastructure makes up around 40% of total supply-side investment to 2040 in the New Policies Scenario, totalling around $800 billion (Figure 3.14). Of this, more than half is for natural gas, with around $100 billion required for pipelines and $30 billion for LNG facilities including for small floating regasification terminals to supply gas to island networks in Indonesia. Investment in oil infrastructure totals around $350 billion, a third of which is for refining, a significantly higher proportion than the global average of 10%. The relatively higher share for refineries reflects the need to expand capacity to meet increasing demand for oil products in the region.
On the oil and gas exploration side, efforts are also made by several governments in the region to encourage upstream investment, aiming to slow the hydrocarbon production decline. Measures include tax incentives and adding flexibility in regulatory frameworks. In 2016, Indonesia revised regulations on import duties and tax treatment during the exploration phase and the exemptions can be applied in the production phase if the project meets the economic criteria. In 2017, Thailand’s legislature approved changes to energy laws in order to broaden options beyond concessions such that companies can seek production sharing or service contracts with the government in order to attract more international energy firms and investors.

**Figure 3.14**  Cumulative investment in fossil-fuel supply in Southeast Asia in the New Policies Scenario to 2040

Among fossil fuels, natural gas requires the largest cumulative investment.

Securing sufficient investment to meet Southeast Asia’s projected electricity demand poses a major challenge. In the New Policies Scenario, the cumulative investment needed in the power sector to 2040 is $1.2 trillion, an annual average of around $50 billion (Figure 3.15). This corresponds to around 10% of total government revenue in Southeast Asia, or around 40% of total foreign direct investment in the region in 2015, illustrating the potentially large burden on government budgets if there is not meaningful private sector participation. Investment for transmission and distribution (T&D) accounts for over half of total power sector investment, reflecting the substantial need to strengthen the current network, as well as to extend grids for access and to meet rising demand in urban areas and to refurbish existing T&D lines. About $570 billion of investment is needed for new power plants, of which about 40% is for fossil-fuel plants and 60% for renewables-based generation. Cumulative investment for renewables-based power generation amounts to over $300 billion to 2040, of which around 45% is for hydropower and 40% for solar PV and wind.
Coal-fired power plants account for around 70% of the cumulative investment for fossil-fuel plants, reflecting their expansion in the region and relatively capital-intensive nature. Around 80% of the cumulative investment of coal-fired power plants, about $120 billion is directed towards supercritical or other advanced technologies\(^8\), leading to the overall efficiency of coal-fired plant fleet in the region to rise from 33% in 2015 to 38% in 2040.

**Figure 3.15** Cumulative investment in the power sector in Southeast Asia in the New Policies Scenario

In the power sector, investment in renewables surpass that of fossil fuels in Southeast Asia

Some Southeast Asian countries have relied heavily on IPPs to secure power supply, in part due to the limited availability of capital for such investments. In Indonesia, where traditionally the national utility, PLN, makes the necessary investments in power sector infrastructure, IPPs now account for the largest share of investment (Box 3.2). This trend is expected to continue, as Indonesia’s government plans to secure 70% of its additional power generation to 2034 through IPPs and surplus electricity from captive power plants owned by the private sector. Success of this approach depends largely on the nature of the off-take agreements that underpin the investment. As such, it is vital that the retail price of electricity fully reflects the cost of generating it.\(^9\)

Although private participation in power generation via IPPs is widely used in Southeast Asian countries, their role in power markets is in many cases limited. For example, private participation in retail power markets in the region is small. Only Singapore and the Philippines have introduced wholesale electricity markets where the private sector can sell electricity through competitive processes. There is room for Southeast Asian countries to

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\(^8\) Including ultra-supercritical coal plants and integrated gasification combined-cycle plants.

\(^9\) Though this should not preclude measures needed to finance electricity access projects that would otherwise not be commercially viable.
allow private sector participants to expand their role in power markets, which would help attract the needed investments. Various regulatory reforms, including electricity market deregulation, liberalisation of electricity pricing and the phase out of subsidies are essential elements to promote private investment in the power sector.

In the New Policies Scenario, demand-side investment makes up around almost a quarter of total cumulative energy sector investment to 2040. These investments, mostly in energy efficiency technologies, are strongly geared towards road transport (around $330 billion) and buildings (around $180 billion), helped by incentive schemes such as tax breaks for more fuel efficient vehicles and soft loans for efficiency measures in buildings.

**Box 3.2 Lessons from Indonesia’s Fast Track and 35 GW Power programmes**

Rapid expansion of the electricity sector is critical to support Indonesia’s economic development and to expand electricity access. Recognising that the state utility, PLN, alone would not be able to meet the necessary investments, the Indonesian government implemented the Fast Track Programmes I and II (FTP I and II) and the 35 GW Power Programme. These initiatives facilitate private sector participation in power generation through IPPs and public-private partnerships (PPP). PLN remains the sole purchaser for the electricity produced.

