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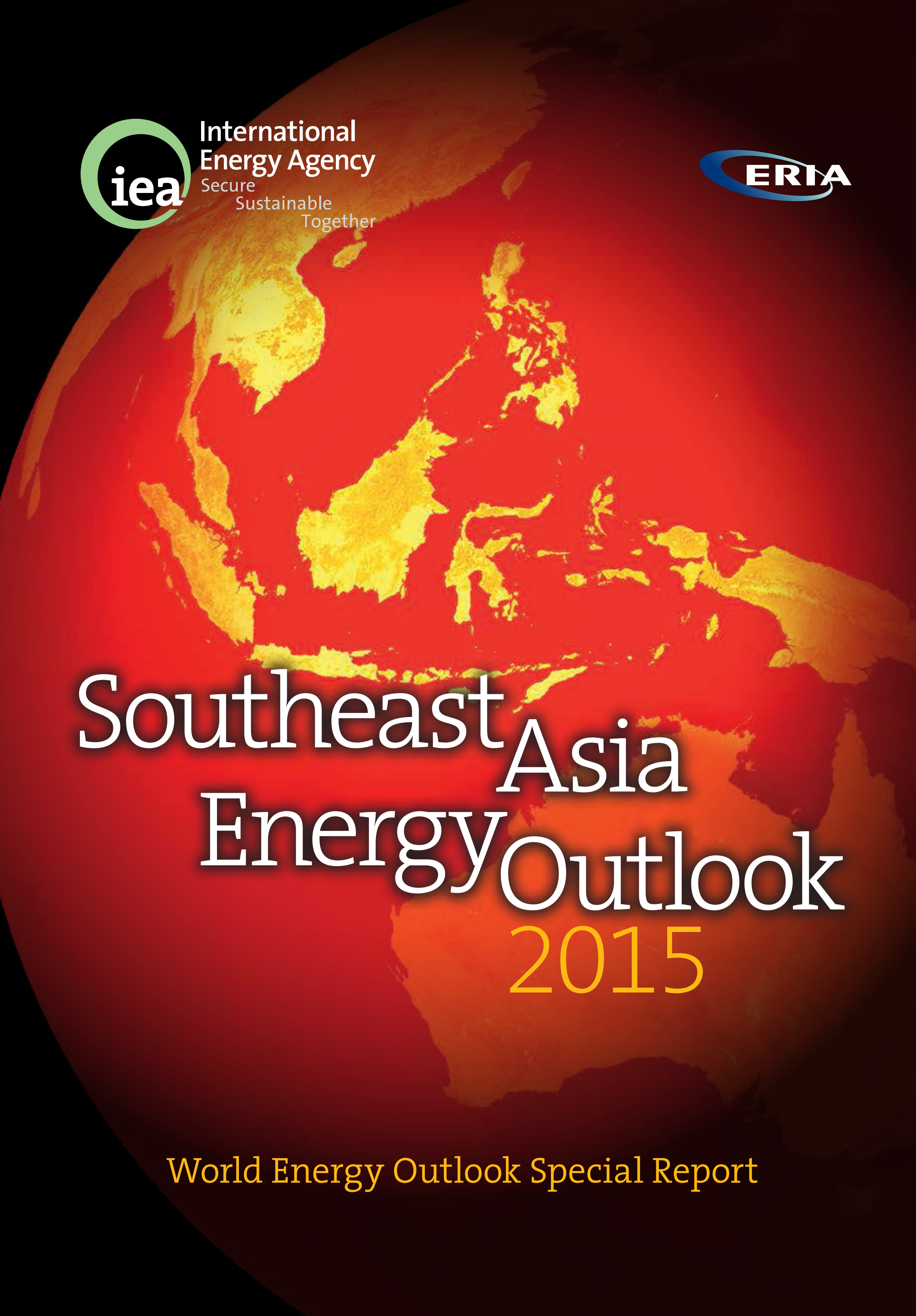

Southeast Asia Energy Outlook 2015

World Energy Outlook Special Report

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INTERNATIONAL ENERGY AGENCY

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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Southeast Asia is moving to the centre of the global energy arena, a trend that is underpinned by economic and demographic drivers, and that is set to continue for the foreseeable future. As the region's importance grows, so too do the challenges and opportunities that are linked to its development. Chief among those are meeting its increasing energy needs in a secure and sustainable manner; continuing to expand modern energy services for those that lack access; encouraging the adoption of energy-efficient practices; and limiting the rise of greenhouse-gas emissions, especially given the expanding role of coal in its energy mix.

The International Energy Agency has long recognised the vitality of this region – indeed, this report marks the *World Energy Outlook's* third in-depth study on Southeast Asia in six years. *Southeast Asia Energy Outlook 2015* is the second collaborative effort between the IEA and the Economic Research Institute for ASEAN and East Asia (ERIA) in response to a request from ministers at the 7th East Asia Summit Energy in Bali, Indonesia in 2013. Throughout the process, the report benefited from valuable input from experts across the region, including – for the special focus on Malaysia – the Prime Minister's Department and Ministry of Energy, Green Technology and Water, Malaysia.

Since joining the IEA 20 years ago as a young energy analyst, I have watched Southeast Asia flourish. I am pleased to present this report to policy-makers, industry and interested readers in my new capacity as Executive Director of the IEA. It is my hope that engagement between the IEA and Southeast Asia will continue to strengthen and that through greater partnership we will be able to put forward solutions to the energy challenges facing the region and also the world.

Dr. Fatih Birol
Executive Director
International Energy Agency

This report was prepared by the Directorate of Global Energy Economics (GEE) of the International Energy Agency (IEA). It was designed and directed by **Fatih Birol**, Executive Director of the IEA. The analysis was co-ordinated by **Amos Bromhead**, **Alessandro Blasi**, and **Shigetoshi Ikeyama**. Principal contributors to the report were **Molly A. Walton**, **Toshiyuki Shirai**, **Shigeru Suehiro**, **Ian Cronshaw**, **Atsuhito Kurozumi**, **Shelly Hsieh** (Office of Global Energy Policy), **Kristine Petrosyan**, **Johannes Trüby**, **Nora Selmet** and **Georgios Zazias**. Other key contributors were **David Wilkinson**, **Tim Gould**, **Marco Baroni**, **Christian Besson**, **Laura Cozzi**, **Carlos Fernandez Alvarez** (Gas, Coal and Power Markets Division), **Florian Kitt** (Office of Global Energy Policy) and **Fabian Kęsicki**. **Sandra Mooney** and **Teresa Coon** provided essential support.

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The individuals and organisations that contributed to this study are not responsible for any opinions or judgements it contains. All errors and omissions are solely the responsibility of the IEA.

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Southeast Asia: a key pillar of Asia's growth

The ten countries that make up the Association of Southeast Asian Nations (ASEAN) are exerting an increasingly important influence on world energy trends. Driven by rapid economic and demographic change, Southeast Asia's energy demand has increased by more than 50% between 2000 and 2013. There is growing political will to implement more secure and sustainable energy policies. Yet solutions will vary by country, as energy profiles across the region are diverse, reflecting their disparate economic, political and cultural backgrounds and the vast differences in the scale and patterns of their energy use and energy resource endowments. This *World Energy Outlook Special Report* examines the current situation and looks at future prospects for energy markets in this vibrant region and their implications for energy security and the environment.

Southeast Asia's energy landscape is set for major change

Southeast Asia's energy demand grows by 80% from today to just under 1 100 Mtoe in 2040, accompanying a regional economy that more than triples in size and a population that rises by almost a quarter to 760 million. In our central scenario, oil demand rises from 4.7 mb/d in 2014 to 6.8 mb/d in 2040, while natural gas use grows by almost two-thirds to around 265 bcm, mainly due to increased industrial demand. Coal demand expands at the fastest rate among all energy sources and reaches 440 Mtce in 2040, a level comparable to coal use in India today. By the end of the projection period, coal overtakes oil to become the largest fuel in the energy mix. Modern renewables – including hydro, geothermal, wind and solar – make inroads in the region's energy mix but the overall contribution of renewables declines from 26% to 21% due to the decreasing traditional use of biomass. The share of fossil fuels in the energy mix rises from 74% in 2013 to 78% in 2040.

The power sector shapes the energy outlook for Southeast Asia as electricity demand almost triples by 2040, with the shift towards coal set to continue. To meet the increase in demand, 400 GW of power generation capacity – roughly equal to the combined installed capacity of Japan and Korea today – is added across the region between today and 2040, of which 40% is coal-fired. The share of coal in power generation rises from 32% to 50%, contrary to the trend seen in most other parts of the world, while that of natural gas declines from 44% to 26%. The rise in coal use is underpinned by economic factors, abundant supplies and the need for rapid electrification, but also highlights the need to accelerate the deployment of more efficient technologies to address the rise in local pollution and CO_2 emissions. There remains significant potential for deploying more efficient coal-fired power plants: while the average efficiency of Southeast Asia's coal-fired power plants increases by more than five percentage points over the projection period, by 2040, subcritical technologies still comprise over 50% of total coal-fired installed capacity in the region. Renewables-based electricity generation increases three and half times from today to 2040, due to the steady rise in hydropower and the rapid expansion of modern renewables.

The efficiency of energy use improves across Southeast Asia, contributing to a rapid decline in the region's energy intensity, but there remains tremendous potential for further efficiency gains across the entire energy system. By 2040, the region requires only 55% as much energy per unit of GDP as it did in 2013, but much more could be done. There is large scope to improve the efficiency of the region's power plants. The potential for further gains in the buildings sector is significant, as only half of the countries in Southeast Asia have introduced mandatory minimum energy performance standards for appliances, with varying levels of rigour and enforcement. Tighter fuel efficiency standards for vehicles offer possibilities for fuel savings as well as benefits in other areas, such as improved local air quality. From a regional perspective, greater harmonisation and increased stringency of standards would also positively impact Southeast Asia's energy and economic balances.

A focus on efficiency, accelerated removal of fossil-fuel subsidies and deployment of low-carbon technologies can slow the rise in energy demand and greenhouse-gas emissions, delivering energy and environmental benefits without harming economic prospects. Southeast Asia is particularly vulnerable to climate change as most of the people and much of the economic activity is located along the coastlines. A "Bridge Scenario" incorporates enhanced action by policy-makers in five areas, including efficiency, subsidy removal and support to renewables, and delivers a near-term peak in global energy-related GHG emissions. In this scenario, Southeast Asia's energy demand is 5% lower by 2030, compared with our central scenario, mainly due to a reduction in oil and coal consumption, while the share of renewables in electricity generation is 7 percentage points higher, providing benefits in terms of energy security and environmental performance.

Rising imports sharpen focus on economic and security aspects of energy use

Southeast Asia is set to remain an important fossil-fuel producer, but domestic oil, gas and coal face a more challenging environment. The oil and gas supply outlook is constrained by a mature resource base with the most prolific fields starting to decline. Reduced output in Indonesia, Thailand and Viet Nam brings total oil output back from today's 2.5 mb/d to 1.6 mb/d by 2040. Natural gas production expands due to increased supply from Indonesia and to a lesser extent from Myanmar, reaching almost 260 bcm by 2040, but grows at a much more moderate pace than in recent decades. Given the increased complexity of remaining oil and gas resources, a prolonged period of low oil prices would put a further brake on investment in the region's oil and gas supply.

Southeast Asia remains a net coal-exporting region and a cornerstone of global supply, but the dynamics of the coal market change as more output is directed towards meeting the region's own needs. Coal production in Southeast Asia rises from 450 Mtce to almost 680 Mtce by 2040. Close to 90% of production in Southeast Asia is from Indonesia, which remains the world's largest coal exporter until it is overtaken by Australia in the near term. An increasing focus on meeting demand within the region means a marginal decline in Indonesia's share of the market for internationally traded coal. Policies in China and India, favouring domestic coal production or more diversification of their energy mix, could have important implications for Indonesia's role in international coal markets.

Southeast Asia loses its traditional role as a major gas supplier to international markets as domestic demand outpaces indigenous production. The region's gas exports steadily decline throughout the projection period, and by 2040, Southeast Asia turns into a net importer of around 10 bcm, alongside increased intra-regional and intra-country trade. Net oil imports (including bunkers) more than double to 6.7 mb/d by 2040, a similar level to China's imports today, and Southeast Asia's dependence on oil imports reaches almost 80%. By 2040, the region's net oil and gas import bill more than triples to $320 billion.

Ongoing changes for Malaysia's energy sector

Malaysia's energy demand almost doubles between today and 2040, with rising contributions from all energy sources. Fossil fuels remain dominant in Malaysia's energy mix, the share still exceeding 90% by 2040, although the hierarchy changes. Coal demand increases by more than a factor of three over the projection period, overtaking both oil and gas to become the primary fuel in the country's energy mix. Oil demand rises to about 1 mb/d by 2040, while the growth in natural gas demand slows, reaching around 55 bcm, close to that of India today. Demand for renewables more than doubles by 2040, with their share of electricity generation rising to 16%, underpinned by strong policy support.

Malaysia's role in international markets shifts as the country becomes increasingly dependent on oil and coal imports, while natural gas exports fall back. Malaysia's efforts to sustain domestic oil and gas production help to slow the natural decline from its mature basins and encourage investment in marginal fields. Although the country's oil output declines slightly to 0.6 mb/d by 2040, Malaysia becomes the largest oil producer in Southeast Asia, above Indonesia. However, this decline implies that its oil import dependence rises to over 40% by 2040. Malaysia has historically played the role of major supplier to the international gas markets and in 2013 was the world's second largest exporter of LNG. Growing domestic needs and flattening production are set to reduce Malaysia's natural gas exports, which decline to less than 10 bcm by 2040.

Continued development will hinge on the strategic direction of its energy policy. Malaysia has made significant progress recently on energy pricing reform, has achieved near universal access for modern energy services and has indicated its intention to pursue greener and more sustainable development. In 2014, the government ended subsidies for 95RON gasoline and diesel, reformed electricity pricing while making sure it remains affordable for low-income households, and moved towards market-parity pricing for natural gas. Malaysia has also implemented several policies to advance the share of renewables in its energy mix. To achieve its development goals in a secure and sustainable manner and to reduce emissions of CO_2 and local pollutants, the use of more efficient coal-fired power plant technologies and a successful continuation of the deployment of renewables will be critical.

Four key issues will shape the future of Southeast Asia's energy system: power grid interconnection, energy investment, energy access and fossil-fuel subsidies

Greater integration of Southeast Asia's energy networks can deliver strong benefits across the region. Building on existing cross-border co-operation, timely implementation of new plans and projects to connect the region's markets, such as the ASEAN Power Grid and the Trans-ASEAN Gas Pipeline, can help to catalyse development of remote or high capital cost energy resources, facilitate more efficient use of the region's resources and enhance energy security. Region-wide energy market development and integration could help to achieve balanced and equitable economic growth for all Southeast Asian countries.

Attracting sufficient investment in energy is vital to ensure continued growth and enhance energy security and sustainability. Securing the region's energy needs in our central scenario requires $2.5 trillion of cumulative investment in energy supply infrastructure to 2040, an annual average of almost $100 billion. More than half of the total is required for the power sector. A further $420 billion is needed over the projection period to improve energy efficiency. In the Bridge Scenario, investment in energy supply infrastructure is 7% lower, while investment in improving end-use efficiency is boosted by more than 40%. In each case, policy-makers will play a critical role in attracting and mobilising energy investment in the region.

Since 2000, the number of people without access to electricity has declined by two-thirds, but progress in improving access to clean cooking facilities has been much slower. Some 120 million people do not have access to electricity in the region, while another 276 million rely on solid fuels, such as fuelwood and charcoal, for cooking. Electrification programmes and innovative business models have succeeded in a number of Southeast Asian countries, and five of them – Brunei Darussalam, Malaysia, Singapore, Thailand and Viet Nam – have achieved, or are very close to achieving, universal electricity access. The picture is less encouraging for access to clean cooking, and there is a need for greater political and financial support for efforts to switch away from the traditional use of biomass.

Southeast Asia currently stands out as one of the most active regions in the world in phasing out or reducing subsidies to fossil fuels, but much remains to be done. Fossil-fuel subsidies, which amounted to $36 billion in 2014 in Southeast Asia, often fail to deliver affordable energy to the poorest, encourage wasteful energy use, burden public budgets and deter much-needed investment in efficient technologies. Recent reforms in Indonesia, Malaysia, Thailand and Myanmar have been primarily driven by the combination of an extended period of high international energy prices and increasing reliance on imports, which have elevated the economic burden on government budgets of the subsidy programmes. In some cases, the drop in oil prices from mid-2014 opened a window to reduce subsidies without having a major upward impact on end-user prices or inflation. The likelihood of durable reform can be improved if the move from subsidised prices follows general best-practice guidelines: get the pricing mechanism right; implement reforms in steps; manage the effects and consult and communicate at all stages.

Understanding the scenarios

What are the drivers of Southeast Asia's energy future?

Highlights

- This report examines prospects for energy demand and supply in the period to 2040 in Southeast Asia. This region encompasses extremely diverse countries with vast differences in their levels and patterns of energy consumption and production. The report also examines the implications for the region's energy security, environmental sustainability and its role in global energy trade.
- Rapid economic and demographic changes have and continue to provide a range of challenges for energy policy-makers in the region. In order to meet rising energy needs in a more secure and sustainable manner, a suite of measures, both at a country and regional level, have been adopted. Measures include improving energy efficiency, fossil-fuel subsidies reform, deploying renewables and increasing grid interconnections. Efforts have also been made to improve emergency preparedness.
- Government policies have a strong influence on energy markets, even though some trends are difficult to shift through policy action. Our central scenario, the New Policies Scenario, assumes the continuation of existing policies and measures as well as the cautious implementation of policy proposals, even if they are yet to be formally adopted. The projections do not assume the deployment of breakthrough technologies, but do allow for efficiency improvements and further cost reductions of energy technologies that are in use or are approaching commercialisation. A second scenario – the Bridge Scenario – illustrates the part Southeast Asia could play in facilitating an early peak in global energy-related GHG emissions at no net economic cost by employing proven policy measures and technologies that are currently available.
- Southeast Asia has been a standout economic performer over a sustained period and has remained relatively resilient in the face of generally weak global economic growth since the 2008-2009 global financial crisis. Its GDP has increased 5.3% per year on average (expressed in real PPP terms) since 2000. In both scenarios in this report, GDP is assumed to grow by 4.6% each year on average between 2013 and 2040. Southeast Asia remains one of the most rapidly growing regions, with its share of global GDP rising from 5.9% to 7.7% over the period.
- Southeast Asia is experiencing rapid changes in key demographic indicators with implications for the size and composition of its energy use. Overall population rises from 616 million in 2013 to 760 million in 2040 and the number of people living in urban areas increases by more than 170 million. Per-capita income across the whole region rises from about $10 000 in 2013 to $27 000 in 2040, from about one-quarter to almost one-half of the OECD average.

Introduction

Southeast Asia Energy Outlook 2015 draws on the latest available energy and macroeconomic data, as well as policy and market developments, to examine the current status and future prospects for energy markets in this vibrant region and considers their implications for energy security and the environment. For the purpose of this report, Southeast Asia is defined as comprising the ten countries of the Association of Southeast Asian Nations (ASEAN): Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand and Viet Nam.

The report provides policy-makers, industry, investors and consumers with a framework to understand the drivers of emerging energy trends and opportunities to address their related challenges. It has been prepared by the International Energy Agency (IEA) in collaboration with the Economic Research Institute for ASEAN and East Asia (ERIA). It comes in response to the Joint Ministerial Statement of the 7th East Asia Summit Energy Ministers meeting in Bali, Indonesia in 2013, which called for the IEA and ERIA to follow-up on their previous collaboration that resulted in the publication of the *Southeast Asia Energy Outlook: World Energy Outlook Special Report* in 2013.[1]

The structure of this report is:

- Chapter 1 explains the modelling approach and the underlying assumptions that have been adopted for the key determinants that will shape future energy trends across the region, including the policy framework, economic growth, demographic trends and energy prices.
- Chapter 2 details Southeast Asia's energy sector as it is today and projects the energy demand outlook for the region, by fuel and sector, to 2040, and the implications for energy-related carbon-dioxide (CO_2) emissions.
- Chapter 3 assesses the fossil-fuel supply outlook for Southeast Asia to 2040. Projections are made by fuel and by key producer. It also examines the implications of the demand and supply projections for energy security and the region's changing position in international energy trade.
- Chapter 4 provides an in-depth look at energy prospects in Malaysia to 2040.
- Chapter 5 analyses four special issues that will influence the future direction of the region's energy system: enhanced co-operation to expand power grid interconnections; energy investment and the challenges of it being made in a timely manner; expanding access to modern energy services; and efforts to phase out fossil-fuel subsidies.

[1] *www.worldenergyoutlook.org/southeastasiaenergyoutlook*. It is envisaged that this report will become a biennial publication, with each edition including an in-depth focus on a specific Southeast Asian economy.

Modelling approach

The energy projections and analysis in this report focus on the New Policies Scenario, the central scenario used in the *World Energy Outlook* (*WEO*) series of reports. The New Policies Scenario takes into account the policies and implementing measures affecting energy markets adopted as of mid-2015, together with relevant policy proposals, even when specific measures needed to put them into effect have yet to be fully developed. We make a case-by-case judgement of the extent to which policies that are not already enacted will be implemented. This is done in view of the many institutional, political and economic obstacles which exist, as well as, in some cases, a lack of detail in announced intentions and how they will be implemented.

We also include results for Southeast Asia of the Bridge Scenario that was presented in full in *Energy and Climate Change*: *World Energy Outlook Special Report* that was released in June 2015 (IEA, 2015).[2] The Bridge Scenario illustrates ways to facilitate an early peak in global energy-related greenhouse-gas (GHG) emissions by using technologies that are currently available and proven policy measures. The scenario is not, in itself, a pathway to the internationally agreed target to limit the rise in global average temperatures to below 2 degrees Celsius (°C) relative to pre-industrial levels – additional technologies and policies would be needed for that. But it indicates a strategy for near-term action as a bridge to higher levels of decarbonisation at a later stage compatible with the 2 °C goal.

The IEA's World Energy Model is the primary tool used to make the projections for this report.[3] The model is a large-scale simulation model, designed to replicate how energy markets function. It consists of three main modules covering final energy consumption (including industry, transport, buildings, agriculture and non-energy use), fossil fuel and bioenergy supply, and energy transformation (including power and heat generation, refinery and other transformation). In previous energy demand modelling exercises undertaken by the IEA, Southeast Asia has typically been analysed by preparing a country-specific model for Indonesia and – due to resource or data limitations – an aggregated model for the remaining economies in the region. However, for this report, both Indonesia and Malaysia have been modelled on a standalone basis (future editions in this series of reports on Southeast Asia will include an in-depth focus on a specific country). On the supply side, projections for oil, natural gas, coal and bioenergy are derived for all major producers within the region.