As of June 2017, progress on the current 35 GW Power Programme has been slower than planned with 23.5 GW contracted (0.8 GW operating; 14.2 GW constructed and 8.5 GW contracted but not yet constructed) and 12.4 GW in the procurement and planning phase. Of the 35 GW target by 2019, PLN is responsible for about 11 GW and IPPs are expected to build 24 GW. Projects developed by IPPs have a much higher progress rate with 74% already contracted (2% operating; 37% constructed; and 35% not yet constructed) compared to less than half of the PLN portion. The government recently announced that completion would likely be delayed until 2025.

Created in 2009 to accelerate infrastructure development in Indonesia and to support implementation of PPP schemes, PT SMI, an infrastructure financing company fully owned by the government, provides equity and long-term debt financing, as well as project development and advisory services. As of April 2017, PT SMI had helped to secure financing for over 1.5 GW of additional power generation capacity and provided electricity access to more than 1.7 million households (6.7 million people) (SMI, 2017).

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10 The Fast Track Programme I started in 2006 and FTP II in 2009 aimed to add 8.75 GW and 17.9 GW of new generation capacity by 2010 (later delayed to 2015) and 2016 (still under development). The current 35 GW Power Programme, started in 2015, aims to add 35 GW by 2019 to reach a total installed capacity of more than 110 GW.

11 While the definition for IPP and PPP are effectively the same where both schemes involve private sector arrangements for delivery of power, in the Indonesian context, a project is considered as a PPP if a government guarantee is required to raise adequate financing.
While the bulk of the electricity projects financed by PT SMI have been for coal- and gas-fired generation, the company is also actively seeking opportunities to finance renewable energy projects and to date has financed 248 MW of mini-hydro and hydro projects. Seeking to access alternative sources of funding for green infrastructure, in 2016, PT SMI became the first and only national institution from Southeast Asia to be accredited with the Green Climate Fund.12

Another important institution created to attract private sector investment is the Indonesia Infrastructure Guarantee Fund (IIGF). Created in 2009, it provides guarantees that are backed by Indonesia’s Ministry of Finance. IIGF, with authorised capital of Indonesian rupiah 9 trillion ($1 billion), provides a single window for project developers of PPP projects for submission, appraisal and approval of guarantees. Its main function is to enhance transparency and accountability in the provision of government guarantees by applying international standards for due diligence in assessing regulatory risks of PPP projects. Government guarantees are crucial to the bankability of projects that are considered high risk due to either their size or where new technology is used.

The government also has established the Viability Gap Fund (VGF) to reduce the investment cost of projects with high project development and construction costs or low returns (i.e. electricity access). For example, the VGF’s Geothermal Revolving Fund is where the private sector can access dedicated funds, which are repaid when the project starts commercial operations.

Lessons learned from the implementation of FTP I and II led to a number of new regulations in 2015 that help to address regulatory issues. In particular, on land acquisition and rights, which have been leading causes of project delays. Enhanced co-ordination between various government institutions, establishment of “One Stop Service of Permitting” at the Investment Coordinating Board Agency and accelerated government approval procedures for business applications have also facilitated project development.

Given the magnitude of investment needs for the power sector in countries such as Indonesia, international financial markets play a vital role. Yet the global financial crisis in 2008 highlighted the risks of dependence on international financial markets (with escalating project costs denominated in foreign currency) and the importance of the availability of local financing (as witnessed in China’s impressive power sector build out), and in particular local long-term debt instruments to support power sector expansion.

Indonesia’s experience in attracting private sector financing has important lessons for other Southeast Asian countries that adopt a similar single-buyer electricity market model. An evaluation of 56 power projects implemented mainly as part of the FTP I

12 The GCF was set up under the framework of the United Nations Framework Convention on Climate Change to assist climate adaptation and mitigation practices in developing countries.
and II and early projects under the 35 GW programme, found that projects under PPPs versus traditional utility procurement demonstrated superior results in terms of both time and performance (Figure 3.16). On average, no significant cost differences were observed between PPPs and traditional procurement projects nationwide. But, as opposed to less-developed areas, the Java-Bali region had better cost performance because it has larger projects and a higher share of industrial consumers that tended to attract more experienced project sponsors.

**Figure 3.16**  Project costs and completion times for PPP and PLN power projects in Indonesia

PPP projects have fared considerably better in terms of cost performance and completion times (Atmo et al. 2017).

Both traditional procurement and PPP projects experienced delays, (85% for traditional procurement versus 54% for PPPs) (Atmo et al. 2017). PPP projects showed significantly higher availability factors linked to operating performance and service payments in the contractual arrangements. Experienced project developers, particularly foreign developers, tended to favour clean energy technologies such as renewables and highly efficient combustion technologies, helping to accelerate deployment and technology transfer.

PPP projects tend to be located in the high demand regions of Java, Bali and Sumatra, while projects allocated for PLN development are in less-developed regions such as eastern Indonesia and are generally associated with electricity access programmes. Export credit agency funding has played an important role in accessing affordable credit for foreign developers. In general, most PPP projects have been financed through 30% equity and 70% debt; many have been funded without the need for government guarantees as the project economics were sufficiently attractive to secure financing. In contrast, projects developed by PLN may not meet cost recovery requirements and...
hence require support to finance them from the government, and multilateral and bilateral development institutions. PLN’s ability to raise debt is currently limited due to existing covenants linked to outstanding liabilities and the company has trouble raising finance in a timely manner, which has also led to project completion delays. As a state-owned enterprise, PLN is also subject to cumbersome administrative procedures that have led to financing difficulties and slowed progress on PLN’s generation projects.

Indonesia’s experience shows that institutional arrangements to facilitate infrastructure investments including dedicated funding and government guarantees played an important role in creating bankable projects that attracted private investors. Project performance was better with experienced project developers and with contractual arrangements that linked operational performance with payment. Other lessons include the need for means to manage regulatory risks and the availability of local debt financing in order to realise ambitious power sector developments.

### 3.2.4 Investment needs for a more sustainable energy path

The path towards a more sustainable energy future for Southeast Asia in which countries move towards decarbonising their energy systems while at the same time improving air quality for all, requires a notable increase in the amount of investment and a fundamental shift in its direction (Figure 3.17). An additional $300 billion of cumulative energy supply and efficiency investment is needed in the period to 2040 in our Sustainable Development Scenario relative to the New Policies Scenario, and is directed away from oil, gas and coal production (where investment falls by around 30% compared to the New Policies Scenario), and towards efficiency (+50%) and the power sector (+20%). The fuel mix for power generation shifts with renewables accounting for more than 60% of total generation by 2040, compared with 30% in the New Policies Scenario, as increased deployment of wind, solar PV, geothermal and hydropower displace the share of coal, which falls to 6% compared with 40% in the New Policies Scenario. Variable renewables account for one-quarter of total electricity production in Southeast Asia in 2040 in the Sustainable Development Scenario. This penetration level requires not just large-scale grid expansion and the deployment of flexible electricity supply technologies, but also additional integration measures such as storage and demand-management options (through either load shifting or load shedding). Efficiency gains across the board imply that electricity demand is 8% lower in the Sustainable Development Scenario than in the New Policies Scenario, but the power generation fleet is almost 20% larger (an additional 110 GW). This is necessary to account for lower capacity factors of some renewable capacity and the need for additional dispatchable generation to integrate higher shares of wind and solar PV (each accounting for 12% of electricity generation).

13 Issues associated with variable renewables integration were explored in depth in World Energy Outlook-2016 (IEA, 2016).
The change in investment emphasis in the Sustainable Development Scenario and the fundamental reorganisation of the energy system that this brings significantly reduces energy-related GHG emissions in Southeast Asia. In this scenario, GHG emissions peak around the mid-2020s, then begin to fall, and are almost half the level in the New Policies Scenario in 2040.

Associated with the fundamental shift in the way energy is produced and how much more efficiently it is used in the Sustainable Development Scenario is the impact on energy security (Figure 3.18). In this scenario, electrification and increased fuel-economy standards have a profound impact on transport, with the consequent fall in oil used in road transport leading to an overall 20% decrease in oil demand compared with the New Policies Scenario (in the Sustainable Development Scenario, oil demand peaks by 2030). This is reflected in a one-quarter reduction in oil imports by 2040, and along with around 50% decrease in natural gas imports, amounts to around $175 billion per year savings on fossil-fuel imports in 2040. The average annual fuel import savings is several times larger than the $14 billion per year increase required to move Southeast Asia from the New Policies Scenario to the Sustainable Development Scenario trajectory.
Figure 3.18  Comparison of selected energy indicators in the Sustainable Development and New Policies Scenarios, 2040

<table>
<thead>
<tr>
<th>Indicator</th>
<th>NPS</th>
<th>SDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final energy consumption</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon intensity of power generation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy import bill</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The Sustainable Development Scenario decreases energy import dependency and lowers the energy import bill

Note: PG = power generation; NPS = New Policies Scenario; SDS = Sustainable Development Scenario; g CO₂/kWh = grammes of carbon dioxide per kilowatt-hour.

Energy efficiency – a key element for cleaner transition and security

The transition associated with the Sustainable Development Scenario indicates that a considerable amount of energy savings potential remains even compared to the gains achieved in the New Policies Scenario. Total final energy consumption in the Sustainable Development Scenario is around 20% lower, although the same economic and population growth assumptions are applied in both scenarios. As shown in Chapter 2, Southeast Asian countries have made efforts to improve efficiency in end-use sectors through measures such as labelling programmes and incentives to purchase efficient vehicles. Such initiatives have been pursued to varying degrees: energy efficiency strategies are completely lacking in several countries, while others have introduced energy efficiency labelling for only a very limited number of products. The share of energy consumption in end-use sectors covered by efficiency measures in Southeast Asia is lower than the global average (Figure 3.19).