The data used in this modelling exercise were primarily sourced from IEA databases of energy (supply, trade, transformation and prices)[4] and economic statistics. These sources were supplemented by data from governments, international organisations, energy companies, consulting firms and financial institutions. The starting year for most of the

2 Available as a free download at: *www.worldenergyoutlook.org/energyclimate*.

3 See *www.worldenergyoutlook.org/weomodel* for a complete description of the World Energy Model.

4 Many of these data are available at *www.iea.org/statistics*.

projections is 2013, as reliable market data were available only up to 2013 at the time of the modelling. However, where more recent preliminary data were available, they have been incorporated.

Long-term projections are always subject to a range of uncertainties, such as a global agreement on climate change or a major geopolitical event, but projections are not forecasts – they describe trends. The projections do, however, take into account prospective technology developments in the energy sector and how they might affect supply costs, energy efficiency and fuel choice, without assuming any fundamental technological breakthroughs.

Policy framework

The energy policy frameworks in place in Southeast Asia are diverse, reflecting the countries' disparate economic, political and cultural situations and the vast differences in the scale and patterns of their energy use and energy resource endowments. The policy assumptions adopted in this analysis were informed by an IEA survey in the first quarter of 2015 of members of the Energy Research Institute Network (ERIN), which brings together energy research institutes in 16 countries (Southeast Asia, Australia, China, India, Japan, Korea and New Zealand) on policy developments in Southeast Asia. Through this survey it was evident that across Southeast Asia there is increasing political will to implement policies aimed at meeting energy needs in a more secure and sustainable manner. Efforts to move to a cleaner, more diversified energy mix have included advancing energy efficiency, increasing physical connectivity, reforming fossil-fuel subsidies and deploying renewable energy technologies. Our projections reflect a cautious view on the prospects for full realisation of the various plans that been announced unless the implementation measures have been fully defined.

Many Southeast Asian countries are seeking to diversify energy supply, due to energy security and economic concerns linked to their rising dependency on imported oil and in some cases natural gas. As part of these efforts, many have been seeking to increase the role of coal in the energy mix. There has also been considerable attention placed on the deployment of renewable energy technologies, including by improving conditions for attracting private investment. Most countries have adopted medium- and long-term targets for renewables, although these are much more ambitious in some countries than in others. Indonesia falls in the ambitious category, targeting an increase in the share of "new and renewable energy"[5] in primary energy supply to 23% by 2025 and 31% by 2050 (Table 1.1).

[5] In Indonesia this category includes the use of other energy technologies, not necessarily from renewables, such as nuclear, hydrogen, coalbed methane, liquefied coal and gasified coal. Traditional use of biomass is excluded.

Table 1.1 ⊳ Selected energy policies and targets in Southeast Asian countries

Country	Sector	Policies and targets
Brunei Darussalam	Efficiency	Reduce energy intensity by 45% from 2005 levels by 2035.
	Renewables	Achieve 10% of electricity generation from renewables by 2035.
Cambodia	Efficiency	Reduce energy consumption 20% from BAU level by 2035.
Indonesia	Efficiency	Reduce energy intensity by 1% per year to 2025.
	"New and renewable energy"*	Increase share of "new and renewable energy" in primary energy supply to reach 23% by 2025 and 31% by 2050.
	Climate change	Reduce GHG emissions 26% from BAU level by 2020, increase to 41% reduction with enhanced international assistance.
Lao PDR	Efficiency	Reduce final energy consumption from BAU level by 10%.
	Renewables	Achieve 30% share of renewable in primary energy supply by 2025.
Malaysia	Efficiency	Promote energy efficiency in the industry, buildings and domestic sectors.
	Renewables	Increase capacity of renewables to 2 080 MW by 2020 and 4 000 MW by 2030.
	Nuclear	Government is developing plans and undertaking feasibility, site selection and regulatory studies.
	Climate change	Reduce carbon intensity of GDP by 40% by 2020 from 2005 levels.
Myanmar	Efficiency	Reduce energy demand by 10% from BAU level.
	Renewables	Achieve 15% to 18% share of renewables in total generation capacity by 2020.
Philippines	Efficiency	Attain energy savings equivalent to 15% of annual final demand relative to BAU by 2020.
	Renewables	Triple the installed capacity of renewables power generation to 15GW by 2030.
Singapore	Efficiency	Reduce energy intensity by 35% by 2030 from 2005 levels.
	Climate change	Reduce GHG emissions by 7% to 11% below BAU levels by 2020, which will be increased to 16%, if there is a legally binding global agreement on climate change. Reduce GHG emissions intensity by 36% by 2030 from 2005 levels.
Thailand	Efficiency	Reduce energy intensity by 30% compared with 2010 by 2036 through the removal of fossil-fuel subsidies and accelerated energy efficiency improvements.
	Renewables	Renewables to reach 20% of power generation by; biofuels to reach 20% of transport fuel use by 2036.
	Nuclear	Two commercial reactors have been planned since 2007, although progress has stalled since the Fukushima Daiichi accident.
Viet Nam	Efficiency	Reduce energy consumption by 5% to 8% by 2015 and 8-10% by 2020 relative to BAU.
	Renewables	Increase the share of renewables in electricity generation to 4.5% by 2020 and 6% by 2030.
	Nuclear	Develop 10.7 GW of nuclear power capacity by 2030.

*See footnote 5.

Notes: BAU = business-as-usual; MW = megawatts; GW = gigawatts.

Numerous countries in Southeast Asia are pursuing the increased deployment of biofuels. Indonesia and Malaysia collectively produce roughly 85% of the global output of palm oil, which is used as a diesel additive and for food production, while Thailand is the world's third-largest producer. To help boost domestic demand for biodiesel and improve energy security, Indonesia increased its biodiesel subsidy to IDR 4 000/litre ($0.33) in early 2015 and raised the biodiesel blending mandate to 15% from 10% and mandated that it must be domestically produced. Implementation, however, has been delayed as low oil prices have made palm oil blending uneconomic. Malaysia increased its palm oil blending mandate from 5% to 7% in 2014 and in mid-2015 announced plans to allow biodiesel to be blended up to 10%. Thailand cut its biodiesel blending target to 3.5% in early 2015 after drought diminished the biomass stock, but has since lifted the target to 7% in order to boost prices. The push to increase mandates for biodiesel could bump against several constraints including weather-related impacts to palm oil crops, lack of infrastructure for transport from supply to demand centres, costs of transportation, the age of vehicle stocks and their ability to operate on biodiesel, competition with the use of palm oil for food products and environmental concerns such as land-use change and deforestation.

Across the region, a broad range of approaches have been adopted to improve energy efficiency and conservation. There has generally been greater reliance on voluntary approaches, such as information and awareness campaigns, than mandatory measures and incentives. Thailand provides a good example of a country that has implemented a comprehensive approach to improving energy efficiency through its new Integrated Energy Blueprint, which includes a target to reduce end-use energy intensity[6] by 30% in 2036 compared with 2010 through fossil-fuel subsidy removal and accelerated energy efficiency actions across a broad range of sectors.

Southeast Asia is highly vulnerable to climate change as most of the people and much of the economic activity are located along the coastlines. Countries in the region are active participants in international climate change negotiations and some have set national targets: Indonesia aims to reduce GHG emissions by 26% from business-as-usual (BAU) levels by 2020, or 41% if it receives enhanced international assistance; Malaysia seeks to reduce the carbon intensity of gross domestic product (GDP) by 40% by 2020 from 2005 levels; and Singapore aims to reduce GHG emissions by 16% from BAU levels by 2020.

Southeast Asian countries are also working collectively to improve the security, accessibility, affordability and sustainability of their energy supply. Currently being prepared, the 4th ASEAN Plan of Action on Energy Cooperation (APAEC) covering the period 2016 to 2020 is expected to focus on the promotion of energy efficiency, developing and deploying renewable energy sources, increasing interconnections between national power grids to enable cross-border power trade, and co-operation on clean coal technologies, reflecting the region's increasing dependence on coal. A pilot project for electricity trade from Lao PDR to Singapore is currently underway, which also involves transit through

[6] Defined as the amount of final energy consumption per unit of GDP.

Thailand and Malaysia. Under the 3rd APAEC (2010-2015), ASEAN member states have a target by 2015 to reduce regional energy intensity by at least 8% from 2005 levels and to increase the share of renewables-based power capacity to 15%. Based on IEA data, both targets have been easily achieved.

The Asia-Pacific Economic Cooperation (APEC) forum targets are also relevant as seven of the ten Southeast Asian economies are also APEC members (the exceptions being Cambodia, Lao PDR and Myanmar). The APEC targets include to double the share of renewables in total energy supply by 2030 from 2010 levels and to reduce aggregate energy intensity by 45% from 2005 levels by 2035.

Currently there are no commercial nuclear power plants in operation in Southeast Asia, but there has been interest in developing nuclear power technology including in Indonesia, Malaysia, Philippines, Thailand and Viet Nam (Box 1.1). Construction was finalised on a nuclear reactor in the Philippines in 1973, but it was never fuelled. More recently, Viet Nam has made the most progress, albeit with major delays, and currently aims to start construction of a Russian-supplied plant in 2019. As is the case when assessing all potential nuclear newcomers, significant caution needs to be exercised in assessing the rate of progress.

Box 1.1 ▹ Nuclear power in Southeast Asia

Rising electricity demand, growing dependence on imported fossil fuels and environmental concerns have prompted several Southeast Asian countries to consider the role that nuclear power could play in their energy mix. However, since the Fukushima Daiichi accident in Japan, the near- to medium-term prospects for nuclear power in the region have diminished. All countries in Southeast Asia that are interested in deploying nuclear power face significant challenges. These include sourcing the necessary capital on favourable terms, creation of legal and regulatory frameworks, compliance with international norms and regulations, sourcing and training of skilled technical staff and regulators, and ensuring public support. These challenges are why we are cautious about the introduction of nuclear power in the region in the New Policies Scenario.

Today Viet Nam has the most active nuclear power ambitions in the region, although it faces several challenges and timelines continue to be extended. Viet Nam's plans for nuclear power date back to the early 1980s, but it was not until 2006 that it proposed to develop 2 000 megawatts (MW) of nuclear power by 2020. The National Assembly approved the plan the next year, quadrupled the target and delayed the timeline to 2025. A master plan calling for nuclear power to provide about 10% of electricity production by 2030 was passed by the government in 2011. In 2010, Viet Nam signed reactor construction agreements with Japan and Russia wherein each country agreed to supply two 1 000 MW reactors. Russia was to build the first one, Ninh Thuan 1, with construction slated to begin in 2014 for operation by 2020 and the second plant for operation by 2021. Construction on the Japanese reactors was envisaged to begin in 2015. In January 2014, Viet Nam announced that the projects had been postponed by four years. Another delay was announced in January 2015, pushing the expected construction start to 2019. Negotiations regarding financing and technology as well as safety and legal concerns have delayed construction of all these reactors.

Malaysia has undertaken feasibility studies for the possible introduction of nuclear power, but the government has yet to make a formal decision on whether it will pursue it. The 11th Malaysia Plan 2016-2020, tabled in parliament in May 2015, notes that an independent atomic energy regulatory commission will be established based on a new comprehensive nuclear power law. Thailand's National Energy Policy Council requested a feasibility study for nuclear power and approved the construction of nuclear capacity in its Power Development Plan (PDP) (2007-2021). In each subsequent PDP the capacity target and timeframe for nuclear power have been revised and extended. The 2015 PDP includes two 1 000 MW nuclear power plants to begin operation by 2036.

Emergency preparedness policy

Countries in Southeast Asia are actively working to improve their energy emergency preparedness through individual efforts and multilateral co-operation frameworks with the IEA, ASEAN+3 (i.e. China, Japan and Korea) and APEC. Oil is their most pressing concern, reflecting the risks associated with the region's rapidly growing reliance on imports, much of which comes from the Middle East and Africa through the Malacca Strait – one of the world's busiest shipping lanes and a chokepoint that is vulnerable to piracy and terrorist attacks. An estimated 13 million barrels per day (mb/d) of crude oil plus 3 mb/d of oil products were shipped through the Malacca Strait in 2013 (see Chapter 3, Box 3.2). Energy security concerns in the region also arise from the geographical mismatch of centres of demand and sources of upstream production.

As the costs associated with building and holding public (or government) oil stocks are an important barrier to their wider use in the region, most countries currently rely on industry stockholding obligations to mitigate the impact of any oil supply disruption. These obligations include 30 days of consumption in Cambodia and around 25 days of consumption in Thailand (reduced from 43 days in May 2015); and 18 to 22 days of consumption in Indonesia held by the national oil company, Pertamina. Myanmar and Viet Nam hold some public stocks. Thailand, Lao PDR and Indonesia are considering the establishment of public stocks. Malaysia, which is on the verge of becoming a net oil importer, currently does not have any significant storage facilities, but there are ongoing oil storage projects in the southern part of Peninsular Malaysia which could possibly be used for public storage.

A number of Southeast Asian countries have committed to increasing their emergency oil stocks. In March 2015, state-owned PetroVietnam announced that it was taking advantage of the decline in oil prices and building a new strategic crude oil storage facility (capacity of 1-2 million tonnes corresponding to around 15-30 days of oil consumption). Thailand and

Viet Nam have committed to achieving stock levels comparable to the 90 days' worth of net oil imports that IEA member countries are required to maintain. Indonesia is considering obliging industry to hold stocks equivalent to 30 days of consumption (increasing to 60 days in five years). Such storage expansions would necessitate the construction of new facilities, irrespective of whether the oil is held by governments or industry.

Southeast Asian countries have also concluded an agreement to work collaboratively to safeguard oil security. The objective of the ASEAN Petroleum Security Agreement (APSA) is to enhance oil security of its member states through the implementation of measures than span the short to long term. Among its short-term measures, APSA envisages the collective assistance among member states for any that experience a severe supply shortfall continuously for at least one month. A task force chaired by the ASEAN Council on Petroleum is currently working on exploring ways to make the APSA operational.

Natural gas security has not been a policy priority in the region, as it has long been a net exporter. Now this is changing. Natural gas use is growing much faster than production, which means the region as a whole faces less surplus for export. An increasing number of Southeast Asian countries are already dependent on imports from outside the region, or inter-regional transfers. Currently no country in the regional has mandatory requirements for natural gas stockholding, but several are in the process of formulating emergency response plans. Thailand, which is a net importer and has suffered from several supply disruptions, has formalised plans to help the gas transmission operators maintain supply during a disruption. While Indonesia remains a net exporter of gas, it is also looking to imports to overcome localised shortages in some parts of the country. System operators in Indonesia have developed emergency measures, including allocation of gas supply to under-supplied areas in the event of a shortfall and putting in place back-up power generators. Indonesia is also developing gas infrastructure, such as floating storage and regasification units (to receive alternate supplies during a disruption and to increase peak-shaving capacity). Malaysia has a minimum gas holding requirement at its liquefied natural gas (LNG) regasification terminals for operational reasons.

Main non-policy assumptions

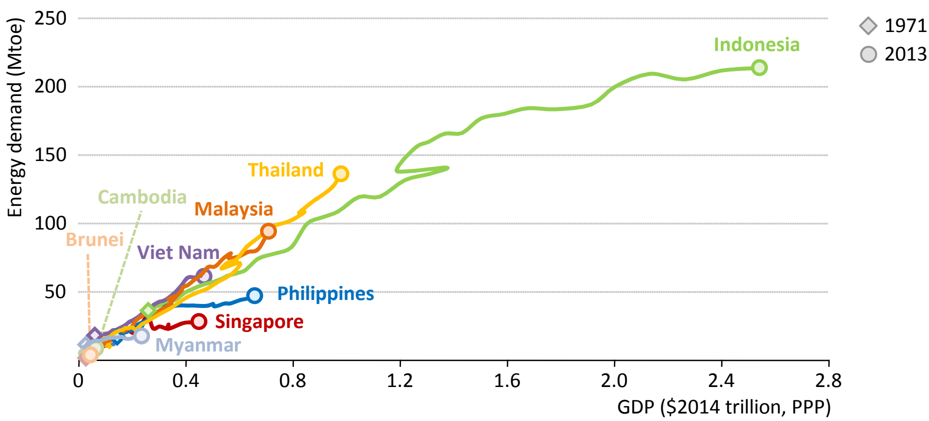
Economic growth

Southeast Asia has recorded remarkably strong economic growth over recent decades. The region's economy has almost doubled in size since 2000 to reach $6.1 trillion in 2013 (year-2014 dollars, purchasing power parity [PPP] terms), making it comparable to that of Japan and Korea combined. While it has not been immune to the general weakness that has characterised world markets since the global economic crisis of 2008-2009, the slowdown has been less marked than in many other economies. Southeast Asia's average annual economic growth rate remained above 5% from 2000 to 2013, which far exceeds the OECD average (1.6%) and is comparable with growth experienced by India (7.2%) and Africa (4.8%).

Economic growth in Southeast Asia has been driven by an expansion of the labour force, as population and participation rates have increased, and a gradual shift in the structure of the economy away from agriculture in favour of manufacturing and services. It remains a very heterogeneous region from an economic perspective: based on the World Bank's criteria, it includes two high-income economies (Brunei Darussalam and Singapore), two upper middle-income economies (Malaysia and Thailand), five lower middle-income economies (Indonesia, Myanmar, Philippines, Viet Nam and Lao PDR) and one low-income economy (Cambodia). Even within countries, wealth distribution is quite heterogeneous.

As in most other parts of the world, demand for energy in Southeast Asia is correlated with economic activity, so the projections in this report are sensitive to the underlying assumptions about the rate of growth of GDP. Since 1971, Southeast Asia's primary energy demand increased by 0.64% on average for every percentage point of GDP growth (PPP terms), although there were considerable differences across the region (Figure 1.1). This ratio is expected to gradually decline over time as Southeast Asia's energy use and economic growth gradually decouple, driven by the adoption of more efficient technologies, increasing saturation of appliances and equipment in some markets, and as the economic structure shifts to less energy-intensive activities.

Figure 1.1 ▷ Total primary energy demand and GDP in selected Southeast Asian countries, 1971-2013



Note: Mtoe = million tonnes of oil equivalent.

A broad range of economic forecasts for Southeast Asia, including by the Organisation for Economic Co-operation and Development (OECD), the Asian Development Bank (ADB) and the International Monetary Fund (IMF), suggest that the region is set for healthy growth over the medium term driven by rising domestic demand, particularly in the middle-income countries such as Thailand and Malaysia, and an increase in foreign investment in the less developed countries such as Cambodia and Myanmar. A contributing factor is expected to be the planned establishment of the ASEAN Economic Community (AEC) by the end of 2015, which aims to boost regional economic integration by improving the flow of goods, services, investment, skilled labour and capital across borders.

The above findings by economic forecasters have been taken into account in the formulation of the assumptions for medium-term GDP growth used in this *Outlook*. The assumptions for longer term growth are based on an assessment of developments in the labour force, accumulation of capital stock (investment) and total factor productivity, supplemented by projections made by various economic forecasting bodies. We assume that Southeast Asia's GDP (PPP terms) grows by 4.6% each year on average between 2013 and 2040, compared with 5.3% since 2000 (Table 1.2). Annual average growth rates moderate from 5.3% in the period to 2025 to 4.0% thereafter. Southeast Asia remains one of the most rapidly growing regions in the period to 2040, with its share of global GDP rising from 5.9% to 7.7%.

Average per-capita income across the region rises from $10 000 in 2013 to $27 000 in 2040, about one-quarter to almost one-half of the OECD average. This will be an important driver of energy demand as increases in per-capita income are typically accompanied by increases in per-capita energy use, especially at relatively low income levels.

Table 1.2 ▷ GDP assumptions by country in Southeast Asia*

	GDP ($2014 billion)		CAAGR**	Per-capita GDP ($2014 thousand)		CAAGR**
	2013	2040	2013-2040	2013	2040	2013-2040
Indonesia	2 548	9 281	4.9%	10	30	4.1%
Malaysia	704	2 112	4.2%	24	53	3.0%
Philippines	652	2 584	5.2%	7	18	3.8%
Thailand	979	2 386	3.4%	15	36	3.4%
Other	1 256	4 128	4.5%	7	21	3.9%
Southeast Asia	**6 138**	**20 490**	**4.6%**	**10**	**27**	**3.8%**

*Calculated based on GDP expressed in PPP terms. **Compound average annual growth rate.

Sources: IMF (2015); OECD (2015); Economist Intelligence Unit and World Bank databases; IEA databases and analysis.

Demographic trends

Population dynamics affect the size and pattern of energy demand. The assumptions adopted follow the "medium variant" of the United Nations projections (UNPD, 2013). Southeast Asia's population grows from 616 million in 2013 to 760 million in 2040, an increase of almost one-quarter (Table 1.3). The annual average rate of population growth slows from 1.0% before 2025 to 0.6% thereafter. By a good margin, Indonesia stays Southeast Asia's most populous country, maintaining a share of around 40% of the total.

Southeast Asia has been urbanising rapidly in recent decades and this is set to continue. The number of people living in urban areas increases by more than 170 million over the projection horizon, as the urbanisation rate rises from 46% in 2013 to 60% in 2040. By contrast, the number living in rural areas falls. Urbanisation tends to push up demand for modern forms of energy, (as they are more readily available in towns and cities, incomes tend to be higher and economic activities are concentrated), although this growth can be mitigated through a strategic approach to planning and transport policy that ensures that sustainable and energy-efficient infrastructure is put in place.

Table 1.3 ▷ Population and urbanisation assumptions

	Population growth			Population (million)		Urbanisation rate	
	1990-2013	2013-20	2013-40	2013	2040	2013	2040
Brunei Darussalam	2.1%	1.2%	0.9%	0.4	0.5	77%	82%
Cambodia	2.3%	1.6%	1.2%	15	21	20%	31%
Indonesia	1.5%	1.1%	0.8%	250	311	52%	67%
Lao PDR	2.1%	1.8%	1.4%	7	10	36%	56%
Malaysia	2.2%	1.4%	1.1%	30	40	73%	84%
Myanmar	1.0%	0.8%	0.4%	53	59	33%	49%
Philippines	2.0%	1.7%	1.4%	98	144	45%	51%
Singapore	2.5%	1.6%	0.9%	5	7	100%	100%
Thailand	0.7%	0.2%	-0.1%	67	66	48%	68%
Viet Nam	1.3%	0.8%	0.5%	90	102	32%	48%
Southeast Asia	**1.5%**	**1.1%**	**0.8%**	**616**	**760**	**46%**	**60%**

Sources: UNPD and World Bank databases; IEA analysis.