On the other hand, awareness of the value of efficiency gains, from consumer and from policy-maker perspectives, has been increasing. Many countries now realise the potential for efficiency to reduce subsidy burdens on budgets and to relieve strains on the energy system in general — including environmental and energy security concerns. This becomes
increasingly important in our Outlook, as declining oil production and rising demand heightens policy-makers’ concerns of the challenges associated with increasing import dependency, increased energy import bills and increased capital requirements to invest in energy supply. Efficiency measures also offer benefits in alleviating some air pollution issues, which are affecting quality of life in urban areas across the region.

Figure 3.19 ➔ Share of energy consumption in end-use sectors covered by energy efficiency regulation in Southeast Asia, 2016

Coverage of energy efficiency regulation in Southeast Asia is lower than the global average

Sources: Analysis based on energy data from: IEA (2017b); IEA (2017c); IEA (2016). Policy data based on: IEA (2017d); CLASP (2017); EES and Maia Consulting (2014); IEA 4E-TCP (2016-2017); IIP (2017); BCAP (2017); GBPN (2017); Odysee-Mure (2017); Siemens (2015) and ICCT (2017).

In the Sustainable Development Scenario, the switch from traditional biomass to liquefied petroleum gas (LPG), natural gas and electricity in households to achieve universal electricity access by 2030 increases energy service demand relative to the New Policies Scenario, but efficiency measures such as mandatory labelling systems for a broad range of appliances more than offset the demand increase, together with the savings from the fuel switching (Figure 3.20). In the transport sector, electric vehicles are more widely purchased, leading to some energy savings, but broader adoption of efficiency measures such as fuel-economy standards adopted across the region also play a role in saving energy. In industry, bioenergy use rises marginally, which leads to a slight increase in energy consumption, but efficiency measures such as energy management systems and audits bring about substantial savings relative to the New Policies Scenario. The net impact of increased efficiency in the Sustainable Development Scenario vis-à-vis the New Policies Scenario is a 14% decrease in overall energy consumption. All end-use sectors contribute, though the industry sector accounts for about half of the efficiency gains.
3.2.5 Energy systems interconnection to bolster energy security

Prospects for power systems interconnection

Increasing energy connectivity among the Southeast Asian countries has been a fundamental goal for decades. While these long-standing objectives cover a number of areas, key among the infrastructure aims is to increase the level of electricity interconnection. To this end, in 1997, the countries agreed to develop the ASEAN Power Grid (APG) to play a number of roles, including: increasing energy security by connecting countries with surplus power to those with a deficit and optimising resource sharing between countries so that peaking plants are used communally (where countries have different demand profiles). A further benefit of grid interconnection is to improve the economics of power system development, allowing for the more efficient development of large-scale power system infrastructure and making it easier for countries to increase access to electricity. In several low-income countries that have large, untapped renewable energy resources, particularly large hydropower, there is insufficient demand in the proximity to justify development; interconnection could expand the service area sufficiently to underpin development. In others, interconnection could help manage variability issues in the power system. For example, Viet Nam with its significant wind potential could benefit by leveraging hydro resources in Lao PDR to balance the variability of wind generation.

Today there are nine cross-border interconnections with a combined capacity of 5,200 MW (Hermawanto, 2016). They connect: Malaysia and Singapore; Malaysia and Thailand; Malaysia and Indonesia; Lao PDR and Thailand; Lao PDR and Viet Nam; and Viet Nam and...
Cambodia. Notably, most of these interconnections are in the northern region, except for the one that connects Malaysia’s Sarawak region to Indonesia’s West Kalimantan and the one connecting Malaysia to Singapore. One of the most well established examples of a regional multilateral power exchange exists in the Greater Mekong Sub-region, which links the northern region to the southern Chinese provinces of Yunnan and Guangxi. It has eight cross-border interconnections with a combined capacity of 3,215 MW (Nai, 2015). Another model for APG power trade is outlined in an agreement announced in 2017 between Lao PDR, Thailand and Malaysia with plans for Malaysia to import 100 MW of power from Lao PDR by 2018, wheeled through existing interconnections in Thailand to minimise costs.

Since it was conceived in the late 1990s, development of the APG has proceeded in a piecemeal fashion. Although a number of interconnections have been developed and the overall level of interconnection has increased, they have been built exclusively on a bilateral basis, using a number of business models. Little progress has been made on the establishment of a regional (or even sub-regional) multilateral power market. Trading is generally driven by concerns over domestic resource availability or a desire to increase the diversity of the generating fleet. It is mostly done on the basis of an agreement between utilities, in which they jointly develop cross-border infrastructure and establish an operating plan. Often these trades are on a non-economic basis, with no price associated with the power exchange and instead power flows are netted out to zero over time. This is the model employed by Singapore and Malaysia. Another model is a direct power purchase from a generator, usually an IPP, located near a national border wherein the importing utility may co-ordinate with the exporting utility, but it is also possible for an IPP to be directly connected to the importing country’s network. This approach has been used to a notable degree by Thailand to import hydropower from IPPs in Lao PDR.

**Moving forward towards a more interconnected electricity market**

The ASEAN Power Utilities Authority (HAPUA), which is responsible for developing the APG, has identified three regional priorities for interconnections: the northern region, which includes five ASEAN countries (Cambodia, Lao PDR, Myanmar, Thailand and Vietnam); the southern region, which includes peninsular Malaysia, Singapore and most of Indonesia; and the eastern region, which includes Malaysian Borneo, Indonesian Borneo, Brunei Darussalam and the Philippines.

Although power network interconnection is a stated objective of policy-makers across Southeast Asia, a concrete plan laying out the steps to achieve this aim has not been developed. Instead, countries agree on general principles of the need to harmonise regulatory frameworks and standards, and on two broad strategies. The first, outlined in the master plan, states that HAPUA will work to accelerate the development of three priority APG projects: Lao PDR and Cambodia; Sarawak and Brunei Darussalam; and the Melaka–Pekan Baru Interconnection (connecting peninsular Malaysia to Sumatra,

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14 Power interconnection features prominently in the “Masterplan on ASEAN Connectivity in 2025” and the “ASEAN Plan of Action for Energy Cooperation (APAEC) 2016-2025”.

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Indonesia). The second strategy states that HAPUA will establish a pilot multilateral trade among three or more Southeast Asian countries. To this end, a Special Task Force has been established and it is to develop a feasibility study to determine whether and how a multilateral trade arrangement might be established. The proposed Laos-Thailand-Malaysia power trade is the most likely candidate for this pilot, though other projects may be considered.

**Figure 3.21**  ASEAN power grid plans

Power network interconnections help Southeast Asia to enhance security, as well as to tap renewable resources

Source: Ibrahim (2016).

One important item not highlighted in the ASEAN Plan of Action for Energy Cooperation is the need to strengthen the role of regional institutions. HAPUA, for example, has been given a broad mandate for supporting development of the APG and of the multilateral trade pilot, but it has a relatively small number of staff and limited resources. It also has
limited ability to influence the development of regulations. The most relevant institution in that regard is the ASEAN Energy Regulators Network, but it has no mandate or staff. Establishing a regulators network secretariat and giving it a mandate to work with national regulators on harmonising regulations while respecting national sovereignty would be a positive step towards supporting regional grid interconnection.

Prospects for greater natural gas integration

The role of gas in meeting growing energy demand in Southeast Asia and its increasing role in the Sustainable Development Scenario as an important source of flexibility in the power sector is highlighted in Chapter 2. Over the period to 2040, the natural gas production and demand picture changes considerably; Thailand and Malaysia are likely to see declining production and increasing imports, while Indonesia and Myanmar see increasing production, but also a doubling of demand. The region as a whole moves from being a large net exporter of over 50 billion cubic metres (bcm) (by pipeline and LNG) to a net importer as soon as 2025, with almost one-quarter of demand imported (over 60 bcm) in 2040 in the New Policies Scenario. Moreover, gas import bills are expected to reach around $26 billion in 2040, compared with a trade surplus of $14 billion in 2016. Even these figures do not convey the true size of gas trade, since it is likely that inter-country and intra-regional trade will also grow. These demand and trade projections highlight potential security and affordability issues with respect to Southeast Asian gas supplies in the period to 2040.

The experience of natural gas disruptions among IEA member countries, for example in the United States in 2005 and in Europe in 2006 and 2009, highlighted a number of lessons. A key factor in coping with breakdowns in supply is a widespread network of delivery infrastructure that is flexible (i.e. gas can be routed via various pathways and pipelines can be reversed). Flexible markets, supported by harmonised regulation across wide geographic areas, are also important. The United States showed an ability to move gas quickly and directed reduced supplies to the highest value users, sustaining supply in the face of dramatically reduced production. In Europe, in areas where gas supplies could be delivered through extra LNG deliveries or storage drawdown, supply security was maintained. Where infrastructure was based on one or two pipelines, supply security suffered.

The lessons for Southeast Asia are clear. As gas imports rise, better interconnections of pipeline networks, analogous to the discussion on electricity networks, both within and between countries, offers the possibility of much improved supply security. For this to be realised, market flexibility would also need to improve markedly, to help establish effective incentives for investment in infrastructure. Today there are thirteen bilateral pipeline interconnections in the region, in addition to a major export line from Myanmar to China. Southeast Asia also has five major LNG production facilities, plus a number of LNG import facilities, notably in Thailand, but also peninsular Malaysia, Singapore and West Java. The region has the ability to utilise the rapidly evolving technology of floating liquefaction and regasification units to complement pipeline enhancements, particularly among islands (see section 3.1). Four such facilities currently are being built and more are planned as they can
deliver affordable, fast and flexible liquefaction and regasification to small and hard-to-reach markets. Malaysia recently brought the world’s first floating LNG production unit online.