Energy supply costs and prices

As with most goods, the demand for a given energy service depends on its price, which in turn reflects the price of the unprocessed energy source as well as the technology used to transform and deliver it. The international fuel prices in the New Policies Scenario reflect analysis of the price levels that would be needed to stimulate sufficient investment in supply to meet projected demand over the period. Average retail prices for end-use, power generation and other transformation sectors are derived from iterative runs of the World Energy Model. These end-use prices take into account local market conditions, including taxes, excise duties and any subsidies.

After a long period of historically high and relatively stable oil prices, international benchmark oil prices fell by more than one-half between their peak levels in mid-2014 to early-2015. This was driven by a marked slowdown in demand growth and record increases in non-OPEC supply. As of early September 2015, Brent prices are close to $50/barrel. In the New Policies Scenario, oil prices at higher than current levels are needed to balance supply with demand. The average crude oil import price in Southeast Asia comes close to $110/barrel (in year-2014 dollars) in 2030 and increases further in the period to 2040.

As trade in LNG in Asia is dominated by long-term contracts with rates indexed to oil prices, the fall in oil prices has been accompanied by a lagged reduction in LNG prices. Spot prices for natural gas in Asia have also fallen dramatically. Since trading at about $18 per million

British thermal units (MBtu) in April 2014, spot LNG in Southeast Asia was on average well below $10/MBtu in early September 2015. In the New Policies Scenario, average import prices in the region are expected to rise again in the longer term to reach $12-$14/MBtu (in year-2014 dollars) in the 2030s. As they do at present, some countries in Southeast Asia (e.g. Brunei Darussalam, Indonesia, Malaysia, Myanmar) are expected to continue to use indigenous natural gas to satisfy at least a share of their needs, meaning that domestic prices will be somewhat lower than these levels, even as we assume the region continues to make progress towards an integrated and liberalised wholesale natural gas market.

Prices for internationally traded steam coal have also weakened over recent years, driven by two main factors: lower than expected demand in China (the world's biggest coal user, producer and importer); and, probably more importantly, increasing supply and hence competition among coal suppliers. In the New Policies Scenario, the average Indonesian steam coal export price rises from $61/tonne in 2014 to just over $80/tonne (in year-2014 dollars; adjusted to 6 000 kcal/kg) in 2040. This is a marker for reasonably high calorific-value coal sold in the international market. As they do at present, many countries in Southeast Asia are expected to continue to use lower cost and lower calorific-value coal.

Energy demand prospects

How will demand evolve?

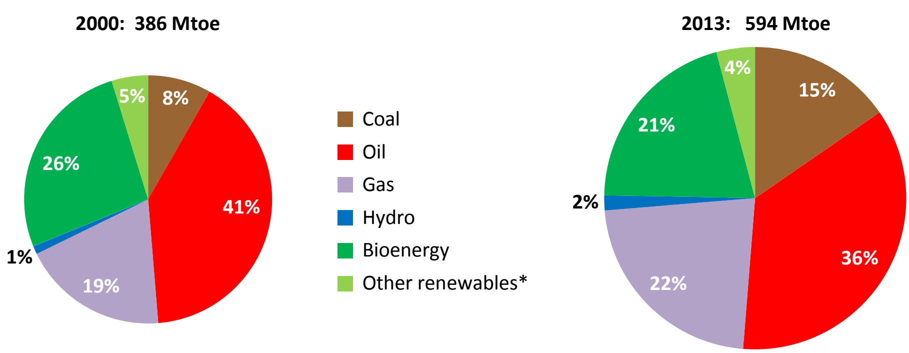
Highlights

- In the New Policies Scenario, the total primary energy demand of Southeast Asia rises by 80% in the period 2013 to 2040. The region's economy more than triples in size and an increasing share of its population moves to urban areas, driving up the demand for modern energy services. Per-capita energy demand rises by almost 50%, yet continues to remain low by international standards, while the amount of energy used to generate a unit of GDP falls by almost half.
- Southeast Asia is one of the few regions in the world that has an increasing share of coal in its primary energy mix over the period to 2040. Coal demand more than triples to become the largest fuel in the energy mix, followed closely by oil. Natural gas demand reaches 265 bcm in 2040 (an increase of 65% over 2013), while oil demand grows from 4.7 mb/d in 2014 to 6.8 mb/d in 2040. The share of renewable energy in the mix declines, as a shift away from the traditional use of biomass offsets an increase in the use of geothermal, hydropower, wind and solar PV.
- Electricity demand almost triples over the period, to around 2 000 TWh in 2040, an increase bigger than current demand in India. The generation mix continues to shift as the shares of coal and renewables grow and those of natural gas and oil decline. Coal is increasingly favoured in the power sector due to its price advantage and the abundance of indigenous supply; natural gas – its main competitor – becomes more expensive due to the depletion of domestic resources. The power sector adds 400 GW of power generation capacity to 2040, almost 40% of which is coal-fired.
- Total final energy consumption rises by 70% from 2013 to 2040, driven by urbanisation and increased economic activity in the industrial and services sectors. Industrial energy demand more than doubles, with natural gas playing a growing role. Energy demand in the buildings sector experiences a modest increase, as a continued shift away from traditional and inefficient use of biomass partly offsets a tripling in the use of electricity. Transport demand continues to rise, increasing by 60%, though growth in oil demand slows in the second half of the period as subsidies are phased out, vehicle efficiency increases and more mass transit projects are completed.
- In the New Policies Scenario, Southeast Asia's energy-related CO_2 emissions double, reaching 2.4 Gt in 2040. The adoption of measures included in the Bridge Scenario slows the growth in CO_2 emissions while limiting energy demand growth and reducing oil imports by 200 kb/d in 2030 for the region.

Overview

Southeast Asia is one of the most dynamic regions in the world. It is home to 616 million people and is continuing to experience robust population growth and rapid urbanisation; the number of people living in its cities and towns has grown by almost 90 million since 2000. Over the same period, Southeast Asia has been a standout economic performer and, despite some headwinds, prospects for further sustained growth remain favourable. To meet the needs of its growing population and economy, Southeast Asia's demand for energy services has increased rapidly, rising by more than 50% between 2000 and 2013 (Figure 2.1). Fossil fuels dominate the mix, accounting for about three-quarters of demand. Oil has the largest share, though in recent decades greater use of coal and natural gas have reduced reliance on oil in power generation and industry. Escalating energy demand has raised some formidable challenges. A growing need for energy imports in most countries in the region has made energy security a pressing concern and increased exposure to volatile international fossil-fuel prices. Energy production and use are increasing air pollution in many of the region's cities as well as increasing its share of global greenhouse-gas (GHG) emissions. Southeast Asia also needs huge investment in energy infrastructure, particularly in the power sector as over one-fifth of the population still does not have access to electricity.

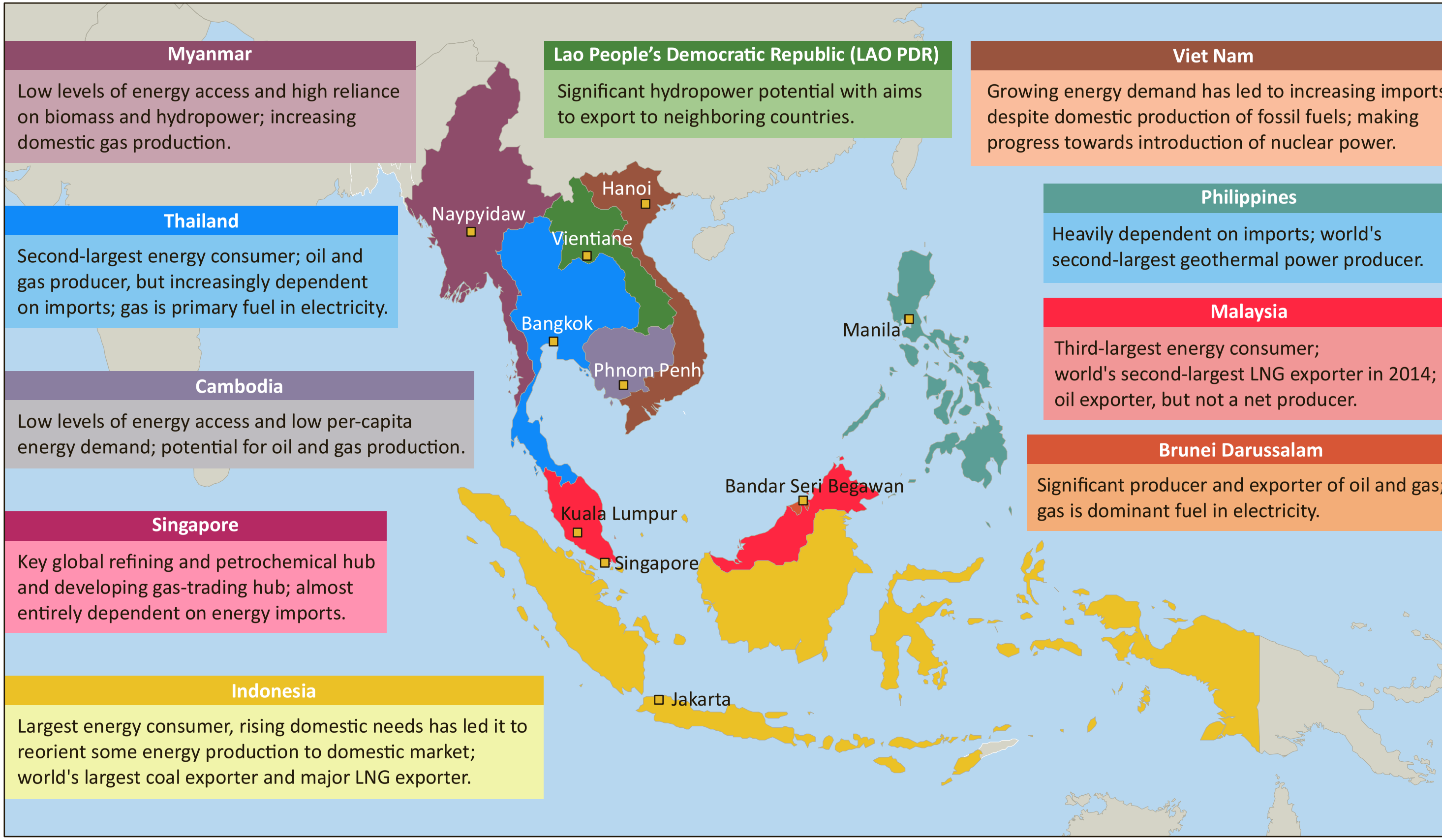
Figure 2.1 ▷ Fuel shares in primary energy demand in Southeast Asia, 2000 and 2013



*Includes solar PV, wind, and geothermal. Note: Mtoe = million tonnes of oil equivalent.

There is significant variation in the energy landscape across the ten countries in Southeast Asia (Figure 2.2). Several countries are endowed with ample energy resources. Indonesia, Malaysia and Brunei Darussalam, for example, have large fossil-fuel resources. A number of the other countries, however, are relatively poor in indigenous energy resources and much more reliant on energy imports.

Figure 2.2 ▷ Energy overview of Southeast Asia



This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries, and to the name of any territory, city or area.

Energy demand to 2040

Southeast Asia's total primary energy demand grows by 80% in the New Policies Scenario, increasing from 594 Mtoe in 2013 to 1 070 Mtoe in 2040 (Table 2.1). In 2013, Southeast Asia accounted for about 4% of global primary energy demand, a share that is set to increase over the *Outlook* period as the region's energy use expands at 2.2% on average per year, a faster pace than the global average, although slower than its 3.4% average growth from 2000 to 2013. This reflects a gradual slowdown in the economic and population growth rates, a shift towards less energy-intensive economic growth, fuel switching away from traditional use of biomass and energy efficiency gains.

Table 2.1 ▷ Primary energy demand in Southeast Asia (Mtoe)

					Shares		CAAGR*
	1990	2013	2020	2040	2013	2040	2013-2040
Fossil fuels	131	437	547	838	74%	78%	2.4%
Coal	13	91	151	309	15%	29%	4.6%
Gas	30	133	149	220	22%	21%	1.9%
Oil	89	213	247	309	36%	29%	1.4%
Nuclear	-	-	-	8	-	1%	n/a
Renewables	102	156	169	223	26%	21%	1.3%
Hydro	2	9	10	22	2%	2%	3.1%
Bioenergy	93	122	127	134	21%	13%	0.4%
Other **	7	25	32	67	4%	6%	3.8%
Total	**233**	**594**	**716**	**1 070**	**100%**	**100%**	**2.2%**

*Compound average annual growth rate. **Includes solar PV, wind, and geothermal.

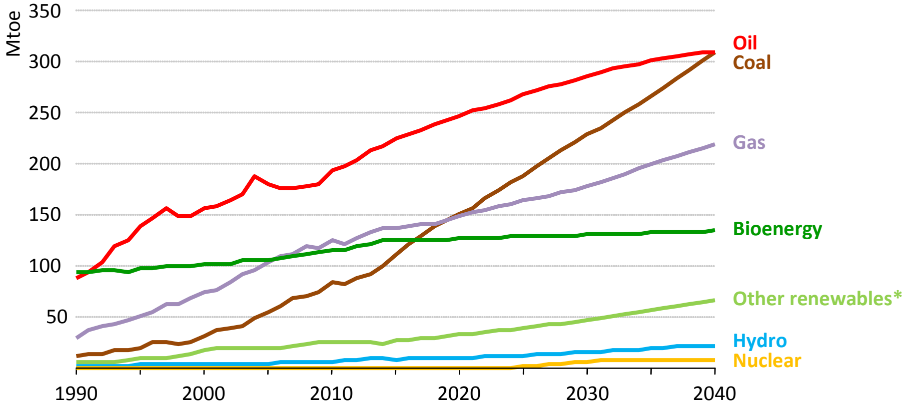
Outlook by fuel

Southeast Asia's total primary energy demand (TPED) remains heavily reliant on fossil fuels with their share of 74% in 2013 expanding to 78% in 2040. However, the fossil-fuel mix shifts and other energy sources, particularly solar photovoltaic (PV) and wind, grow at rapid rates, but from very low levels.

Oil demand rises steadily from 4.7 million barrels per day (mb/d) in 2014 to 5.4 mb/d in 2020 and 6.8 mb/d by 2040. Despite the increase, oil's share of TPED drops from 36% to 29% over the period. Contributing factors include: fuel switching to less expensive coal and natural gas in electricity generation and industry; efficiency gains in the transport sector; expanded use of biofuels; and a push to improve energy security by diversifying the energy supply mix.

Coal demand more than triples over the *Outlook*, growing at 4.6% per year on average. Large coal reserves, particularly in Indonesia and to a lesser extent in Viet Nam, its lower price relative to other fuels and the need to provide electricity to the 120 million people in the region that still lack access all contribute to coal's expanding role in the fuel mix, especially in Indonesia, Malaysia, Philippines, Thailand and Viet Nam. Southeast Asia is one of the few regions in the world where coal's share of the energy mix is projected to increase: by 2020, coal's share of primary energy demand rises to 21%, overtaking natural gas. By 2040 coal just surpasses oil to become the most consumed fuel, accounting for 29% of the mix (Figure 2.3).

Figure 2.3 ▹ Primary energy demand by fuel in Southeast Asia, 1990-2040



*Includes solar PV, wind, and geothermal.

Demand for natural gas increases by almost two-thirds, from 161 billion cubic metres (bcm) in 2013 to 265 bcm in 2040, driven by expanded use in industry and power generation. Indonesia is responsible for almost half of the increase, though without adequate investment, a lack of infrastructure could constrain growth in natural gas use. The share of natural gas in Southeast Asia's total primary energy demand, currently around 22%, declines by almost two percentage points by 2040. There are several reasons for this relatively slow growth. First, gas faces competition from abundant and cheap coal. Second, several supply challenges related to natural gas confront the region. There is a mismatch between centres of demand and the location of natural gas reserves. Additionally, many of the existing natural gas basins are mature and Southeast Asia's difficulties in bringing new production online mean that increasingly gas demand will need to be met by liquefied natural gas (LNG) imports, which are likely to be relatively expensive.

The share of renewable energy sources in TPED decreases from 26% in 2013 to 21% in 2040.[1] However, this trend masks significant changes in the overall contribution of renewables to the region's primary energy mix. Most importantly, the share of bioenergy – the traditional use of which is often associated with significant hazards for human health – declines steadily from 21% in 2013 to 13% by 2040, related to rapid urbanisation and rising living standards that encourage the adoption of modern fuels. The decline in the traditional

[1] Renewables includes bioenergy, geothermal, hydropower, solar PV, and wind.

use of biomass is partially compensated by the increased use of other renewables, such as wind, solar, hydro and geothermal (mainly in power generation) where their contribution to TPED increases throughout the *Outlook* period, reaching 8% by 2040 (Box 2.1).

Box 2.1 ▷ How has the *Outlook* for energy demand in Southeast Asia changed since the 2013 report?

The projections in this *Outlook* differ in many important ways from those in the *Southeast Asia Energy Outlook: World Energy Outlook Special Report* (*Outlook-2013)* that was published in 2013.[2] In this edition the projection period has been extended by five years to 2040 so comparison is best done using the data for 2035. In the New Policies Scenario, we now project that Southeast Asia's total primary energy demand will be 2.1% lower compared with *Outlook-2013.* This is the result of two main factors. First, the prolonged period of high international energy prices between 2010 and mid-2014 led many governments in the region to take more stringent action to improve energy efficiency, even though efforts are still expected to fall short of its full potential. The region's energy intensity is now projected to decline more rapidly (at an average annual rate of 2.2% compared with 1.9% in *Outlook-2013)*. Second, Indonesia, Malaysia, Myanmar and Thailand have made more progress with fossil-fuel subsidy reform than assumed in the 2013 report. These factors counteract the increase in demand that would result from lower prices as well as from an increase in economic growth.

Looking at projected demand by fuel, we have lowered oil demand in 2035 by 0.2 mb/d due to the significant progress that many countries in Southeast Asia recently have achieved in removing subsidies to oil products and the implementation of more stringent fuel-economy standards. Coal demand is also 5%, or around 20 million tonnes of coal equivalent (Mtce) lower compared with the 2013 data, reflecting the reduction in the region's total primary energy demand, larger efficiency improvements in the coal-fired power fleet as well as switching from coal to natural gas in the industrial sector. Compared with the *Outlook-2013*, projected electricity demand and the generation mix are essentially unchanged as faster penetration of electricity use in final consumption offsets slower growth in total primary energy demand.

These projections for renewables represent a modest expansion relative to their potential. While many countries in Southeast Asia are promoting the penetration of modern renewables (see Chapter 1, Table 1.1), significant barriers will need to be overcome in order to exploit their full potential. In addition to reforms to the domestic electricity sectors and the elimination of market distortions (especially in terms of electricity and fossil-fuel subsidies), the renewables sector would benefit from strengthening the grid, which would facilitate the integration of distributed generation, and the introduction of suitable financing options for the development of renewable energy projects.

[2] Available at: *www.worldenergyoutlook.org/southeastasiaenergyoutlook*.

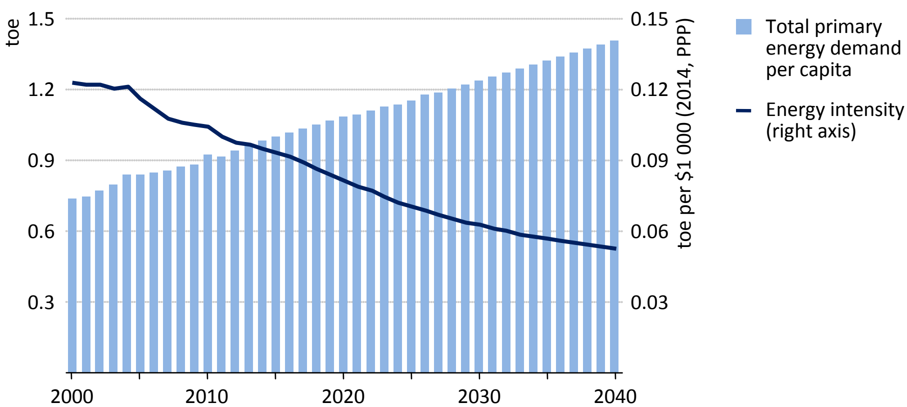
Over the *Outlook* period, nuclear power does not play a major role in Southeast Asia, with the region's first operating plant coming online late in the projection period in Viet Nam. The limited role for nuclear can be explained by the high upfront capital costs, limited access to financing, and uneven and tepid public support in the wake of the Fukushima Daiichi nuclear accident. Public opposition has been especially evident in Indonesia, Malaysia, Philippines and Thailand.

Per-capita energy demand and energy intensity

Southeast Asia's per-capita energy demand has grown steadily since 2000 to reach 0.96 tonnes of oil equivalent (toe) per person by 2013, though levels vary widely among the countries. For the region as a whole, per-capita demand increases to 1.4 toe by 2040, however, when compared to other emerging economies in Asia it remains well below China's average and just above India's.

Southeast Asia's energy intensity – the amount of energy required to generate a unit of gross domestic product (GDP) – declines by 2.2% per year over the *Outlook* such that by 2040 the region requires just 55% as much energy per unit of GDP as it did in 2013 (Figure 2.4). Several factors help reduce energy intensity over the period. They include: a shift in the population from rural to urban areas and an associated shift away from the traditional use of solid biomass to more modern and efficient energy sources; the removal of fossil-fuel subsidies in Indonesia, Malaysia and Thailand; and the penetration of more efficient appliances and technologies (see Chapter 5 for discussion on subsidies). Significant scope for improving energy efficiency remains despite these gains. Untapped efficiency potential is available throughout the energy transformation and end-use sectors (Box 2.2). Further improvements in the efficiency of fossil-fuel power plants, vehicles, appliances and lighting, and reduced losses from the transmission and distribution of electricity would contribute to a further decline in energy intensity.

Figure 2.4 ▹ Primary energy demand per capita and energy intensity in Southeast Asia



Notes: PPP = purchasing power parity; toe= tonne of oil equivalent.

Box 2.2 ▷ Southeast Asia: still plenty of scope for greater energy efficiency

As primary energy demand in Southeast Asia is projected to increase at a rapid pace, the extent to which countries in the region improve energy efficiency will have huge implications for their energy and economic balances. *Outlook-2013* highlighted that the region is on track to tap only a quarter of its economically viable energy efficiency potential. Since that report, Southeast Asia has made some progress by introducing more stringent policies, but there remain huge opportunities for energy efficiency improvements across the entire energy system.