Southeast Asia is well endowed with natural gas resources. Pipeline and LNG facilities exist, however, they do not resemble the depth and flexibility of the IEA regions noted above, nor do market and trading come close to the levels commensurate with Southeast Asia’s needs. For example, third-party access, a key determinant of flexibility (and indeed contestability, to ensure prices are determined by markets) is almost entirely absent from Southeast Asia (though Thailand is in the process of liberalising its gas market, including third-party access). The type of transparent hub-based trading, seen for example in North America and Europe, is almost completely lacking in the Asia-Pacific region, although a number of attempts are being made to establish such hubs (Spotlight). Hub-based trading offers significant energy security advantages in the event of supply disruption or even a sudden upsurge in demand, for example in the power sector. In addition, it benefits important price discovery functions to ensure the most affordable prices, particularly as global gas markets look to be in oversupply into the medium term. So far, however, Southeast Asian gas markets rely on oil-indexed prices.

For these reasons, interest in a Trans ASEAN Gas Pipeline (TAGP) to establish multilateral pipeline interconnections is strong. The project has been entrusted to the association of national oil companies (ASCOPE) in the Southeast Asia region. Where countries have no national oil company, the government authority in charge of petroleum issues is represented. Petronas Nasional Berhad (PETRONAS), Malaysia’s fully integrated oil and gas multinational company, is the lead agency. Its Peninsular Gas System, which links to Thailand, and a joint development area between the two countries, would likely form the spine of a TAGP. Since 2012, the project has also recognised the potential role of LNG, notably for those areas where undersea pipelines may prove impractical. The option of using an LNG import terminal to supply a local pipeline network is also being studied. The barriers to advancing this project are important, and include:

- Harmonising technical issues, such as gas quality rules. For example, Singapore allows only 5% CO₂, while Thailand allows 13%.
- Unifying market structures, pricing and some subsidies, which currently differ across the region. Vertically integrated monopolies in some countries contrast with freer trade in others.
- Producing a multilateral pipeline system from a number of existing bilateral systems.
- Creating and harmonising a flexible third-party access code across the region, considered crucial for a fully functioning network. Countries in Southeast Asia have varying hydrocarbon production and leasing arrangements, which have evolved over many decades and present significant obstacles to TAGP.
Chapter 3 | Addressing Southeast Asia’s energy priorities

Development of a gas hub in Singapore

Hub-based trading has become a feature of gas markets in North America, the United Kingdom and increasingly in Europe. Such hubs provide a focus for physical gas trading, leading to more accurate price discovery through publicly available price reporting, backed by robust governance and regulation to improve confidence. Such indices allow more advanced trading forms such as swaps, derivatives and futures, enabling risk to be better managed (for example, by allowing producers to lock in certain price levels, thus facilitating production investment, or buyers to purchase gas for a set time period and price). Disruptions to supply and demand can be met by rapid adjustments, thus enhancing security of supply and affordability. Successful hubs have a high degree of liquidity, at both physical and financial levels, numerous buyers, sellers and intermediaries, including strong financial players, access for all participants to essential transport and storage infrastructure, and low transaction costs, through standardised contracts and dispute resolution procedures. Government price controls and other types of regulatory interventions must be absent, except those facilitating hub trading, notably rules enforcing access to infrastructure, so called open access.

Gas trading in the broad Asia-Pacific region lacks this style of transparent hub trading. The Asia-Pacific’s geographic diversity and relatively high dependence on LNG for gas supply, where oil linked pricing and rigid destination clauses persist, (at least for the medium term) and transparency is low, have made flexible trading and more accurate price discovery difficult. Nonetheless, several centres are being advanced as a basis for hub-based trading in the region, including Singapore.

Singapore has made important moves towards liberalising its gas market, providing the basis for more competitive price setting. These moves include creating a well-functioning domestic market for gas and greater transparency. A spot market for local use of gas is being created, including secondary markets for gas consumers, and third-party access to facilities such as gas storage is also under development. These moves put Singapore ahead of most countries in the Asia-Pacific region in terms of progress towards conditions that might enable a hub-style market to develop.

Looking at the role of Singapore in the oil market, its refining capacity of around 1.5 million barrels per day, its position astride major oil trade routes and relatively high levels of transparency have given Singapore a prominent position as far as price discovery is concerned. A strong regulatory regime and a large financial sector also underpin its position. This is especially so for oil product prices, such as gasoline, where no other comparable markers exists in the Asia-Pacific region. For these reasons, Singapore has become a major trading hub for oil and other commodities. But can it duplicate this approach for LNG or gas more widely?