In the buildings sector, wherein significant potential remains untapped, mandatory minimum energy performance standards (MEPS) for appliances, including equipment and lighting, have proven to be one of the most cost-effective energy efficiency measures in many parts of the world, but only half of the countries in Southeast Asia have introduced MEPS. To further promote their effective introduction, it would be helpful if roadmaps were developed and adopted that set a schedule for increasingly stringent standards over time, thereby enabling manufacturers to adapt over the course of their business cycles. The harmonisation of standards across the region would also provide equipment and appliance manufacturers with larger market opportunities and reduce the cost of meeting standards, while also lowering consumer costs. While efforts to harmonise energy standards have already been initiated by the ASEAN Centre for Energy (ACE), closer collaboration among member countries through sharing experiences in administration, testing and monitoring activities could maximise the benefits.

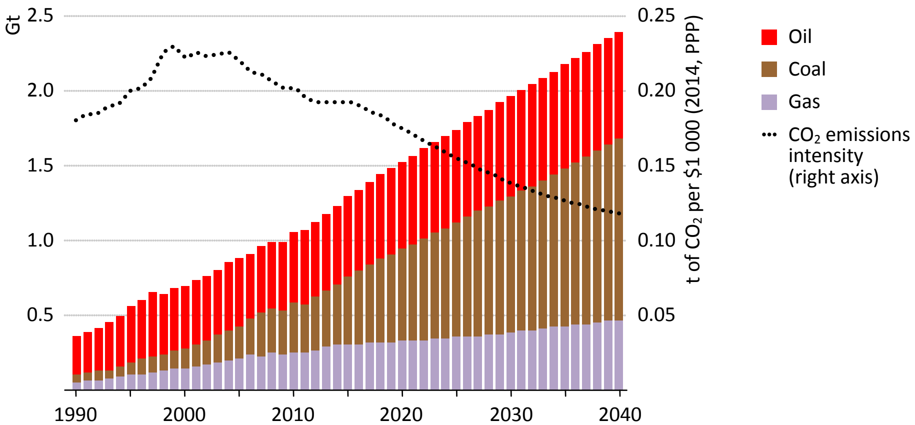
Although most countries in Southeast Asia have adopted building energy codes, their rigour and enforcement vary significantly and in many cases they are not mandatory. Harmonisation and close collaboration in policy planning and implementation of building energy codes could deliver significant benefits across the region through sharing resources such as research into performance levels, capacity building, design and ratings tools, and compliance monitoring. The benefits of such action could be particularly significant as the region is going through rapid and large-scale urbanisation, meaning that early implementation of best practices could lead to immediate gains.

The transport sector is another area where Southeast Asia would benefit from experiences and practices in other parts of the world, especially in terms of fuel efficiency standards for two-, three- and four-wheel passenger vehicles. A faster convergence with international best practices would provide significant gains in terms of reduced spending on oil, while improving local air quality and moderating GHG emissions growth in the sector.

Energy-related CO_2 emissions

In the New Policies Scenario, the increasing dominance of fossil fuels in Southeast Asia's energy mix drives an increase in energy-related carbon-dioxide (CO_2) emissions. They rise from less than 1.2 gigatonnes (Gt) of CO_2 in 2013 to almost 2.4 Gt in 2040, an increase almost equivalent to the current CO_2 emissions of Japan. Southeast Asia's share of global emissions, at 4% in 2013, is small, but it almost doubles by 2040. CO_2 emissions grow at a faster pace than primary energy demand due to the increasing share of coal in the energy mix.

Figure 2.5 ▷ CO_2 emissions from fossil fuels and CO_2 emissions intensity in Southeast Asia, 1990-2040



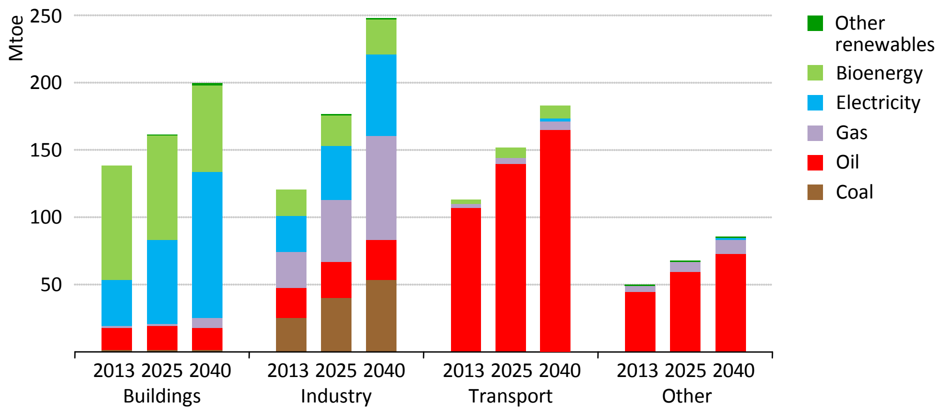
Notes: t = tonnes; PPP = purchasing power parity; Gt=gigatonnes.

Today, oil is the largest contributor to CO_2 emissions, but it is overtaken by coal before 2020. By 2040, coal accounts for half of the region's CO_2 emissions with oil making up 30% and natural gas 20% (Figure 2.5). The power sector accounts for just under two-thirds of the increase over the period, followed by industry which is responsible for 20%. The transport sector's share of CO_2 emissions declines from 28% in 2013 to 21% in 2040 as vehicle efficiency standards take hold, and as natural gas and biofuels make some in-roads as transport fuels. Compared with global averages, Southeast Asia has a high-carbon intensity per dollar of GDP. Its carbon intensity per $1 000 GDP (PPP) improves significantly by 2040, falling by nearly 40% compared with 2013, however, it falls less than the improvements in energy intensity.

Outlook by end-use sectors

Total final energy consumption grows an average 2% per year, rising about 70% over the period to just over 710 million tonnes of oil equivalent (Mtoe) by 2040, driven by ongoing urbanisation and increased economic activity across the region, especially in the services and industry sectors (Figure 2.6).[3] Compared with the previous two decades where total final energy consumption increased an average of 3.9% per year, growth slows over the period to 2040 as the structure of the economy shifts, energy intensity declines and efficiency measures are expanded and take hold.

Figure 2.6 ▹ Final energy consumption by fuel and sector in Southeast Asia



Notes: Buildings sector includes residential and services. Other includes agriculture and non-energy use. Other renewables includes solar PV, wind, and geothermal.

Energy demand in industry grows at 2.7% per year on average to almost 250 Mtoe in 2040, or more than twice the level in 2013, making it the largest end-use sector. Natural gas use in industry grows the most, at an average of 4% per year to meet almost a third of the sector demand in 2040, an increase of nine percentage points from 2013. This increase is driven by natural gas use in the chemicals sub-sector, and iron and steel production. Electricity and coal use also expands, with each accounting for over 20% of industrial energy demand throughout the *Outlook*. In Southeast Asia, cement and chemicals are the largest industrial energy consumers in 2013, but energy demand from the iron/steel sub-sector grows an average 5.6% per year, and by 2040 is the largest consumer followed by chemicals. Growth in the chemicals industry, in particular, is a large driver as higher domestic demand spurs the increase in energy consumption, with oil the predominant feedstock. Among the countries in the region, Malaysia is projected to make use of its advantaged position in terms of petrochemical feedstock to grow their domestic petrochemical industries. Energy demand in the paper/pulp sub-sector also increases, particularly in Thailand, Malaysia, Viet Nam and Indonesia, most of it for domestic consumption though Indonesia is an exporter. Industrial energy intensity, measured as tonnes of oil equivalent (toe) per $1 000 of value added, declines such that by 2040 the region requires 62% as much energy per unit of GDP as in 2013 in the industrial sector. Contributing factors include replacing outdated and less-efficient technologies and more widespread use of energy audits and management systems.

[3] Total final consumption is the sum of energy consumption in industry, transport, buildings (which includes residential and services sectors), agriculture and non-energy uses. It excludes international bunkers.

Energy demand in buildings, which includes residential and services, grows at an annual average of 1.4% between 2013 and 2040. Residential energy demand continues to account for the majority, though at a lower average growth rate of 0.9%, reflecting the ongoing shift from solid biomass to more modern and efficient forms of energy in households, including electricity and natural gas. Excluding traditional biomass, the growth of residential energy consumption between 2013 and 2040 averages 3.7% per year. Electricity's share of energy demand in the residential sub-sector increases by almost 30 percentage points between 2013 and 2040 to reach 45%. The biggest share of electricity consumption is for appliances which account for over half of residential electricity demand by 2040, followed by cooling. Increasing energy demand in households is driven by several key factors, including rising living standards and the accompanying uptake of appliances, urbanisation and a push to improve electricity access in rural areas. Demand in services – energy used in commercial and institutional buildings – more than doubles, driven by rising demand for electricity for lighting, appliances and cooling.

Economic growth, increased demand for mobility and limited public transport networks in some countries spur the increase in transport energy demand, which grows at 1.8% per year to 2040. Its share of total final consumption declines marginally, from 27% in 2013 to 25% in 2040. In 2013, the transport sector accounted for half of Southeast Asia's total oil demand, a share that rises to 53% by the end of the projection period. Oil remains dominant, representing more than 90% of energy demand in transport in 2040. The progressive phase-out of subsidies in most of the region, deployment of more efficient vehicles and the development of mass transport systems in large urban areas such as Jakarta, Kuala Lumpur and Bangkok all contribute to a slowdown of growth in oil demand in the second-half of the *Outlook*. Moreover, the continued problem of congestion in urbanised areas further constrains individual car use. As a result, the average annual growth of oil demand slows from 2.2% from 2013 to 2025 to 1.1% from 2025 to 2040. In the New Policies Scenario, alternative transport fuels (natural gas and biofuels) meet about 8% of demand in transport by 2040, up from 5% in 2013. A number of countries in the region have policy measures to promote alternative liquid fuels in order to decrease oil imports and address air pollution concerns (Box 2.3).

Car ownership in Southeast Asia is low compared to global averages, so there is ample potential for growth. The passenger light-duty vehicle (PLDV) stock rises from 22 million in 2013 to over 62 million in 2040 in the New Policies Scenario. Yet, while the PLDV ownership per capita more than doubles over the period, to 82 vehicles per 1 000 people in 2040, it remains significantly lower than the global average (of around 230 PLDVs per 1 000 people at that time). Indonesia, with roughly 40% of the region's population, accounted for 38% of total motor vehicle sales in 2014, as more consumers shifted from motorcycles to cars as their incomes increased (AAF, 2014). Other energy demand, which includes agriculture and non-energy use (primarily oil and gas feedstock for the petrochemical industry) constitute a small though steady share of total final consumption (at 12%) over the *Outlook* period.

Box 2.3 ▷ Air pollution in Southeast Asia

Rapid expansion of industrial activities, increasing motorisation and urbanisation processes often have adverse impacts on the environment, deteriorating air quality and increasing greenhouse-gas emissions. According to the World Health Organization (WHO), the largest contributors to outdoor air pollution in urban areas include coal-fired power plants, biomass and coal use for cooking, vehicle transport and industries (WHO, 2011).

Southeast Asia is no exception and almost all urban areas in the region present high levels of air pollution, including particulate matter less than 10 microns diameter (PM10) and 2.5 microns (PM2.5), which can cause serious respiratory problems. The latest available WHO data show that the annual mean PM10 levels are 38 micrograms per cubic metre ($\mu g/m^3$) and 48 $\mu g/m^3$ in Jakarta, exceeding the WHO Air Quality Guidelines threshold of 20 $\mu g/m^3$ (WHO, 2014).

The continuing rise of Southeast Asia's energy demand, as well as increasing industrialisation and transportation needs, are set to create substantial challenges to the region's stated goals of moderating air pollution while balancing energy and economic priorities. However, economic development and urbanisation also present opportunities to facilitate the transition to modern forms of energy and improving energy efficiency, energy-related carbon emissions and air quality. Those include the more efficient use of coal and the introduction of advanced control technologies for local pollutants, more stringent vehicle fuel standards, smart traffic systems that can minimise energy use in a cost-effective manner and efficient urban planning. Various efforts are being taken, both on a regional and country basis. For example, Clean Air Asia – a UN-recognised partnership to promote better air quality and liveable cities – works with governments, the private sector and development organisations to transfer technical knowledge that can be incorporated into policies and actions. Another example is the National Land Public Transport Master Plan, formulated by Malaysia in an effort to encourage modal shifts in transport. Similar efforts are being made in other countries. Energy policy-makers will need to increasingly consider the local pollution implications of the choices they take to meet growing energy needs.

Power sector

Electricity generation

Electricity generation in Southeast Asia grows by 3.9% per year on average in the New Policies Scenario. By 2040, Southeast Asia's total electricity generation almost triples from 789 terawatt-hours (TWh) in 2013 to about 2 200 TWh in 2040. The increase is more than the current generation of India. To meet electricity demand growth, which almost triples, all sources of generation increase, with the exception of oil that sees its share dropping from 6% to less than 1% by 2040 (Table 2.2).

Table 2.2 ▷ Electricity generation by fuel in Southeast Asia (TWh)

	1990	2013	2020	2040	Shares 2013	Shares 2040	CAAGR* 2013-2040
Fossil fuels	120	648	925	1 699	82%	77%	3.6%
Coal	28	255	482	1 097	32%	50%	5.6%
Gas	26	349	406	578	44%	26%	1.9%
Oil	66	45	36	24	6%	1%	-2.2%
Nuclear	-	-	-	32	-	1%	n.a.
Renewables	34	141	180	481	18%	22%	4.7%
Hydro	27	110	119	255	14%	12%	3.2%
Geothermal	7	19	27	58	2%	3%	4.2%
Bioenergy	1	10	22	75	1%	3%	7.7%
Other**	-	2	12	93	0%	4%	16.0%
Total	**154**	**789**	**1 104**	**2 212**	**100%**	**100%**	**3.9%**

*Compound average annual growth rate. **Includes wind and solar PV.

Coal increases its share in power generation from 32% to 50%, while the share of natural gas declines from 44% to 26%. This trend is underpinned by the price advantage and relative availability of coal versus gas in the region. Southeast Asia's three largest energy consumers, Indonesia, Thailand and Malaysia, have stated their intention to expand their use of coal. Coal-fired generation grows faster than every other source (except bioenergy, wind and solar PV) to reach almost 1 100 TWh by 2040. This continued ramp-up of coal-fired generation is a departure from many other parts of the world which are experiencing a decline in coal's share due mainly to environmental concerns. Several countries, international development banks and financial institutions recently have decided to scale back or to stop funding new coal-fired power plants (see Spotlight).

The share of fossil fuels in Southeast Asia's electricity generation mix declines from 82% in 2013 to 77% in 2040, in line with the rapid growth in renewables, which supply 22% of generation in 2040. The share of hydropower in total generation decreases from 14% to 12%, although its incremental output is the third-largest after coal and gas. The share of geothermal rises marginally to 3%, led by increasing exploitation of the large potential in Indonesia and Philippines. Onshore wind and solar PV grow at a particularly fast pace, though from low levels. Nuclear power enters the mix in the latter half of the *Outlook* as Viet Nam completes construction of some of its planned reactors.

SPOTLIGHT

Is the end in sight for international financing of coal-fired generation?

Over the last few decades, international financial institutions (IFIs) have provided financial support for coal plants (IEA, 2014a). Projects in Asia, especially India, Indonesia, Philippines and Viet Nam have been major recipients of financing. Much of this financing has been directed towards the deployment of more efficient coal-fired generation technologies, as without it countries that build new capacity may be less inclined to select the more efficient, though more expensive design.

In 2013, the landscape of coal financing shifted, as several international development banks, financial institutions and credit agencies – including the World Bank Group, European Investment Bank, US Export-Import Bank, the European Bank for Reconstruction and Development and the UK Export Credits Guarantee Department – announced that they would stop or limit funding for coal-fired power plants. The Asian Development Bank originally stated that it would selectively fund coal projects if cleaner technologies and other safeguards were used; in practice the funding possibilities have become very narrow. The United States, United Kingdom and other European nations are cutting funding for coal plants and banning export credit agencies from providing financial backing for overseas projects. These decisions are part of the ongoing dialogue on how best to reduce global CO_2 emissions while providing adequate energy to further economic development and improving access to electricity.

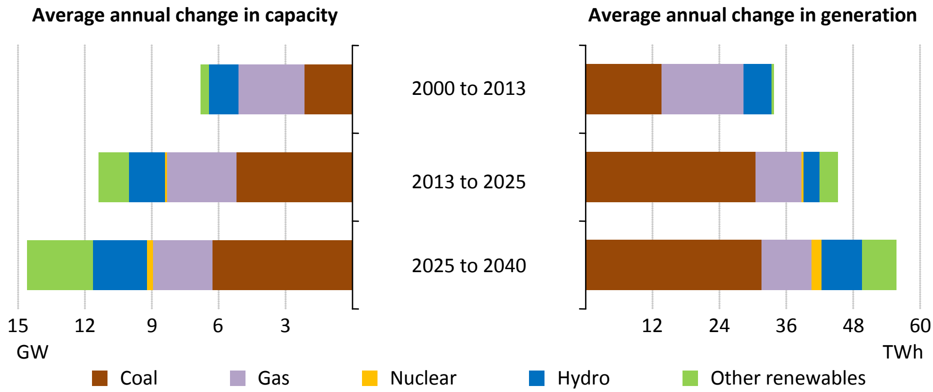
The decisions by IFIs to withdraw or limit funding will not impact all countries equally. Some economies, such as China, will likely be less affected as they have large financial resources, well-established capital markets and a track record with foreign banks, plus the ability to attract private investment. But for other countries, including some in Southeast Asia, private investment sources are wary of investing in places where they lack experience with local regulations or where financial systems are less robust. And many of these countries lack the domestic financial resources that could enable them to finance power plants on their own. Given the still relatively small size of power systems in some parts of Southeast Asia, a standard coal-fired power plant can easily be a significant fraction of its entire system capacity and would be a large investment for any player in the country.

Yet the international development banks are not the only sources of funding. Chinese banks and equipment manufacturers are a key source of funding for coal projects both domestic and abroad, including in Southeast Asia. While a 2014 report stated that China was the largest source of overseas public funding of coal power plants, the study acknowledges that a lack of transparency and data scarcity make it hard to confirm (Uneo, et al. 2014). Nevertheless, it does highlight the growing role of China in financing overseas coal power plant projects. China has already invested in Indonesia, Viet Nam and India among others. Additionally, the establishment of new institutions, such as the Asian Infrastructure Investment Bank, the Silk Road Fund and the New Development Bank could fill the gap in funding left by the other international institutions that have withdrawn from coal financing.

Generation capacity

In the New Policies Scenario, Southeast Asia's generation capacity increases from 210 gigawatts (GW) in 2014 to almost 550 GW in 2040. The power sector has already begun to shift towards coal; in the last five years, over half of gross thermal capacity additions were coal-fired, a trend we project to continue in the medium-term. Over the projection period, coal accounts for about 40% of gross capacity additions, followed by renewables at 33% (of which 14% is hydro) and gas at 24% (Figure 2.7). The expansion of power grids to reach remote areas and the higher cost of oil relative to other fuels results in retirements of oil-fired plants which more than offsets construction of new ones.

Figure 2.7 ⊳ Average annual change in capacity and electricity generation in Southeast Asia



Note: Oil is not shown as its change is negligible.

Southeast Asia's coal-fired capacity grows at an average annual rate of 5.4% to 2040, expanding by 150 GW. Coal's share of generation capacity grows from 24% in 2014 to 37% in 2040. It overtakes natural gas by 2030 to become the largest source of power capacity in Southeast Asia. The pace at which coal-fired capacity expands slows markedly in the second part of the *Outlook*, due to lower growth in electricity demand and more development of renewables capacity. Indonesia, Malaysia and Thailand are expected to lead the expansion of coal capacity in Southeast Asia. Thailand has proposed the construction of coal-fired power plants in neighbouring Cambodia and Myanmar, in order to export electricity back to Thailand, as it has faced significant opposition to building domestic coal plants. Several of these projects, however, have been put on hold as opposition to the environmental impacts of coal-fired generation has triggered a political backlash to exports in several countries (developments in Malaysia's power sector are detailed in Chapter 4).

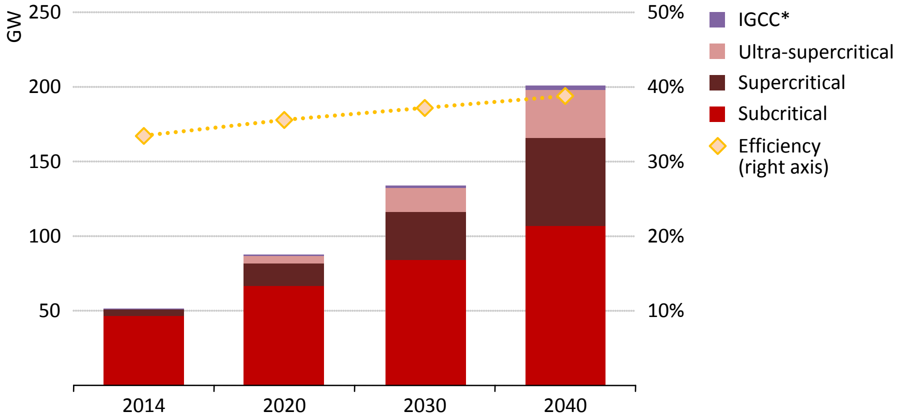
Given the increasing significance of coal in power generation, the region will need to find a way to balance its energy security, development and access needs with environmental considerations. In this respect, there is an urgent need to deploy more efficient coal-fired power plant technology rather than the subcritical units that are currently the norm. In 2014, subcritical technologies represented more than 90% of installed coal-fired capacity and over 70% of the coal capacity added. The widespread adoption of more efficient plants heretofore has been limited by financing, the ready availability of cheap coal (which discourages investment in more efficient plants), a lack of technical expertise and in some parts of the region the structure of the grid (as high-efficiency coal plants are typically large, smaller grids are not capable of handing the increased load). By contrast, subcritical plants have been favoured because of their lower upfront costs and shorter lead times.

Subcritical coal-fired power plants in Southeast Asia operate at low average efficiency (33% in 2014 increasing to 35% by 2040) and have higher operating costs since their lower efficiency levels imply larger volumes of fuel input. This compares with efficiencies of supercritical and ultra-supercritical units that are projected to reach as high as 40% and 45% respectively. For countries such as Malaysia and Thailand, which rely on the international market to procure the bulk of their coal needs and therefore face greater risk of price fluctuations, there is additional incentive to build more efficient power plants. Indeed, Malaysia completed construction of its first ultra-supercritical plant (1 GW capacity) in the first half of 2015. By comparison, Indonesia has less incentive to develop higher efficiency power plants as it has ample low-cost domestic coal resources.