Gas demand in Singapore has risen rapidly to 12 bcm, of which almost 90% is for power generation. With no production, imports come chiefly by pipeline from Indonesia

SPOTLIGHT

Development of a gas hub in Singapore

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(7.4 bcm), Malaysia (1.4 bcm) and as LNG from Qatar, Trinidad and Tobago, and Equatorial Guinea. LNG storage capacity, at around 540 000 cubic metres appears large, but is very small relative to the region’s gas markets. While a substantial portion of LNG shipping passes nearby, (as much as half of current global LNG cargoes), the small size of the Singapore gas market, and that for LNG, may make it much harder to duplicate the trading success of Singapore with respect to oil for LNG. Its distance from the major markets of Japan, Korea and increasingly China may further militate against successful trading hub development, given higher transport costs for LNG relative to oil. Singapore is promoting itself as a site for bunkering and trans-shipment of LNG cargoes, for example to smaller isolated power facilities, a role it would appear well placed to assume. This will help offset some of the drawbacks noted above.

Nonetheless, dating from late 2014, LNG pricing indices have been created by SGX (the Singapore Exchange) and its subsidiary EMC (the Energy Market Company, operating as an exchange for wholesale electricity trade in Singapore). Two such indices have been created, known as the Singapore LNG Index Group, or SLing. The first is designed to reflect the spot price of LNG cargoes in the vicinity of Singapore, as a proxy for southern Asian seaborne LNG. The second is designed to reflect the price of delivered bulk LNG cargoes (135 000 - 175 000 cubic metres) in North Asia (Japan, Korea, Chinese Taipei and China). These assessments are based on regular input from 50 reporting entities, including oil and gas majors, LNG or gas producers, plus LNG importers and traders: the latter group dominate. A third index, designed to reflect South Asian prices (the Dubai/Kuwait/India or DKI SLing) has been developed more recently. Indices are published twice weekly. Despite the relatively small number of participating entities, the standard deviation of indices has continued to fall, indicating probable growing convergence and robustness of the indices. The index does not depend on cargoes actually being landed in Singapore, so does not represent a physical market.

These indices certainly provide some visibility on LNG trade in the Asia-Pacific region. However, the extent that these indices are used in trading, price setting or contracting remains to be seen. Furthermore, hopes that SLing swaps and derivatives trading might be introduced as next steps in hub trading, remain subject to regulatory approval. For such a trade to succeed, the market must first acknowledge the value of the indices, and be prepared to adopt them in hedging, risk management and futures trading. Based on experience elsewhere, these will take some time to emerge, develop and be widely adopted.
General note to the tables

The tables detail projections for fossil-fuel production, energy demand, gross electricity generation and electrical capacity, and carbon-dioxide (CO₂) emissions from fossil-fuel combustion in the New Policies, Current Policies and Sustainable Development Scenarios in ASEAN member countries, which include Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, the Philippines, Singapore, Thailand and Viet Nam. By convention, in the table headings CPS and SDS refers to the Current Policies and Sustainable Development Scenarios respectively.

Data for fossil-fuel production, energy demand, gross electricity generation and CO₂ emissions from fuel combustion up to 2015 are based on IEA statistics, (www.iea.org/statistics) published in World Energy Balances, CO₂ Emissions from Fuel Combustion and the IEA Monthly Oil Data Service. Historical data for gross electrical capacity are drawn from the Platts World Electric Power Plants Database (April 2017 version) and the International Atomic Energy Agency PRIS database (www.iaea.org/pris). The formal base year for this year’s projections is 2015, as this is the last year for which a complete picture of energy demand and supply is in place. However, we have used more recent data wherever available, and we include – for the first time – our 2016 estimates (2016e) for energy production and consumption in this annex. Estimates for the year 2016 are derived from a number of sources, including latest monthly data submissions to the Energy Data Center, other statistical releases from national administrations and most recent market data also used in IEA Medium-Term Market Reports for coal, oil, gas and renewables.

Both in the text of this book and in the tables, rounding may lead to minor differences between totals and the sum of their individual components. Growth rates are calculated on a compound average annual basis and are marked “n.a.” when the base year is zero or the value exceeds 200%. Nil values are marked “-“.

Definitional note to the tables

Total primary energy demand (TPED) is equivalent to power generation plus other energy sector excluding electricity and heat, plus total final consumption (TFC) excluding electricity and heat. TPED does not include ambient heat from heat pumps or electricity trade. Sectors comprising TFC include industry, transport, buildings (residential, services and non-specified other) and other (agriculture and non-energy use). Projected gross electrical capacity is the sum of existing capacity and additions, less retirements.

Total CO₂ includes emissions from other energy sector in addition to the power generation and TFC sectors shown in the tables. CO₂ emissions and energy demand from international marine and aviation bunkers are included only at the world transport level. Gas use in international bunkers is not itemised separately. CO₂ emissions do not include emissions from industrial waste and non-renewable municipal waste. For more information please visit: www.iea.org/statistics/topics/CO2emissions.
### Southeast Asia: New Policies Scenario

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### Southeast Asia: Current Policies and Sustainable Development Scenarios

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**Petrochem. feedstock**

- **Annex A** | Southeast Asia projections | 135
## Southeast Asia: New Policies Scenario

### Electricity generation (TWh)

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## Southeast Asia: Current Policies and Sustainable Development Scenarios

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## Annex A | Southeast Asia projections
## Units and conversion factors

This annex provides general information on units, and conversion factors for energy.

### Units

<table>
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<tr>
<th>Energy</th>
<th>Coal</th>
<th>Emissions</th>
<th>Gas</th>
<th>Mass</th>
<th>Monetary</th>
<th>Oil</th>
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<td>Mtoe</td>
<td>Mtce</td>
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<td>bcm</td>
<td>kg</td>
<td>$ million</td>
<td>b/d</td>
<td>kW</td>
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<td>million tonnes of oil equivalent</td>
<td>million tonnes of coal equivalent (equals 0.7 Mtoe)</td>
<td>parts per million (by volume)</td>
<td>billion cubic metres</td>
<td>kilogramme (1 000 kg = 1 tonne)</td>
<td>1 US dollar x 10^6</td>
<td>barrel per day</td>
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<td>MBtu</td>
<td>Mtoe</td>
<td>Gt CO2-eq</td>
<td>bcm</td>
<td>kg</td>
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<td>mb/d</td>
<td>MW</td>
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<td>million British thermal units</td>
<td>gigatonnes of carbon-dioxide equivalent (using 100-year global warming potentials for different greenhouse gases)</td>
<td></td>
<td>billion cubic metres</td>
<td>kilogramme (1 000 kg = 1 tonne)</td>
<td>1 US dollar x 10^9</td>
<td>million barrels per day</td>
<td>megawatt (1 watt x 10^6)</td>
</tr>
<tr>
<td>Gcal</td>
<td>Mtce</td>
<td>ppm</td>
<td>bcm</td>
<td>kg</td>
<td>$ trillion</td>
<td>b/d</td>
<td>GW</td>
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<td>bcm</td>
<td>kg</td>
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<td>1 US dollar x 10^6</td>
<td>barrel per day</td>
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### Annex B | Units and conversion factors
## Energy conversions

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<th>Gcal</th>
<th>Mtoe</th>
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<th>GWh</th>
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<td>TJ</td>
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<td>MBtu</td>
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<td>8.6 x 10^-5</td>
<td>3 412</td>
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Chapter 1: Energy in Southeast Asia today


McCoy Power Reports (2017), Dataset, McCoy Power Reports, Richmond, VA, United States.


– (2015a), Myanmar Investment Climate Assessment, World Bank, Washington, DC.


– (2013), Turn Down the Heat: Climate Extremes, Regional Impacts and the Case for Resilience, World Bank, Washington, DC.

**Chapter 2: Southeast Asia’s energy prospects to 2040**


BGR (German Federal Institute for Geosciences and Natural Resources) (2015), Energiestudie 2015, Reserven, Ressourcen und Verfügbarkeit von Energierohstoffen, (Energy Study 2015, Reserves, Resources and Availability of Energy Resources), BGR, Hannover, Germany.


McCoy Power Reports (2017), Dataset, McCoy Power Reports, Richmond, VA, United States.

OGJ (Oil and Gas Journal) (2015), Reserves Grow Modestly as Crude Oil Production Climbs, OGJ 113 (12), Pennwell Corporation, Oklahoma City, OK, United States.


Chapter 3: Addressing Southeast Asia’s energy priorities


The ten Association of Southeast Asian Nations (ASEAN) countries are among the most dynamic parts of the global energy system and a rising force in international energy affairs. Thanks to its growing partnership with Southeast Asia, the International Energy Agency (IEA) has conducted regular in-depth studies of the energy challenges facing this region. This new report, which was prepared as part of the IEA’s flagship World Energy Outlook series, provides insights for policy makers, industry and other energy stakeholders to help address the energy sector challenges facing Southeast Asia today.

The report highlights:

- The state of play across the Southeast Asia’s energy sector, based on the latest data and announcements.
- How today’s policies shape this region’s energy demand and supply outlook to 2040, and the implications for energy security, the environment and development.
- The opportunities that broader changes in global markets and low-carbon technologies open up for Southeast Asia.
- The investment required to improve efficiency and expand energy supply infrastructure, especially in the electricity sector.
- The mix of fuels and technologies that can help Southeast Asia achieve universal electricity access.
- An alternative pathway, the Sustainable Development Scenario, to meet energy security and environmental goals.