In the New Policies Scenario, the existing and planned subcritical coal capacity is essentially locked-in as operating lifetimes are usually 40 to 50 years. However, we project a gradual shift towards more efficient coal-fired generation as a growing share of new capacity additions are supercritical or ultra-supercritical; over the *Outlook* period, supercritical and ultra-supercritical technologies represent the majority of new coal-fired gross capacity additions at 35% and 21% respectively, while the remaining coal-fired capacity additions are subcritical power plants. As a result, the share of subcritical plants in installed coal capacity declines to 76% by 2020 and 53% in 2040 (Figure 2.8). This shift drives an increase of more than five percentage points in the average efficiency of Southeast Asia's coal-fired power plants over the *Outlook* period, in absence of which, coal consumption in the power sector would be almost 16% higher. A shift to supercritical and ultra-supercritical technology will be an important way to limit the rise in energy-related CO_2 emissions and mitigate some environmental impacts.

Renewables-based installed capacity increases from 49 GW in 2014 to almost 170 GW by 2040 when it accounts for 31% of power generation capacity. Renewables remain an attractive option for Southeast Asia, in part because of their widespread availability and their ability to help meet key policy goals such as energy security and sustainability, although their deployment is projected to fall short of the potential (Box 2.4). Considerable investment, additional infrastructure and in many cases targeted government measures will be required to facilitate more renewables-based generation. Most Southeast Asian countries have adopted related targets and measures (see Chapter 1, Table 1.1). The most common form of support is feed-in tariffs (FiT), which are in place in Indonesia, Malaysia, Philippines and Thailand.

Figure 2.8 ▷ Installed coal-fired capacity by technology type in Southeast Asia, 2014-2040



*Integrated gasification combined-cycle.

Hydropower had the largest share of installed capacity among renewables in 2014 and by adding about 54 GW of gross capacity over the period it is set to remain the largest renewable energy source by 2040. Currently hydro is the dominant source of installed generation capacity in Lao PDR, Myanmar and Viet Nam. According to a Strategic Environmental Assessment (SEA) conducted by the Mekong River Commission in 2010, current designs for 12 mainstream dams in the lower Mekong Basin have potential capacity of up to 15 GW (ICEM, 2010). This is equivalent to more than 40% of Southeast Asia's hydro capacity in 2014 and 7% of total installed capacity in 2014. Sites for hydro development are often far from demand centres which is a common issue in the region. This is especially a concern for Malaysia and Myanmar, which have the largest technical potential for hydropower development, as inadequate transmission infrastructure could constrain development. This coupled with the socio-economic concerns which typically accompany proposed large hydro projects has slowed development. It has also encouraged a view of cross-border projects that could expand electricity access and stimulate economic progress at a regional level. Export-oriented hydro projects, however, are facing increasing political difficulties.

Wind, geothermal and solar PV represent 11% of total installed capacity in 2040 in the New Policies Scenario, an increase of nine percentage points from 2014. Continued policy and fiscal support and the removal of fossil-fuel subsidies contribute to their expansion. Together they add around 63 GW of gross capacity by 2040. Installed renewables capacity from wind and solar PV increases from just over 2 GW in 2014 to 54 GW in 2040. Bioenergy also makes in-roads over the *Outlook* period: its share of installed capacity remains at 3%, though it grows in absolute terms from 6.5 GW in 2014 to 16 GW by 2040.

Southeast Asia's power sector will require \$1.3 trillion of investment over the projection period (see Chapter 5). While investment in all fuel types is required, it will be especially important to invest in more efficient power plants and transmission and distribution (T&D) networks to meet increasing demand. The large mismatch in supply and demand due to the geography of the region and the distributed nature of the population mean that a larger portion of investment needs is in T&D, accounting for 53% of the total. Southeast Asia has several initiatives underway to strengthen and expand the intra-regional grid interconnections to address some of these needs (see Chapter 5).

Box 2.4 ▷ Potential for renewables in power generation in Southeast Asia

Renewable energies are already an important component of Southeast Asia's energy mix, accounting for more than one-quarter of total primary energy demand. However, today the largest share of renewables, about 70%, is solid biomass, primarily used for household cooking in traditional stoves. There is significant scope for countries in the region to expand the penetration of renewables in their energy mix. Although there are large variations among countries, the technical potential for modern renewables is significantly larger than what has been developed. Hydropower is by far the largest source with technical potential estimated at 170 GW, compared with an installed capacity of 37 GW in 2014. Malaysia and Myanmar have the largest technical potential at 40 GW each. There is also significant potential in Cambodia, Lao PDR and Indonesia.

The technical potential of solar and wind in Southeast Asia is significant, but when compared with other regions, not exceptional. The region has an annual global horizontal irradiance ranging from 1 200 to 1 800 kilowatt-hours per square metre, a value comparable with southern Europe. Cambodia, Indonesia, Malaysia, Thailand and south Viet Nam are often referenced as having strong potential for solar development. Onshore wind potential is mainly concentrated in parts of Viet Nam and Lao PDR. The potential is larger for offshore wind and developments along coastlines, especially in the Philippines.

Southeast Asia is also endowed with significant geothermal potential, largely concentrated in the Philippines and Indonesia (respectively the world's second- and third-largest producers of geothermal power generation behind the United States) and, to a lesser extent, in Malaysia. Geothermal technical potential is estimated at more than 27 GW in Indonesia and around 5 GW for the Philippines, but assessments vary widely reflecting the uncertainty of the quality of the resource including temperature and depth, and the type of technology to be employed (IEA, 2014b).

Generation costs

Financial considerations will be a key determinant of the evolution of the mix of fuels and technologies used in Southeast Asia to generate electricity. The levelised cost of electricity generation – which includes fixed costs, variable costs (operation and maintenance and fuel) and financing costs for new power plants – is one metric that can be used to compare the costs of different technologies.[4] In order to make meaningful comparisons it is necessary to make a range of assumptions about various cost and operating parameters of competing technologies (Table 2.3).

2

Table 2.3 ▷ Cost and operational features of key power generation technologies in Southeast Asia, 2030

	Capital cost ($/kW)	Fixed O&M cost ($/kW)	Thermal efficiency	Capacity factor	Construction time (years)
Coal supercritical	1 600	64	41%	75%	5
Gas CCGT	700	25	58%	60%	3
Wind (onshore)	1 700	43	n.a.	27%	1.5
Solar PV (large scale)	1 600	24	n.a.	17.5%	1.5
Large hydro	2 500	55	n.a.	33%	4
Geothermal	3 200	64	10%	75%	4

Notes: The figures reflect assumptions in the New Policies Scenario and are used for the analysis of levelised electricity generating costs in Figure 2.9. All costs are in year-2014 dollars. The assumptions are considered representative averages for the region and are for projects that are completed in 2030. Capital costs include interest during construction and costs such as legal expenses, engineering, procurement and construction. The thermal efficiencies listed are the maximum currently attainable by each technology under standard conditions. Environmental factors, such as ambient temperature and operation conditions may mean that actual efficiencies achieved are lower. For coal, capacity factors are estimated averages for baseload operation, with mid-load operation for gas. O&M = operation and maintenance; CCGT = combined-cycle gas turbine. Source: IEA databases.

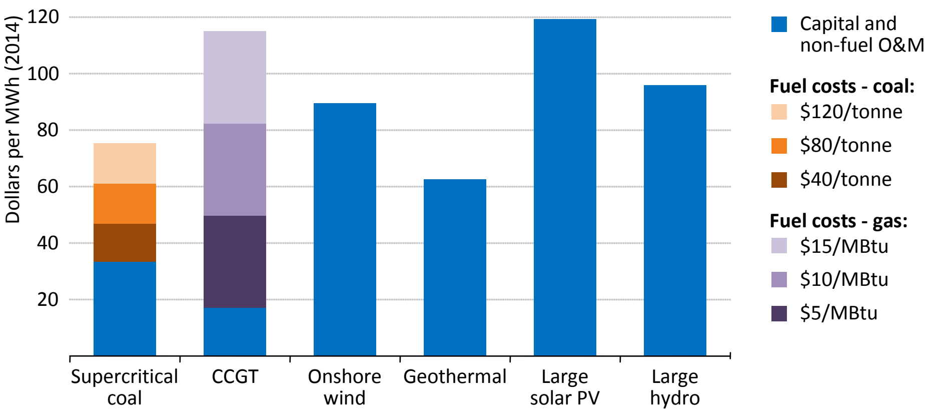
When both coal and natural gas are available relatively cheaply ($40 per tonne for coal and $5 per million British thermal units [MBtu] for gas), supercritical coal plants and combined-cycle gas turbines (CCGT) have similar generating costs, with coal being slightly lower at $47/megawatt-hour (MWh) and gas CCGT at $50/MWh (Figure 2.9). However, if fuel prices double (coal at $80/tonne and gas at $10/MBtu), coal becomes about 27% cheaper than the generating cost for a new CCGT plant. If gas prices increases to $15/MBtu, the generating costs for large hydro and onshore wind are cheaper than CCGTs. At almost $120/MWh, large-scale solar PV is the most expensive.[5] The generation cost for geothermal at $63/MWh can be competitive with mid-priced gas and high-priced coal (and just slightly more expensive than mid-priced coal). However, geothermal is concentrated in Indonesia and the Philippines, and is highly site specific.

[4] The levelised cost of electricity is useful for comparing the unit costs of technologies over their economic lifetime, but power companies also use portfolio investment-valuation methodologies to evaluate risks over their entire asset base, rather than focusing on the technology with the lowest stand-alone generating costs. Depending on the project, different risk profiles may be acceptable for different technologies.

[5] While this reflects the average costs of deployed solar technologies, some projects may be built at lower cost.

Coal prices in the region are set to remain relatively low in the medium to long term given the abundance of domestic resources, the absence of carbon pricing and the projected slower growth in international coal trade. Additionally the ongoing removal of subsidies to natural gas in some Southeast Asian countries and the reduced availability of indigenous gas production point towards a likely increase of gas prices in region's domestic markets.

Figure 2.9 ▹ Levelised cost of electricity by technology under different coal and gas price assumptions in Southeast Asia, 2030



Notes: CCGT = combined-cycle gas turbine. Assumed capital costs, non-fuel operation and maintenance (O&M) costs, thermal efficiency and construction lead times by technology are in Table 2.3. The assumed economic lifetime of plants – the period over which the initial investment is recovered – are assumed to be 30 years for coal; 25 years for CCGT; 20 years for wind; 20 years for geothermal; 20 years for large-scale solar PV; and 35 years for large hydro. The weighted average cost of capital is assumed to be 7%. No CO_2 price is assumed.

Energy and climate change in Southeast Asia

Climate change poses significant challenges for Southeast Asia as the region has a high concentration of settlements and economic activity along its long coastlines, and a strong reliance on natural resources, agriculture and forestry making it vulnerable to the effects of climate change, including extreme weather events. Effective action in the energy sector is an essential component of the global approach to combat climate change. Both factors have increasingly been incorporated in policy objectives and measures in the countries of Southeast Asia. However, while some decoupling of economic growth and energy-related CO_2 emissions is being witnessed in other parts of the world, in Southeast Asia the economy/emissions growth relationship remains robust as emissions are set to increase at an even faster pace than energy demand, due to growing penetration of coal in its energy mix.

Identifying near-term opportunities to reduce energy demand and emissions

The Bridge Scenario, developed for the *Energy and Climate: World Energy Outlook Special Report* (IEA, 2015), proposes a strategy to deliver a near-term peak in global energy-related emissions with the effective use of proven policy measures and currently available technologies. The scenario is not, in itself, a pathway to the internationally agreed target to limit the rise in global average temperatures to below 2 degrees Celsius (°C) relative to pre-industrial levels – additional technologies and policies would be needed for that. But it provides a strategy for near-term action as a bridge to higher levels of decarbonisation at a later stage compatible with the 2 °C goal. As a means to illustrate steps that could achieve an "early" peak in emissions, the Bridge Scenario has a shorter timeframe (2030) than the 2040 horizon in the New Policies Scenario. This section provides a brief overview of the Bridge Scenario, with a focus on the implications for Southeast Asia.

The Bridge Scenario depends upon five measures:

- Increasing energy efficiency in the industry, buildings and transport sectors.
- Progressively reducing the use of the least-efficient coal-fired power plants and banning their construction.
- Increasing investment in renewable energy technologies in the power sector from $270 billion in 2014 to $400 billion in 2030.
- Gradual phasing out fossil-fuel subsidies to end-users by 2030.
- Reducing methane emissions in oil and gas production.

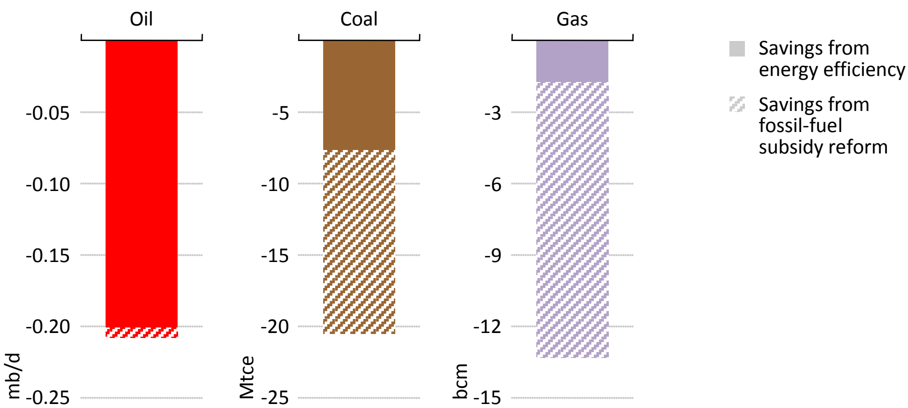
Effective implementation of the measures proposed in the Bridge Scenario would have profound implications for the region's energy demand and CO_2 emissions.[6] In the Bridge Scenario, Southeast Asia's primary energy demand is 2% lower in 2020 and 5% lower in 2030 compared with the New Policies Scenario. The primary energy mix shifts markedly between the two scenarios in 2030. The share of fossil fuels declines to 74% by 2030 in the Bridge Scenario, driven mainly by reduced coal consumption, while the contribution of renewables rises steadily to 26%. The power sector is fundamental to the change of Southeast Asia's energy mix in the Bridge Scenario. Coal's contribution to electricity generation is 35% lower and its share in the power mix declines to just above one-third by 2030. This results from measures that discourage the utilisation of less-efficient coal-fired power plants and from reduced electricity demand. Additional investment supports a fast expansion of renewables, which account for more than one-quarter of the electricity generation in 2030.

Natural gas demand increases by 2% in the Bridge Scenario. While the measure targeting the removal of fossil-fuel subsidies helps temper the rise in natural gas demand, it does not fully offset growth, especially in the power sector. The adoption of more stringent energy

[6] The measures assumed in the Bridge Scenario are in addition to the Intended Nationally Determined Contributions (INDCs). For more details, see *Energy and Climate Change*: *World Energy Outlook Special Report* (IEA, 2015) available at: *www.worldenergyoutlook.org/energyclimate/*.

efficiency requirements, especially in the transport sector, reduces Southeast Asia's oil demand by 0.2 mb/d in 2030. The phase-out of fossil-fuel subsidies (and the resulting reduction of fossil fuels that are combusted) and energy efficiency measures, including in the industrial sector and buildings, are important drivers of the reduction in the demand for primary energy and electricity (Figure 2.10).

Figure 2.10 ▹ Fossil-fuel savings from energy efficiency and fossil-fuel subsidy reform in Southeast Asia in the Bridge Scenario relative to the New Policies Scenario, 2030



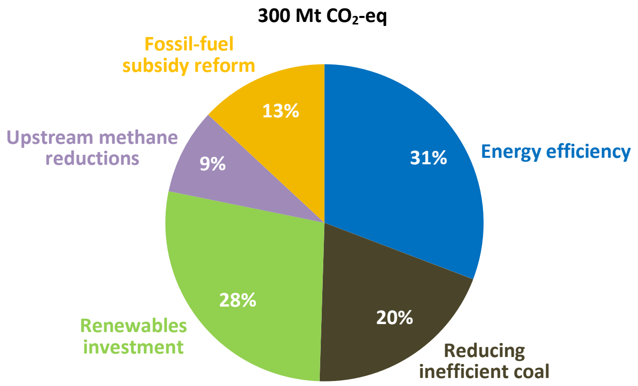
For net importing regions, as is the case for Southeast Asia with respect to oil, fossil-fuel subsidies are assumed to be phased out completely in ten years in both the Bridge Scenario and the New Policies Scenario.[7] This explains the limited savings in oil use linked to fossil-fuel subsidy reform in Southeast Asia in the Bridge Scenario (i.e. the savings have already been realised in the New Policies Scenario). The reduction in energy demand due to the phase-out of fossil-fuel subsidies is much more marked for natural gas (13 bcm) because in the Bridge Scenario, natural gas subsidies are completely phased out by 2030, while this is not achieved in the New Policies Scenario. However, as noted prior, the overall gas demand in Southeast Asia by 2030 is higher in the Bridge Scenario compared to the New Policies Scenario mainly due to a higher penetration of gas into the power sector principally at the expense of coal.

As a result of the various measures adopted in the Bridge Scenario and the accompanying shifts in energy demand, energy-related GHG emissions are also reduced. In the New Policies Scenario, Southeast Asia's energy-related CO_2 emissions rise from 1.3 Gt in 2014 to over 1.6 Gt in 2020 and almost 2.0 Gt in 2030, an average annual increase of 2.7%. In the Bridge Scenario, emissions rise to 1.5 Gt in 2020 and 1.7 Gt in 2030, growing an average 1.8% per year. Though Southeast Asia's emissions continue to rise even after 2030 in the Bridge Scenario, the average annual growth rate is less than in the New Policies Scenario.

[7] For more details on the assumptions in the Bridge Scenario, see *Energy and Climate Change: World Energy Outlook Special Report* (IEA, 2015).

As a result, emissions are reduced by around 300 million tonnes (Mt) of carbon-dioxide equivalent (CO_2-eq) in 2030, relative to the New Policies Scenario, equal to a 14% reduction. The largest GHG reductions come from improvements in energy efficiency and increasing renewable energy use followed by the reduced use of inefficient coal power plants, fossil-fuel subsidy reform and methane reductions from upstream oil and gas (Figure 2.11).

Figure 2.11 ▹ Energy-related GHG emissions reduction by policy measure in Southeast Asia in the Bridge Scenario relative to the New Policies Scenario, 2030



Prospects for fossil-fuel supply in Southeast Asia

An energy exporter or an energy importer?

Highlights

- Southeast Asia's fossil-fuel resources remain crucial to the region's future energy mix. Rising coal and natural gas production are increasingly earmarked for domestic markets in order to support the region's rapid economic growth and development. Oil output continues to decline as the most productive fields are progressively exploited and only partially replaced by new production.
- Oil production remains flat around 2.5 mb/d by 2020, but then steadily declines to 1.6 mb/d in 2040. Although their oil output flattens, Indonesia and Malaysia remain the dominant producers in the region; their combined share increases slightly to almost two-thirds of the total. The outlook for Southeast Asia's oil production will depend on the ability of the region's major resource holders to incentivise investment in under-explored areas and to deploy advanced production technologies to slow the decline in key fields.
- Natural gas production in Southeast Asia grows from 214 bcm in 2013 to around 260 bcm in 2040, led almost entirely by Indonesia and expanded output in Myanmar. The increase in gas output principally meets rising domestic consumption, driven by the development of LNG infrastructure that enables the exploitation of stranded resources and their delivery to regional demand centres.
- Indonesia remains a cornerstone in global coal markets. Coal production increases by more than 50%, reaching over 600 Mtce in 2040. Indonesia cedes its status as the world's largest coal exporter before 2020 to Australia, as domestic demand surges and coal demand growth on international markets slows.
- The outlook for fossil-fuel production in Southeast Asia varies by fuel and by country, hinging on their individual resource endowments, and remains subject to a number of uncertainties. The ability to attract private and foreign investment, to improve fiscal and regulatory frameworks and to push reforms in fossil-fuel subsidies will be critical to the development of Southeast Asia's energy supply.
- The projected trends in energy demand and supply in Southeast Asia imply that the region is set to increasingly rely on oil and gas imports. By 2040, net oil imports more than double to 6.7 mb/d, while the reliance on imported oil products declines as the region's refinery capacity expands by 2.6 mb/d and its utilisation rates increase. Due to rapid growth in domestic consumption, Southeast Asia surrenders its role as a major gas supplier to international markets, becoming a net gas importer of around 10 bcm in 2040. As a result, the net oil and gas import bill more than triples to about $320 billion in 2040.

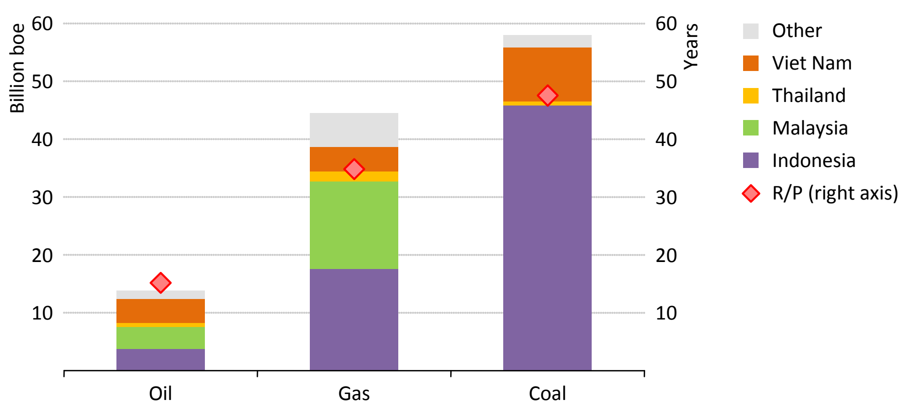
Supply

Overview

The prospects for fossil-fuel production in Southeast Asia vary by fuel and by country, based on specific resource endowments, their capacity to attract investment and ability to expand energy supply infrastructure, plus success in designing appropriate regulatory, environmental and fiscal policy frameworks. Overcoming longstanding territorial disputes – such as those in the South China Sea – could give a boost to prospects by triggering exploration in largely under-explored areas. This chapter sets out projections to 2040 for fossil-fuel production and oil refining in Southeast Asia as well as the implications for energy trade. (The prospects for Malaysia's oil and gas production are explored in more detail in Chapter 4.)

Southeast Asia's oil and gas resources, including 13.8 billion barrels of proven oil reserves and 7.5 trillion cubic metres (tcm) of proven natural gas reserves, are relatively modest compared with its current and projected energy demand. Its oil and gas reserves as of the end of 2014 represent less than 1% and 3.6% of the world total and are unevenly distributed across the region. Indonesia and Malaysia together hold the lion's share with 56% and 74% of the region's proven oil and gas reserves. Thailand and Philippines have very limited indigenous oil and gas reserves, while there is a significant upside potential – mainly for natural gas production – in Myanmar, which remains largely under-explored but has recently opened its energy sector to foreign companies. Southeast Asia has significant coal resources, the bulk of them in Indonesia – one of the world's largest producers and the largest exporter – and to a lesser extent in Viet Nam (Figure 3.1).

Figure 3.1 ▷ Proven reserves of oil, natural gas and coal, and reserves to production ratio for Southeast Asia



Note: boe = barrels of oil equivalent. The reserves to production ratio (R/P) provides an indication of how many years of production a country's current proven reserves would cover: it is not though a guide to long-term production potential, which depends on underlying recoverable resource base (the World Energy Model uses estimates of remaining recoverable resources as a key input to the modelling of future energy supply). Indonesia's coal resources are about six-times larger than its proven reserves and most of them could be put into production with relative ease.

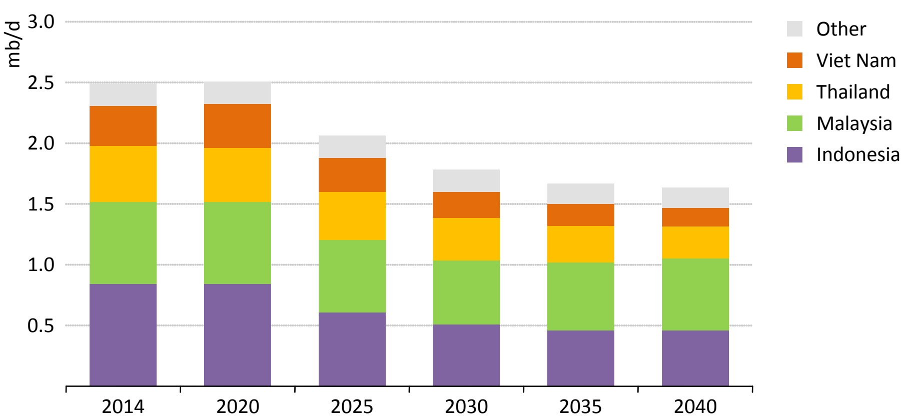
Fossil-fuel production in Southeast Asia has expanded significantly over recent decades, driven by increasing demand in domestic and export markets, but has been facing growing challenges in the last few years. Southeast Asia's oil production, which averaged 2.5 million barrels per day (mb/d) in 2014, has been in decline since peaking at 3 mb/d in 2001, mainly due to reduced production in Indonesia and to limited new discoveries. Southeast Asia's natural gas production stood at 214 billion cubic metres (bcm) in 2013 and has increased by about one-third since 2000, on rising output mainly in Malaysia and Thailand, and increased supply from Myanmar.[1] The region produced 450 million tonnes of coal equivalent (Mtce) in 2013, of which 89% was from Indonesia. Indonesia's coal exports have increased by a factor of seven since 2000, underpinned by its ample reserves of low-cost and low-sulphur coal and its proximity to major coal importers, particularly China and India. However, India's target to reduce its coal import dependence and China's ambition to diminish the share of coal in its energy mix might translate into a more difficult export environment for Indonesia's coal industry.

Outlook for energy supply

Oil

In the New Policies Scenario, Southeast Asia's oil production remains essentially flat to 2020 (at around 2.5 mb/d) and then gradually declines to 1.6 mb/d in 2040 (Figure 3.2). The resilience of Southeast Asia oil production in the period to 2020 could apparently contrast with the steep decline of oil prices since the second-half of 2014. In reality, the oil supply industry tends to respond slowly to price fluctuations, with operators reducing spending on new projects, while maximising already producing assets as a way to recover costs. Moreover, countries such as Malaysia and Viet Nam (the only one with oil output increasing, by about 50 thousand barrels per day [kb/d] by 2020) had already started to implement measures to counteract declining domestic oil production before the oil price plunged.

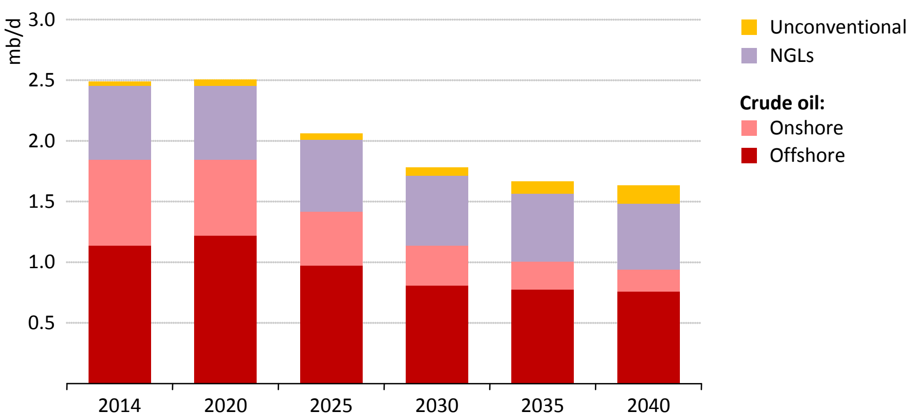
Figure 3.2 ▷ Oil production in key producer countries in Southeast Asia



[1] The base year for natural gas data is 2013. This chapter also includes preliminary estimates for 2014.

Post 2020, the outlook for Southeast Asia's oil supply deteriorates as there is an ongoing, gradual decline in production, mainly by reduced output in Indonesia, Thailand and Viet Nam. The assumed start of coal-to-liquids production (in Indonesia) and natural gas liquids (NGLs) output are able to slow, but not fully offset, the decline of crude oil production (Figure 3.3). The region's total oil production is set to account for less than 2% of global supply in 2040, down from 2.7% in 2014 and 3.8% in 2001. The vast bulk of the production by the end of the *Outlook* period comes from new fields which are yet to be brought online, as the majority of the major existing fields are already in decline. The trends and the drivers vary from country to country, but the overall result is that by 2040 oil production remains concentrated in the two largest oil-producing countries, Indonesia and Malaysia, with their combined share rising a few percentage points to reach almost two-thirds of the total.

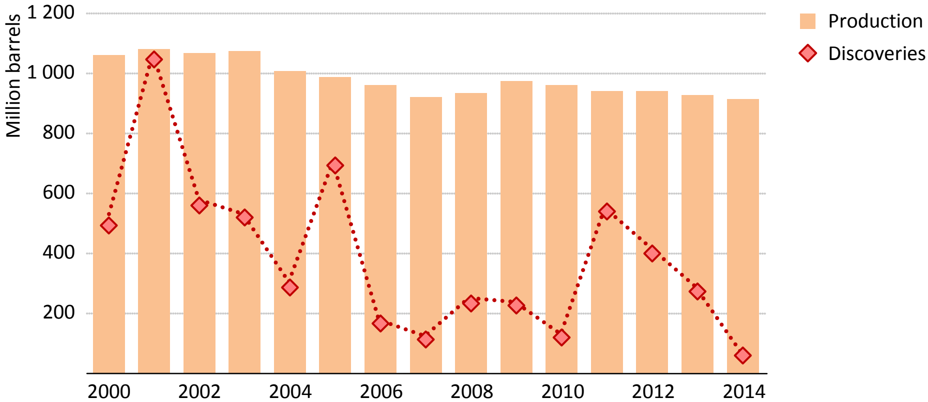
Figure 3.3 ▷ Oil production by type in Southeast Asia



Note: NGLs = natural gas liquids.

The *Outlook* rests on assumptions regarding several issues that remain uncertain, including the ability of the major resource holders in the region to incentivise investment, by domestic and international companies alike, in under-explored areas, and deploy new production technologies, which can be costly, to slow the decline in key fields. Our projections are consistent with the limited amount of new oil resources discovered in the region, which has long been less than oil produced. Since 2000, a total of 5.7 billion barrels of oil have been discovered, less than 40% of the volume of oil produced over the period (Figure 3.4).

Figure 3.4 ▷ **Oil discoveries and production in Southeast Asia, 2000-2014**



Note: Oil discoveries are for ultimately recoverable resources. Source: IEA analysis based on data from Rystad Energy AS.

Indonesia's proven reserves, at 3.7 billion barrels at the end of 2014, are the third-largest in the region, after Viet Nam and Malaysia, but its remaining recoverable resources, at about 40 billion barrels, are by far the most abundant, accounting for about half of the total in Southeast Asia. The country's oil sector is characterised by declining production in its largest oil fields, a low reserves replacement ratio and delays in developing new fields. Since it peaked at 1.7 mb/d in 1991, oil production has been declining steadily, and the current production, at 0.8 mb/d in 2014, covers only around half of the Indonesia's oil consumption.[2] A significant portion of its current production comes from the giant Minas and Duri fields, which are located on the eastern coast of central Sumatra and have been in production since 1952 and 1955. Both fields are in decline despite the use of steam-flooding and enhanced oil recovery (EOR) techniques which have been able to increase substantially the recovery factors. Other principal oil-producing basins are in Sumatra, Java and East Kalimantan, all of which have been well explored and are also in decline.

The biggest source of new oil production in Indonesia in the New Policies Scenario is the Banyu Urip field, located in the Cepu block in offshore East Java and operated by ExxonMobil. The field has failed to reach its targeted production levels since it came online in 2008, but its expected peak production of 205 kb/d is on track to be reached by end of 2015 or in early 2016. Other new sources of oil in the coming years are likely to include liquids associated with natural gas projects, such as South Mahakam and Gendalo-Gehem, both located in the Makassar Strait, although the final investment decision (FID) on the latter, which was expected in 2014, has been postponed by Chevron, the project operator.

[2] Indonesia suspended its membership of the Organisation of Petroleum Exporting Countries (OPEC) in 2009 as a result of its change in status to a net oil importer. At the OPEC meeting held in June 2015, Indonesia submitted its request to re-join OPEC.

Prospects for maximising the potential of Indonesia's sizeable oil resources have been hampered by the challenging regulatory environment, that affects in particular development approval and license extensions, increasing resource nationalism and slow decision-making processes.[3] There is optimism, however, that the regulatory and administrative conditions may improve under the new administration, which has identified reform of the energy sector as a key priority and has announced plans to revamp the upstream regulator and simplify business processes.

In the New Policies Scenario, Indonesia's oil production remains flat at around 0.8 mb/d in the medium term to 2020 but then progressively declines for the remainder of the projection period and reaches 0.5 mb/d by 2040. The declining output of producing fields is only partially offset by increased production in areas that currently remain relatively unexplored (mainly offshore in eastern Indonesia) and the growing contribution from NGLs from gas production and coal-to-liquids projects.

S P O T L I G H T

What are the implications for Southeast Asia of lower oil and natural gas prices?

The significant fall in oil and natural gas prices from the highs in 2014 is expected to have mixed effects in Southeast Asia in the short and medium term. Importing countries are set to benefit from reduced oil and gas import bills, while economies of the largest Southeast Asian oil and gas producers might be negatively affected by lower revenues from energy exports and reduced inflow of investments in their energy sectors. The extreme cases in the region are represented by Thailand, which, as the largest oil and gas importer, is set to see the biggest reduction in import bills, and Brunei Darussalam, which is expected to see the sharpest fall in export earnings as (up until recently) oil and gas export revenues represented more than 90% of its total exports and two-thirds of its gross domestic product (GDP). However, such trade figures are not fully representative of the impact of lower international energy prices on an economy. Other factors that play an even bigger role include the economic structure, its composition and the importance of product exports.

The implications of lower prices are not straightforward for the energy sector itself.[4] Many major oil companies (including Indonesia's Pertamina and Malaysia's Petronas) have announced cuts to capital expenditure in response to the fall in prices, which is already slowing the rate of development of new projects, reducing the positive spill-over effects they would have had on the broader economy. Many of the most

[3] In Indonesia, the amount of time taken to bring new discoveries into production has steadily risen over recent decades, contributing to higher development costs.

[4] The forthcoming *World Energy Outlook 2015* – to be released 10 November 2015 – will present an in-depth analysis that will examine the implications for global markets, policies, competitiveness, investment and other fuels if lower oil prices persist.

promising fields in Southeast Asia are located in deepwater and often require processing facilities to remove hydrogen sulphide (H_2S) and carbon dioxide (CO_2). Any protracted period of low prices would undermine the appetite to develop resources in frontier regions. This would not only result in an additional weight on the country's national accounts but also affect efforts to improve domestic energy security by slowing the development of energy infrastructure within the region.

Lower oil and natural gas prices represent an important opportunity for several Southeast Asian countries to accelerate energy pricing reforms without provoking public outcry and without having a major impact on inflation. A number of countries in the region have a long history of artificially lowering domestic energy prices and spending on subsidies often represents a serious burden for government budgets (see Chapter 5). Several countries, including Indonesia, Malaysia and Thailand, have recently taken advantage of this opportunity to reform pricing. However, the durability of such reforms may be challenged if and when international markets move back into a higher price environment. The likelihood of long-term success can be improved if the move from subsidised (typically fixed) pricing is accompanied by the introduction of a formula-based pricing system under which retail prices track movements in international markets and the establishment of an autonomous body to oversee energy pricing. This will help consumers gradually get used to frequent small price movements and depoliticise price-setting.

Malaysia is the second-largest oil producer in Southeast Asia. Production of 670 kb/d in 2014 represents slightly more than one-quarter of the region's total output. Malaysia's oil production has been falling steadily since peaking at around 830 kb/d in 2003, mainly due to declining production in the mature basins located in shallow waters offshore Peninsular Malaysia and Sarawak that have contributed the most to its oil production. In the medium term to 2020, the efforts introduced by Malaysia's government to encourage the exploitation of marginal fields and the implementation of EOR technology in the mature reserves are expected to counterbalance falling output from existing fields, with production set to remain flat around current output levels. However, given the limited success in finding new resources and with prospects increasingly moving towards more costly and challenging deepwater environments, oil production from new fields will not be enough to fully compensate for the natural decline. By 2040, Malaysia's total oil production declines gradually to around 600 kb/d.

Excluding the contributions of Indonesia and Malaysia, **Thailand** and **Viet Nam** account for more than 80% of the remaining oil production in Southeast Asia. Thailand's proven oil reserves stood at below than 0.5 billion barrels at the end of 2014 and at current levels of production are sufficient for around three years. Most of its proven reserves are located in the Gulf of Thailand, including the Joint Development Area between Thailand and Malaysia, where exploration activities are now focussed. Thailand is struggling to find new reserves to replace production: resource additions have been less than 20% of production since 2000. Although Thailand is carrying out a new licensing round in 2015 (for the first time in seven years, although at the time of writing it remains uncertain when and under what conditions this will take place), expectations are that the 29 blocks on offer are likely to contain mostly gas rather than oil.[5] In the New Policies Scenario, Thailand's oil production, which was 470 kb/d in 2014, declines marginally to 2020 (as the development of new fields in the Gulf of Thailand, mainly Manora, Nong Yao and Wassana almost offsets production declines elsewhere), before declining faster to around 270 kb/d in 2040.[6]

Viet Nam has 4.4 billion barrels of proven oil reserves, enough to sustain current levels of production for 38 years. Most of its reserves are located offshore in the Cuu Long and Nam Con Son basins, which also account for the bulk of production. Despite the potential of these proven reserves, the outlook for Viet Nam's oil production remains negative over the long term. Most of the producing fields are in decline (including its largest, the Bach Ho field) highlighting the need to shift attention towards under-explored deepwater areas. However, the ongoing tension with China over disputed areas of the South China Sea is making exploration activities difficult. In the New Policies Scenario, Viet Nam's oil production increases slightly, from 320 kb/d in 2013 to over 360 kb/d in 2020, thanks to the ramp up of projects currently underway, before declining to 160 kb/d in 2040.

Oil product demand and refining

Southeast Asia is one of the regions with the fastest growth of oil product demand between 2014 and 2040. Total oil demand, including bunker fuel use, reaches 8.5 mb/d by 2040, an increase of 2.6 mb/d and equivalent to almost half of its current demand.[7] Growth in the region's oil demand slows in the second-half of the projection period, but with an average annual growth of 1.4% between 2014 and 2040 is around three times the global average.

Apart from a faster rate, Southeast Asia's oil product demand growth pattern is not that different from the global average, with increasing demand in the petrochemicals and transport sectors dictating higher growth rates for feedstocks and transport fuels. The fastest-growing product is kerosene, with increased demand exclusively coming from air travel expansion (Table 3.1).

[5] Some upside might come from the resolution of the Thailand-Cambodia Overlapping Claims Area which is thought to hold significant undiscovered oil and gas resources. Diplomatic relations between the two countries have improved recently, following a meeting of the prime ministers that resulted in several memorandums of understanding in July 2014.

[6] Thailand's state-owned company PTTEP announced an 11% cut to its 2015 capital and operating expenditure, but this is not expected to impact its short-term oil outlook as all 17 projects the company operates in Thailand are already in the production phase.

[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.

Table 3.1 ▷ Oil demand by product in Southeast Asia, 2014-2040 (mb/d)

	2014	2040	Difference 2014-2040	CAAGR* 2014-2040
Ethane	0.1	0.1	0.0	-0.2%
LPG	0.6	0.9	0.3	1.6%
Naphtha	0.5	0.6	0.2	1.3%
Gasoline	1.2	1.6	0.4	1.1%
Kerosene	0.5	0.9	0.4	2.5%
Diesel	1.6	2.4	0.8	1.6%
Fuel oil	0.9	0.9	0.0	-0.2%
Other products	0.6	1.1	0.5	2.5%
Total	**5.9**	**8.5**	**2.6**	**1.4%**

*Compound average annual growth rate.

Gasoline remains the dominant road transport fuel, but diesel has a higher overall consumption with the addition of international low-sulphur bunkers. The use of liquefied petroleum gas (LPG), as in most other parts of the world, expands especially in petrochemical feedstocks and road transport due to continued policy support and its lower environmental impact. The use of fuel oil remains flat as incremental demand for marine bunkers is mainly met by diesel.[8]

Southeast Asia is a mix of countries with quite different refining sectors. Three countries, Singapore, Indonesia and Thailand, have large refining sectors with above 1 mb/d of capacity. Export-oriented Singapore has a relatively small local market, while its bunkering demand, by far the world's biggest in terms of fuel consumption, gets supplied mostly by imported fuel oil. Thailand and Indonesia, by contrast, have large domestic markets, with declining crude production, making it increasingly difficult to maintain utilisation rates to keep up with growing demand. Malaysia and Philippines used to have sufficient refining capacity to supply their respective markets, but their import requirements have grown with rising demand. Viet Nam, where total oil demand is about to cross the half a million barrels a day mark, so far has only one modest sized refinery of 130 kb/d. Myanmar and Brunei Darussalam run a small refinery each, while Lao PDR and Cambodia have none.

Refineries in Southeast Asia process just under 4 mb/d, at about 80% utilisation rates, slightly below the global average. In our projections about 2.6 mb/d of new capacity, at a total cost of almost $100 billion, is expected to be brought online between now and 2040, with Malaysia and Thailand likely to build one relatively big refinery each, Indonesia and Viet Nam possibly two each, along with some other smaller additions elsewhere in the region (Table 3.2). Average utilisation rates are expected to increase as well, reaching about 88% by 2040. However, in most other regions of the world, especially in Europe, OECD Asia and North America, refinery utilisation rates will decline, with over almost 15 mb/d of excess capacity at risk of shutdown by 2040.

[8] See *World Energy Outlook-2014* (Chapter 3, Box 3.2) for a discussion on marine bunkers development in the light of expected future regulation of its sulphur content.

Table 3.2 ▷ Southeast Asia refining capacity and refinery runs (mb/d)

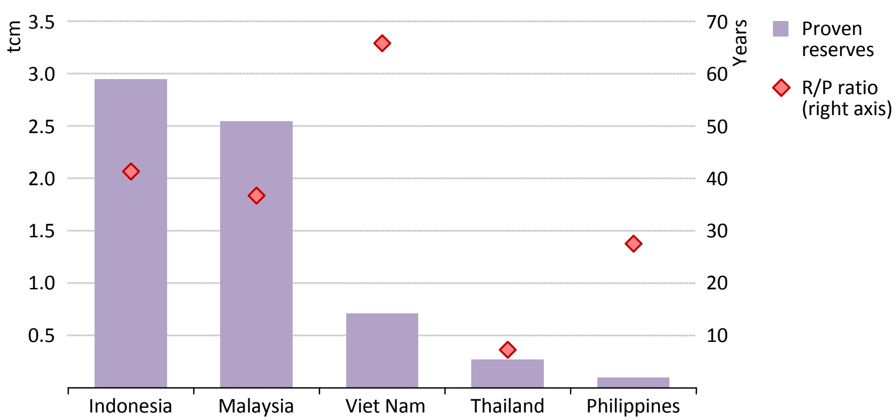
	2014 Capacity	Net capacity additions to 2040	Refinery runs			Capacity at risk*	
			2014	2020	2040	2020	2040
Southeast Asia	4.9	2.6	3.9	4.4	6.6	0.2	0.1
World	94.1	14.5	77.9	81.6	86.2	5.9	14.6

*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.

Natural gas

The outlook for natural gas supply in Southeast Asia is brighter than that for oil, reflecting the larger remaining resource base. As with oil, Southeast Asia's natural gas reserves are unevenly distributed, with the bulk found in Indonesia and Malaysia. In recent years, exploration efforts have produced mixed outcomes, with Malaysia accounting for the majority of gas discoveries, mainly offshore Sarawak, while Indonesia and Thailand have registered disappointing results. At current levels of production, Southeast Asia's proven reserves of natural gas would sustain production for another 35 years; on a country basis for the main gas producers, the ratio ranges from 7 years in Thailand to 66 years in Viet Nam (Figure 3.5).

Figure 3.5 ▷ Proven natural gas reserves by selected country in Southeast Asia and reserves to production ratio, 2014

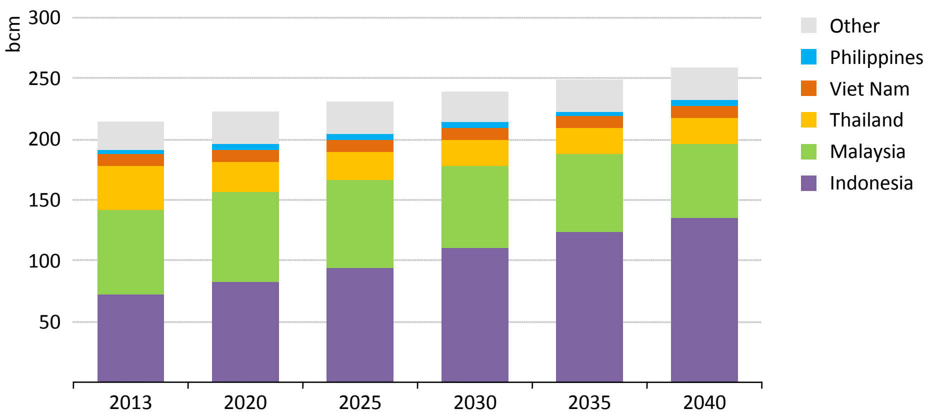


Note: tcm = trillion cubic metres.

An increasing share of Southeast Asia's remaining gas reserves are located offshore, in deepwater, and in remote areas far from demand centres. Their development is made more costly and complex due to the need to develop transportation infrastructure, either to export the gas or to bring it to domestic markets. There is an ongoing need for governments to ensure they have in place regulatory frameworks and market structures that are attractive to the companies, including foreign companies, that have the technology and financial resources required to develop these resources. Linked to this, recent moves made by a number of countries in the region to reduce consumption subsidies to natural gas have been an important means of increasing incentives for the necessary large, long-term capital-intensive investments in gas supply.

In the New Policies Scenario, natural gas production in Southeast Asia expands from 214 bcm in 2013 to almost 260 bcm in 2040, an average annual growth rate of 0.7%, which is significantly slower than the 3.7% experienced over the last two decades (Figure 3.6). Growth is largely driven by Indonesia and, to a lesser extent, by Myanmar (Box 3.1), while Malaysia's production expands slightly in the first part of the *Outlook* period and gradually declines thereafter. By 2040, more than half of the region's gas production comes from Indonesia alone (up from around one-third in 2013). Thailand experiences the largest drop in production, from 36 bcm in 2013 to around 20 bcm in 2040.

Figure 3.6 ▷ Natural gas production by selected country in Southeast Asia



Indonesia, with around 3 trillion cubic metres (tcm) of proven reserves, has the largest conventional natural gas reserves in Southeast Asia. Most of its production comes from fields located in Sumatra, the Natuna Sea and the Mahakam block in East Kalimantan, which is currently the country's single largest source of production. Indonesia's remaining recoverable resources of natural gas amount to over 15 tcm, including 2.6 tcm of coalbed methane (CBM), which are located mainly in Sumatra and Kalimantan. Production from CBM is currently minimal and hopes for its rapid development have not been realised, prompting the government to slash its CBM production targets. Over recent years, a number of CBM projects that have been approved did not proceed as planned – mainly due to lack of clarity in regulation and environmental concerns – which have discouraged companies from investing in other projects. The recent decision of companies such as BP and ExxonMobil to exit from CBM operations in Indonesia has also cooled the interest of other players.

There is a geographical mismatch between Indonesia's main natural gas demand centres (Java and Sumatra) and regions that are either producing gas today or have the potential to do so (concentrated in the eastern part of the country). In many cases, the development of new resources is complicated as they are located in frontier regions that are far from markets and lacking in pipeline infrastructure, meaning that LNG development is probably the only option if they are to be exploited. Interest from foreign companies in investing in such high-capital projects is further complicated by a domestic market obligation (DMO), which requires that around 25% of production is supplied to the domestic market. This creates uncertainty for investors about possible regulatory changes, including about the exact share of the allocation and the prices they will receive (domestic gas prices have been rising, but are still lower than in export markets).

In the New Policies Scenario, over the medium term, Indonesia's gas production rises from 72 bcm in 2013 to 83 bcm in 2020. The decline in some mature fields, such as the Arun and Koridor fields in Sumatra, is more than offset by the start of production of new fields supplying LNG plants (the Senoro-Toili and Matindok fields feeding gas to the Donggi-Senoro LNG plant in Central Sulawesi and the Jangkrik field to the Bontang LNG plant in East Kalimantan). Compared with the previous edition of this *Outlook*, the medium-term outlook for Indonesia's gas production has been revised slightly downwards due to ongoing uncertainty in regulatory conditions and postponements or delays in a number of key projects, linked in large part to the fall in international prices. Another key factor is the uncertainty surrounding the future of existing production sharing contracts (PSC); a significant share of current production is under PSCs that are set to expire in the next few years and lack of clarity in some cases has led to delays in the development of some fields.[9]

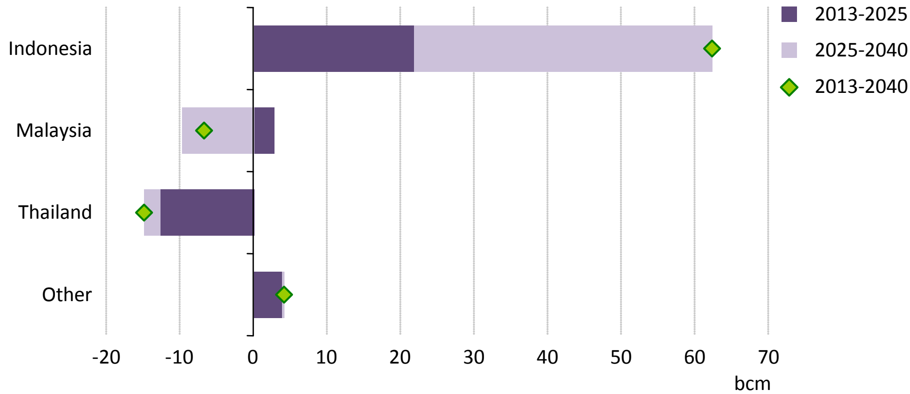
Over the longer term, we assume a progressive improvement in the business environment, consistent with recent government commitments to unlock the vast potential of the Indonesia's natural resources. In the New Policies Scenario, gas production rises to over 130 bcm in 2040, sustained by the development of large offshore projects and rising output from unconventional gas resources, mainly shale gas and CBM (Figure 3.7). The East Natuna project, the largest untapped gas fields in Asia with 1.6 tcm of recoverable gas reserves, represents the biggest prospect for Indonesia's gas sector. The high CO_2 content of the field – exceeding 70% – means that it will be expensive and technically challenging to develop, but remains of considerable interest as it is expected to have a potential peak production in excess of 40 bcm per year (or more than half of Indonesia's current gas production), although contract details among partners of the project still need to be finalised.[10] Another key contribution to our projections comes from the Chevron-operated Indonesia

[9] For example, Total and Inpex's PSC for the large Mahakam gas project, which provides the bulk of the gas for the Bontang LNG plant in East Kalimantan, expires in 2017. It was announced in February 2015 that control of the field will then pass to Pertamina, the state-owned oil and gas company. In June 2015, Indonesia's upstream regulator, SKK Migas, said that it expects that this will impact field gas production in 2016 as PSC expiry approaches.

[10] The partners developing the project are Pertamina, ExxonMobil, PTTEP and Total.

Deepwater Development (IDD) project including the Bangka, Gendalo, Gehem, Gandang and Maha fields in East Kalimantan (which is targeting 12 bcm/year of peak production for the Bontang LNG plant).

Figure 3.7 ▷ Change in natural gas production in selected countries in Southeast Asia, 2013-2040



The projections in this *Outlook* should not disguise several challenges that Indonesia has to overcome in order to exploit its gas supply potential. These include creating the right conditions for the timely development of large complex projects, such as East Natuna and the IDD, the progressive exploitation of its vast unconventional gas resources (which contribute for about one-quarter of its gas production in 2040 in the New Policies Scenario), and major progress in energy policies, pricing reform as well as realisation of infrastructure. In the absence of such improvements, Indonesia's gas production is unlikely to reach the levels projected herein.

Malaysia is richer in natural gas than it is in oil but its gas reserves tend to be concentrated in remote locations. The relative remoteness of Malaysia's gas reserves from domestic demand centres has been a key driver in the development of the country's gas industry. Offshore production at Peninsular Malaysia traditionally has been dedicated to supply domestic needs while fields offshore at Sarawak and Sabah, where local demand is modest, have been mainly developed for LNG export. Malaysia's gas production reached 69 bcm in 2013, of which about half (34 bcm) was exported as LNG, making it the world's second-largest LNG exporter after Qatar.[11] However, the country was facing the risk of shortages given the progressive decline of gas fields that serve demand mainly in the industry and power sectors in Peninsular Malaysia. This has led to the construction of a first LNG regasification terminal in Melaka and plans for a second one to be built in Johor.

[11] Peninsular Malaysia is also supplied by piped gas from Indonesia's fields in Natuna Sea (in 2013, gas imports exceeded 13 bcm).

Box 3.1 ▷ Myanmar: the last frontier in Southeast Asia for natural gas?

Myanmar's economy has been developing rapidly since the easing of international sanctions in 2012. Its GDP grew at 7.7% on average between 2011 and 2014, thanks largely to the opening of parts of the economy to private participation and an inflow of foreign investment. Myanmar's government has included energy and mining sectors among the key priorities for sustaining economic growth. According to the UK Trade and Investment Department (2015), by the end of the third-quarter of the 2014/2015 financial year, total foreign direct investment (FDI) in the oil and gas sector exceeded $14 billion, accounting for more than 36% of total FDI in the country.

Myanmar is already an important gas producer with the bulk of its output coming from offshore fields – Yadana, Yetagun and Zawtika – which mainly supply Thailand, while gas from the offshore Shwe field is exported to Yunnan province in southwest China through a new pipeline. In the next few years, production is set to rise as the export-oriented Shwe and Zawtika fields ramp up, likely pushing total gas output above 20 bcm.

In the longer term, prospects for gas production are very uncertain, reflecting the lack of knowledge about the scale of Myanmar's hydrocarbon resources. It is the least explored country in the region, but many experts are optimistic that it holds significant potential. The 2013 licensing rounds resulted in 36 blocks being assigned (16 onshore and 20 offshore), mainly to major international companies eager to gain access to one of the less-explored regions of the world. Fifteen blocks were scheduled to be auctioned in 2015, but the fall in global oil prices and government's focus on the finalisation of the recently signed production sharing contracts, could lead to a delay in the round to 2016-2017.

The outlook for production will also be closely tied to the policies adopted by the government. So far they have put in place what is regarded by industry as an attractive regulatory framework that includes a range of different production sharing contracts and exemptions from all local content requirements for deepwater projects.[12] Still predominantly an economy focussed on agriculture, Myanmar's energy consumption is largely dominated by traditional biomass. But as the economy expands, the country's energy needs are expected to rise rapidly. With over two-thirds of its more than 50 million citizens lacking access to electricity, the government plans to increasingly rely on its domestic resources, mainly hydro and natural gas, to expand power generation. Currently there is a domestic market obligation that requires 20% of crude oil and 25% of natural gas production to be sold on the domestic market, typically at 90% of international prices.

[12] Myanmar introduced a new Foreign Investment Law in November 2012, which offers a series of incentives to foreign investors including the possibility of fully owning local enterprises; a five-year tax exemption and protection of foreign-owned enterprises from nationalisation (subject to issuance of the relevant permit from the Myanmar Investment Commission).

Thanks mainly to the production from of a series of important discoveries made over the last few years, primarily in offshore Borneo, Malaysian gas production is set to increase in the medium term, reaching 74 bcm by 2020. Beyond that, the country's gas output is projected to steadily fall to 62 bcm by 2040, as the natural decline from existing fields is only partially offset by the development of new resources.

Natural gas production in the rest of Southeast Asia totalled 73 bcm in 2013. About half of that is in **Thailand**, where gas production has increased by two-thirds over the last ten years following the development of projects in the Gulf of Thailand (such as Arthit, Platong and Bongkot) and the development of projects in the Malaysia-Thailand Joint Development Area.[13] As is the case with oil, the potential upside for gas production in Thailand is closely linked to the resolution of a dispute with Cambodia involving overlapping claims in the Gulf of Thailand. Another factor affecting prospects for Thailand's oil and gas production is the attractiveness of its upstream sector. Currently, more than 65% of Thailand's production comes from concessions expiring in 2023 and without clear indications over the longer term, operators are reluctant to implement investments and activities aimed at sustaining production. In the New Policies Scenario, Thailand's gas output steadily declines to around 20 bcm in 2040. Output from new production, including supplies that are projected to come from the forthcoming licensing round (although at the time of writing it remains uncertain when and under what conditions this will take place), and through efforts to sustain output in currently producing fields (as envisaged by 2015 Thailand's "Integrated Energy Blueprint") is not sufficient to offset decline in mature basins.

Viet Nam's proven reserves of natural gas have grown significantly over recent years, as a result of several offshore licensing rounds aimed at encouraging the participation of international investors. As of end-2014, its reserves totalled 0.7 tcm. Gas production has also been rising steadily, reaching 10 bcm in 2013. The bulk of the growth came from production at Lan Do and Lan Tay fields in the Nam Con Son basin and in the form of associated gas from oil fields. Considering the size of Viet Nam's resource base, there is upside in terms of production. Historically low domestic gas prices and a lack of infrastructure have reduced the incentive for broader exploitation of its potential.

Viet Nam's gas production remains relatively stable throughout the projection period. Prospects for gas production in Viet Nam rely heavily on developments in the Nam Con Son basin and the Song Hong basin in the north. These will be challenging and expensive to develop due to their high concentrations of CO_2 and H_2S. Prospects could also be boosted significantly if there is a favourable resolution to longstanding territorial disputes in the South China Sea.

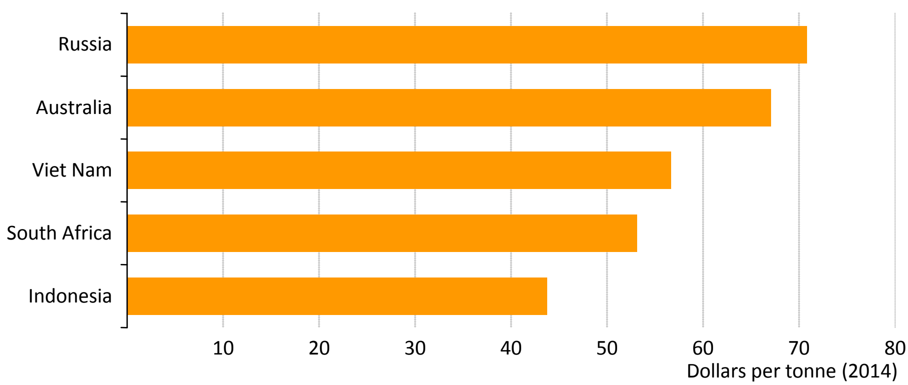
[13] The Malaysia-Thailand Joint Development Area covers approximately 7 250 square kilometres in the southern part of the Gulf of Thailand. Claimed by both Malaysia and Thailand, the two countries agreed in 1979 to jointly explore and exploit mineral resources.

Coal

Southeast Asia is a cornerstone of the global steam coal market, a role the region is set to continue to play in the coming decades. At the end of 2013, Southeast Asia had 28 billion tonnes of proven coal reserves, about 3% of the world total, with the vast majority (80%) located in Indonesia and most of the remainder in Viet Nam. The region has a considerably larger resource base which could be converted to reserves as production expands.

Coal production in the region has experienced spectacular growth over the last decade. Since 2000, Southeast Asia's coal output expanded by a factor of five from 83 Mtce to 450 Mtce, mainly driven by rising consumption from large importing countries, China and India. The proximity to fast-growing coal markets and low production costs has provided a significant competitive advantage to Southeast Asian coal producers (Figure 3.8). However, the growth in production and exports recently has slowed markedly from this very rapid pace in response to the overcapacity in the coal market and the low price environment.

Figure 3.8 ▷ Indicative steam coal free-on-board costs by selected country, 2014



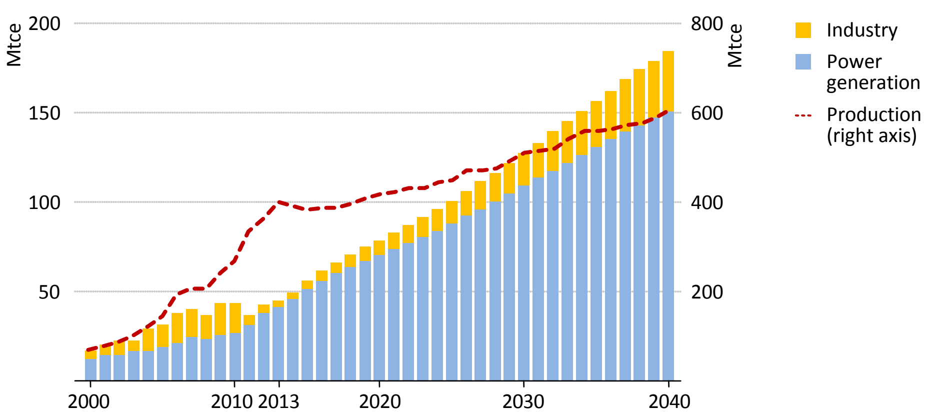
In the New Policies Scenario, coal production in Southeast Asia increases on average by 1.5% per year, from 450 Mtce in 2013 to almost 680 Mtce by 2040. Indonesia remains by far the key regional producer with its share of Southeast Asia's total coal production stable at close to 90% throughout the entire projection period. The drivers for the expansion of coal output in Southeast Asia are significantly different than those that have dominated the regional coal industry over recent decades. Southeast Asia's coal demand is set to grow much faster than domestic supply, at an annual average rate of 4.6%, implying that although the region remains a large coal exporter to international markets, production growth is increasingly driven by domestic demand rather than export-oriented projects.

Indonesia's coal production skyrocketed during the last decade with average growth of 15% per year. As domestic coal consumption grew only moderately in this time period, increased production fuelled an export growth of similar magnitude, making Indonesia the world's largest coal exporter since 2011. Coal reserves in Indonesia are primarily of the sub-bituminous type with relatively high moisture and consequently low calorific content. However, sulphur content is typically low, making Indonesian coal attractive for blending with high-sulphur coal or for use in power plants without scrubbers. The energy content of Indonesian coal output has been declining over the last decade as buyers in India and China were willing to take coal with lower-than-usual energy content – effectively creating a new market for such varieties. With lower quality reserves left to be exploited, the calorific content of Indonesian coal is expected to decline further in the future, requiring a higher output in tonnage terms for the same amount of energy.[14]

3

In the New Policies Scenario, Indonesia's coal production continues to rise, although at a much slower pace compared with the last 15 years, reaching over 600 Mtce by 2040 from 402 Mtce in 2013 (Figure 3.9). Its production growth is underpinned by its own fast rising electricity demand, with coal-fired power generation set to increase by more than a factor of four to supply the rapidly growing economy and also to provide electricity to those that lack access (around 50 million in 2013, see Chapter 5). The increased focus on domestic needs sustains the development of the coal fields of Sumatra which are closer to the main power demand hubs on the island itself and on neighbouring Java. Currently over 90% of the coal production comes from the sparsely populated island of Kalimantan from where it is either exported or shipped to power stations on Java.

Figure 3.9 ▷ Indonesia coal production and consumption by key sector



The Indonesian coal industry is quite open and competitive. It is composed of a multitude of small and large players and the state directly controls only a limited share (around 5%) of the nation's coal mining assets. This differs significantly from the average in other non-OECD countries, where about two-thirds of hard coal production comes from state-owned assets (IEA, 2014). The structure of the industry has a strong influence on business strategy

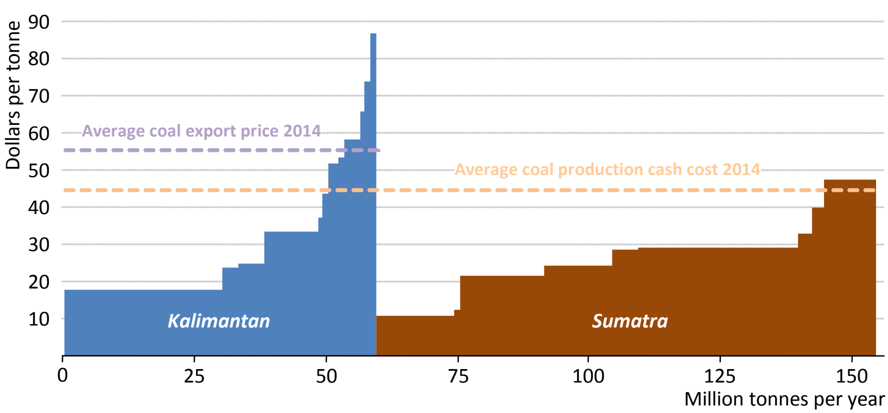
[14] For more detail, see the 2013 *Southeast Asia Energy Outlook: World Energy Outlook Special Report*, Chapter 3, Figure 3.6, available at: *www.worldenergyoutlook.org/southeastasiaenergyoutlook*.

and the ability of smaller Indonesian coal companies to react promptly to plunging coal prices by halting higher cost mines has been instrumental in keeping Indonesia among the lowest-cost coal producers in the world.

Indonesia has a number of favourable conditions that provide a significant competitive advantage for its coal industry and have sustained the strong export growth achieved over the last decade. These include coal reserves that allow for surface mining, proximity of mines to the coast and short transport distances to demand hubs in India and southern coastal China. In addition, Indonesia has plenty of low-cost coal still in the ground.

While brownfield expansion – increasing the capacity of an existing mine – has played an important role in the Indonesian growth model and continues to do so over the projection period, there are also over 150 million tonnes per annum (Mtpa) of mining capacity in the greenfield project pipeline. Almost two-thirds of this capacity is on Sumatra with the domestic market as its primary target, highlighting the increasing importance of coal mining on this island. Such projects are often remunerated through regulated prices or a contract with a utility that ensures recovery of both cash costs and capital costs.[15] Cash costs of the projects in Sumatra are markedly lower than the national average, due to their size which favours economies of scale, but coal quality is often poor. Projects on Kalimantan target mainly the international market and their economics are more subject to the international market price. Since capital expenditure is a minor component of the full costs of a coal mining project, the market price needs to exceed the cash costs of a new mine typically only by a couple of dollars to make it break-even. Even in the current low price environment the majority of the proposed projects would be economically viable, underlining Indonesia's long-term potential as a low-cost producer (Figure 3.10).

Figure 3.10 ▹ Cash costs of proposed greenfield coal projects in Indonesia



[15] Cash cost includes mining costs, costs of coal washing and preparation, inland transport, mine overhead as well as port charges (this definition corresponds to the C1-cash costs definition widely used in the mining industry). It excludes royalties and taxes, as well as seaborne shipping costs.

Indonesia has made important progress in simplifying the licensing process for mining areas and easing bureaucratic hurdles for mine development, but foreign investors still face substantial political uncertainty, including the need to reduce their ownership stake to 49% after ten years of mine operation. This domestic market obligation, i.e. an obligation that requires coal producers to sell a certain share of their production to domestic consumers, has so far not posed a problem to coal companies.[16] However, with domestic demand projected to rise more rapidly in the future, an obligation to sell to domestic consumers – possibly at a price below market prices – might cut into the profit margins of investors.

Viet Nam is the second-largest coal producer in Southeast Asia with 33 Mtce in 2013. Unlike with Indonesia, the Vietnamese coal industry is dominated by the national coal mining company Vinacomin, which accounts for virtually the entire output of the country. The majority of coal production comes from the deposits in the Cam Pha and Hon Gai basins in Northern Viet Nam. The country primarily produces anthracite of which a little over one-third is exported. Vietnamese exports primarily serve Chinese consumers that are willing to deal with the high ash content of Vietnamese coals. Coal production has stagnated in recent years and is projected to continue to remain relatively flat throughout the projection period. Labour productivity in the Vietnamese coal industry is low. Production costs vary strongly among operations: some mines have very low costs while others are expensive and need cross-subsidisation. Regulated prices currently do not provide sufficient incentive to cut costs and expand production. Pricing reform and increasing competition could help unlock the huge potential of the Vietnamese coal industry.

Strong growth in domestic coal demand, underpinned by a significant expansion in the country's coal-fired generation capacity, is reducing export availability while imports continue to play an increasingly important role in the Vietnamese coal balance.[17] The country is set to switch from being a net exporter of coal to being a net importer before 2020.

Thailand has significant reserves of brown coal, estimated at 1.1 billion tonnes, primarily located in the north of the country (Lampang province), where it is produced for local use in power generation. In 2013 the country produced 7.3 Mtce of coal, a figure that is set to remain broadly stable over the *Outlook* period. Thailand is importing rising quantities of hard coal, primarily sourced from Indonesia and Australia, to fuel its power stations in coastal areas. Coal imports amounted to about 17 Mtce and are expected to increase significantly throughout the projection period, as a result of an expanding coal-fired power generation fleet.

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[16] In January 2015, the Indonesian Ministry of Energy and Ministry Resources revised its coal domestic market obligation for 2015 down from 110 Mt to 92 Mt, equivalent to about 20% of targeted coal production.

[17] Vinacomin announced in early 2015 that it expects to export just 3 Mt of coal over the course of the year, less than half of the previously established target of 7.5 Mt and a quarter of the 12 Mt achieved two years ago.

Philippines has a sizeable coal mining complex on Semirara Island that accounts for the majority of the country's coal production and produced more than 5.3 Mtce of sub-bituminous coal in 2013. Coal production in Semirara Island is of low quality and a significant share is exported to China, India, Thailand and other countries. Apart from this, there are a handful of small coal mining operations scattered across the country. Given rising electricity and industrial demand, the Philippines is expected to significantly expand its status as a net importer of coal, which currently is mainly from Indonesia.

International energy trade

The energy demand and supply trends envisaged for Southeast Asia in the New Policies Scenario are set to affect both regional markets and its energy trade with the rest of the world. A major change takes place in the natural gas sector. Over the last four decades, Southeast Asia has played the role of a major gas supplier to the rest of the world, notably in the form of LNG; indeed, the region has met a significant share of gas needs of the large importing countries, such as Japan and Korea. By 2040, the rising domestic demand and the limited scope for further expanding gas production in most of the countries result in the region becoming a net gas importer of around 10 bcm, in contrast to the 54 bcm it exported in 2013.

Southeast Asia's current status as a net oil-importing region expands significantly throughout the projection period. Net oil imports more than double from 3.3 mb/d in 2014 to 6.7 mb/d by 2040 and the region becomes the fourth-largest oil importer in the world, behind China, India and the European Union. Rising domestic consumption affects coal trade, but by 2040 the region remains a significant net coal exporter (around 230 Mtce). This is largely driven by Indonesia, which remains the world's third-largest coal producer behind China and India throughout the projection period. Indonesia is overtaken by Australia as the world's largest coal exporter before 2020.[18]

The projected trends for energy demand and supply in Southeast Asia have two far-reaching consequences for the region's economy and its energy security: a significant increase of fossil-fuel import dependency for most Southeast Asian countries, and a higher level of spending for oil and gas imports. Overall dependence on oil imports increases from 57% in 2014 to 79% by 2040 (Table 3.3), although there are notable differences among countries in the region.[19] Thailand and Philippines, with rising oil demand and limited production, are set to see their dependence rise strongly. In Indonesia, dependence on oil imports is projected to rise sharply, from 48% in 2014 to 78% by 2040. Trends for Malaysia, which only marginally depends on oil imports, and Brunei Darussalam, which is self-sufficient in oil, differ throughout the projection period. Malaysia becomes dependent on oil imports (its dependence on oil imports rises from close to zero to over 40% in 2040) as

[18] Indonesia keeps its role as the world's largest steam coal exporter throughout the projection period.

[19] The dependence on oil imports is calculated taking into consideration bunkers and processing gains.

oil demand growth outpaces its output. Brunei Darussalam is expected to remain self-sufficient thanks to stable oil production and limited upside to domestic consumption because of its small population.

Table 3.3 ▷ Southeast Asia net trade by fossil fuel

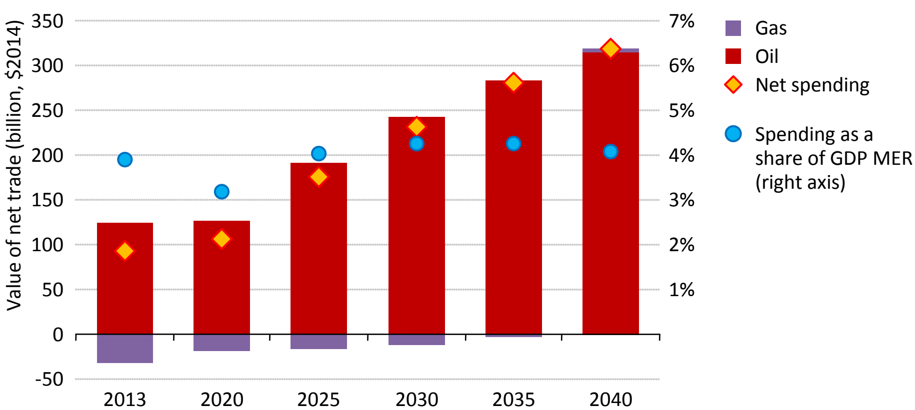
	2013*	2020	2025	2030	2035	2040
Oil (mb/d)	-3.3	-4.1	-5.0	-5.8	-6.4	-6.7
Import dependency	57%	61%	70%	75%	78%	79%
Gas (bcm)	54	41	32	22	5	-11
Import dependency	25%	19%	14%	9%	2%	4%
Coal (Mtce)	319	253	236	243	241	234
Import dependency	71%	54%	47%	43%	39%	35%

*Oil data is for 2014.

Notes: Negative values represent imports. Percentages for net imports are calculated as a share of total demand and for net exports as a share of total production.

The New Policies Scenario projections imply a rising level of spending on oil imports (and progressively also on gas imports) in Southeast Asia. While this is set to significantly weigh on the national accounts of several Southeast Asian economies, it also highlights the urgency for those countries in the region that are still subsidising domestic energy prices to continue their process of energy reforms introduced over the last few years (see Chapter 5). The oil and gas import bill for the region as a whole more than triples over the projection period, rising from \$92 billion in 2013 (and estimated \$88 billion in 2014) to about \$320 billion in 2040 as a consequence mainly of rising oil prices and a 44% growth in domestic oil demand. As a share of GDP (at market exchange rates), Southeast Asia's oil and gas import bill remains around 4% throughout the *Outlook* period (Figure 3.11).

Figure 3.11 ▷ Spending on oil and natural gas imports as a share of GDP in Southeast Asia

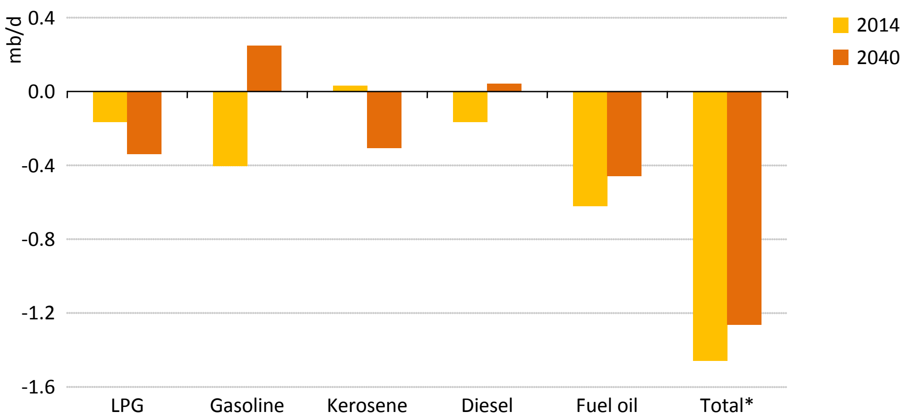


Note: MER = market exchange rate.

Oil products and crude trade

Current Southeast Asia refinery capacity and utilisation rates are not sufficient to satisfy the region's total oil product demand, leaving about 1.5 mb/d to be covered from imports. In the New Policies Scenario, the region's refinery capacity grows by about 2.6 mb/d and average utilisation rates increase by eight percentage points. However, due to the rapid increase of Southeast Asia's oil demand, the net imports of oil products in the region are projected to decrease only slightly, to 1.3 mb/d by 2040. Imports of LPG double by 2040 and the region turns into a net importer of kerosene. Higher refinery runs help to balance the local diesel market, with the likelihood of gasoline exports. Fuel oil imports decrease as demand is flat while higher refinery runs increase its local supply (Figure 3.12).

Figure 3.12 ▷ Southeast Asia net trade by selected oil product



*Also includes other oil products.

Much more dramatic are the changes in crude oil and condensate trade, as local output of refinable liquids decreases by 0.9 mb/d while refinery runs increase by 2.7 mb/d. This means that net imports of crude and condensate more than triple, from 1.8 mb/d in 2013 to 5.5 mb/d in 2040. The additional 3.7 mb/d of imports into Southeast Asia are part of the 11 mb/d increase in net crude and condensate inflows into Asian markets by 2040.

The Middle East remains the most important source of supply to Asia, accounting for some 70% of total crude import requirements. However, even today Middle Eastern exports of crude oil and condensate do not fully cover Asian refiners' demand. By 2040, Asia will be looking to Russia, North and South America and West Africa to bring in an additional 8 mb/d to 9 mb/d of crude oil (Box 3.2). Given these developments, it is not easy to pinpoint the specific mix of crude oil suppliers for Southeast Asian countries, although the Middle East likely remains the dominant source. Unlike China and Japan, importers in Southeast Asia are far from Russia's Far East export outlets. For the moment, Southeast Asian countries lack the scale of Chinese, Japanese, Indian and Korean conglomerates to strike long-term deals for significant volumes with crude oil exporters. Some Southeast

Asian countries are trying to attract Middle Eastern national oil companies as joint-venture partners in new refineries to secure oil supplies. They may also become attractive markets for expansion for other Asian refiners who face overcapacity and slowing demand at home.

Box 3.2 ▷ Malacca Strait – no straightforward alternative?

In 2013 about 13 mb/d of crude oil, around 2.5 mb/d of products and about 90 bcm of LNG (2.6 mb/d in terms of shipping volume) transited through the Strait of Malacca from west to east. This means an average of 15 vessels passed through the strait each day, just in one direction and carrying only oil or gas. At its narrowest point, near Singapore, the strait's shipping channel measures less than three kilometres across, which means that the potential for costly bottlenecks and serious accidents is quite high. Over time, this problem is expected to be exacerbated as the west-to-east flows of oil and gas are estimated to grow from about 18 mb/d in 2013 to 25 mb/d in 2040 (a number that takes into account direct supplies from Russia and the Caspian region to China and other Asian markets, and the Myanmar-China oil link, bypassing the strait). With the trade of other commodities expected to rise, especially agriculture, and possibly also manufactured goods, the Strait may become too crowded which may accelerate considerations of creating viable alternatives.

Other shipping routes, such as going through the Indonesian archipelago either through Sunda Strait, between Java and Sumatra, or through the Lombok Strait, between Bali and Lombok islands, are much less used alternatives.[20] Sunda Strait is only 20 metres deep at its shallowest and hence cannot accommodate large oil vessels. Lombok Strait is both wider and much deeper than the Malacca and Sunda Straits. However, it is also further to the east and adds three days to the voyage for oil coming from the Middle East or Suez Canal and heading to the Pacific. The distance from the bunkering facilities of Singapore is also an issue for vessels on a long voyage. However, with both West Africa and South America increasing their oil exports to Asia, and with LNG exports expected to start from East Africa, Lombok may become a more used alternative to Malacca, especially if the necessary infrastructure is developed around it.

The Asian continent could contribute its own trans-ocean canal to the list of the world's existing two canals of Panama and Suez by realising the long-proposed Kra Isthmus canal in Thailand. This would bypass Malacca, not only avoiding traffic jams and potential collisions but also saving on voyage duration. However, the proposed canal is subject to various economic and geopolitical debates that will likely involve not just Southeast Asian countries and other Asian nations, but also leading countries from other continents.

In the meantime, other routes could also reduce the "call on Malacca". Russia could fully realise its ambitions to send more than half of its oil exports eastward and also start more frequent shipments through the Northern Sea Route – depending on sea-ice

[20] Some of gas and iron exports from Australia to Asia transit through Lombok Strait.

conditions. Canada could choose the Pacific route to export some of its excess crude to Asian markets; China could double its Myanmar oil link capacity. Ultra-large crude oil vessels, which have draft requirements in excess of Malacca's capacity, would have to use the Lombok straits were they to become more frequent carriers to Asia. However, even applying a best case assessment of alternative routes, the eastward oil and gas traffic through Malacca by 2040 would still be projected to rise (by just under 3 mb/d), meaning that the Malacca Strait will remain a major chokepoint throughout the projection period.

Natural gas trade

Southeast Asia is currently an important exporter of LNG to world markets and as of the end of 2014 had around 20% of global LNG production capacity, equivalent to more than 85 bcm per year, located in Indonesia (42 bcm), Malaysia (35 bcm) and Brunei Darussalam (10 bcm). As of 2014, in terms of LNG volumes exported, Malaysia and Indonesia were respectively the second- and the fifth-largest LNG exporters (GIIGNL, 2015).

Malaysia and Indonesia are also planning an expansion of their liquefaction capacity as a way to develop stranded reserves located in remote areas far from domestic demand centres. In Malaysia, Petronas took a final investment decision in 2013 on a ninth liquefaction train of 4.9 bcm at the MLNG complex located in Bintulu, which should bring its total liquefaction capacity to 37.8 bcm by the end of 2015. The new liquefaction train is designed to be able to process gas with higher CO_2 content to produce from some of the high CO_2 fields offshore Sarawak which would otherwise not be developed. Two floating LNG (FLNG) plants are also currently under construction: the 1.6 bcm Kanowit FLNG offshore Sarawak, which is expected to enter into production by early 2016, and the 2 bcm Rotan FLNG project in Sabah waters which should commence production in 2018.

In Indonesia, with most remaining gas reserves located in the eastern part of the country, where local demand is small, the expansion of liquefaction capacity represents the only viable option to develop its gas fields. Two new LNG plants on Sulawesi Island, each with 2.7 bcm liquefaction capacity, are entering into operation: the Donggi-Senoro liquefaction plant, that shipped its first LNG cargo in August 2015, and the Sengkang terminal that is expected to commence activity by the end of 2015. However, the construction of the Abadi FLNG plant and the planned expansion of Tangguh project have been recently delayed and are scheduled to start respectively in 2022 and 2020. Overall, taking into account existing LNG plants, those under construction and projects proposed, the region's total liquefaction capacity is set to expand by about 20% over the next decade, exceeding 100 bcm per year (Table 3.4).

An increasing share of Southeast Asia LNG volumes are expected to remain within the region. Given the rising natural gas demand, declining production in most Southeast Asian countries and the geographical mismatch between consumption centres and location of gas resources, the region is increasingly looking towards LNG imports as a way to meet demand. Thailand, Singapore, Indonesia and Malaysia have become LNG importing countries in recent years, with a total regasification capacity exceeding 30 bcm per year, while Philippines, Viet Nam and Myanmar, although at different stages of development, have ambitions to import LNG.

Table 3.4 ▹ LNG export and import terminals in Southeast Asia

		Project (location)	Capacity		Status	Start
			Mtpa	bcm/yr		
Liquefaction	Brunei Darussalam	Brunei LNG (Lumut)	7.2	9.8	Operating	1972
	Indonesia	Bontang A-H (East Kalimantan)	21.6	29.4	Operating	1978
		Tangguh LNG (Papua)	7.6	10.3	Operating	2009
		- expansion	3.8	5.2	Proposed	2020
		Donggi-Senoro (Central Sulawesi)	2.0	2.7	Operating	2015
		Sengkang (South Sulawesi)	2.0	2.7	Construction	2015
		Abadi FLNG (Arafura Sea)	2.5	3.4	Proposed	2022
	Malaysia	MLNG I, II & III (Bintulu)	25.7	34.9	Operating	1983
		- expansion	3.5	4.8	Construction	2016
		Kanowit FLNG (Sarawak)	1.2	1.6	Construction	2016
		Rotan FLNG (Sabah)	1.5	2.0	Construction	2018
Regasification	Indonesia	Nusantara FSRU (West Java)	3.0	4.1	Operating	2012
		Lampung FSRU (South Sumatra)	2.0	2.7	Operating	2014
		Arun* (North Sumatra)	3.0	4.1	Operating	2015
		Cilacap FSRU (Central Java)	0.7	1.0	Proposed	2017
		Cilamaya** FSRU (West Java)	0.7	1.0	Proposed	
	Malaysia	Melaka FSRU	3.8	5.2	Operating	2013
		Pengerang (Johor)	5.0	6.8	Construction	2018
	Philippines	Pagbilao (Luzlon)	1.5	2.0	Construction	2015
		Batangas FSRU	4.0	5.4	Proposed	2018
	Singapore	Jurong Island	3.5	4.8	Operating	2013
		- expansion 1	2.5	3.4	Operating	2014
		- expansion 2	3.0	4.1	Planned	2018
	Thailand	Ma Ta Phut	5.0	6.8	Operating	2011
		- expansion	5.0	6.8	Construction	2017
	Viet Nam	Thi Vai	1.0	1.4	Proposed	2017
		Son My (Bin Thuan)	1.8	2.4	Proposed	2018

* Arun is conversion of LNG exporting terminal. **Final investment decision pending by Pertamina.

In the last few years, Indonesia has developed three regasification terminals to supply various local markets: the conversion of the Arun terminal is intended to supply a fertiliser plant in Aceh, power plants in Belawan and the industrial zones in Medan and Sei Mangkei. The Lampsung floating storage regasification unit (FSRU) is designed to supply the industrial sector in Greater West Java, which is supposed to have significant prospects related to fuel switching from oil to natural gas in the industry due to the potential replacement of oil consumed in the industry sector with natural gas. And the Nusantara FSRU's main aim is to supply power plants in the Jakarta area and compensate for the declining production of fields in the Java Sea. Indonesia also plans to build two additional FSRU in Central and West Java.

Malaysia joined the club of countries with LNG import infrastructure in 2013 with the opening of the Melaka FSRU situated in the Peninsular Malaysia, where the bulk of domestic gas demand is located. A second regasification plant is under construction at Pengerang in the Johor state of Peninsular Malaysia.

LNG infrastructure in Singapore has developed quickly over the last few years and with the opening of the Jurong LNG regasification terminal in 2013, the country's total capacity has been expanded to about 8 bcm per year. It also plans further expansion of an additional 4 bcm and announced its intention to build a second LNG terminal in order to further diversify its natural gas imports from piped gas and to support its ambitions to become the first natural gas hub in Asia region (Box 3.3).

With gas demand in the region expected to grow significantly over the next decades, Southeast Asia's net contribution to inter-regional natural gas trade is set to change dramatically. From 54 bcm of net exports in 2013, Southeast Asia is expected to become a net gas importer of around 10 bcm in 2040. Some countries are strategically prioritising the use of local gas resources for domestic purposes in order to support industrial development and rising electricity demand. In the short term this approach is expected to be sustained by the fall in Asian LNG spot prices which in some cases, such as Indonesia, have incentivised local authorities to not approve exports of uncommitted LNG volumes in favour of domestic needs. In the medium to long term, although Asian LNG prices are projected to rise in the New Policies Scenario, the differential between domestic gas prices in Southeast Asia and those on international gas markets is set to gradually narrow. This is expected to be driven by the overall trend towards the removal of subsidies in the natural gas and power sectors across the Southeast Asia, by the rising cost of domestic natural gas production, due to more expensive and complex fields, as well as by an increasing share of LNG in domestic gas consumption, that – even if produced within the region – will require the development of additional infrastructure (Figure 3.13).

Box 3.3 ▷ Singapore as the first LNG Asian hub?

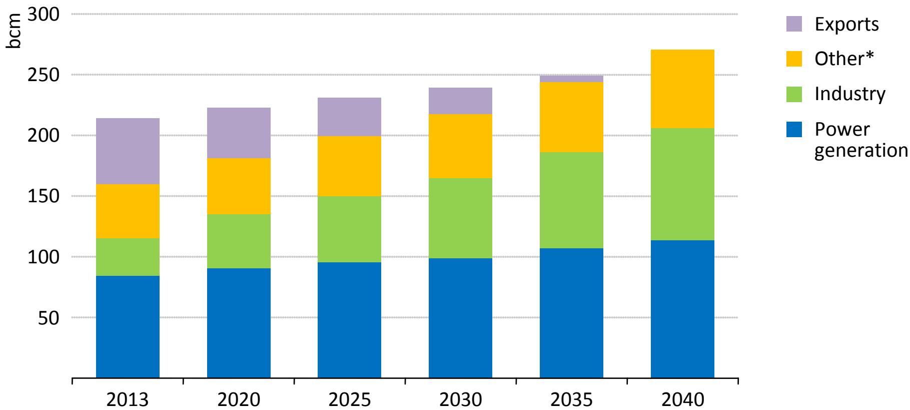
In Asia, the way that gas is priced in international trade remains largely anchored to long-term oil-indexed contracts, with the widespread adoption of clauses that restrict the potential for the re-direction of the gas. This differs substantially from Europe, where pricing set by gas-to-gas competition has gained ground over the last decade and especially in the last few years.

The prolonged period of high oil prices (and consequently elevated gas prices) between 2010 and 2014 spurred strong interest from several Asian countries in diversifying gas pricing away from oil indexation. Singapore has been a front-runner in trying to develop a competitive LNG trading hub in Asia on the basis of its favourable geographical position, located at the crossroads of many of the LNG trade routes in the region, and its status as a major oil trading hub. While the steep fall in oil prices since mid-2014 has reduced the push for hub pricing by Asian LNG buyers, it appears clear that alternatives to oil indexation and more flexibility in gas contracts are set to make inroads in the Asia Pacific region, although at slower pace than experienced in Europe.

The ultimate goal of Singapore is to establish an alternative gas pricing mechanism which should better reflect regional supply and demand. This system would also take advantage of the increasing quantity of LNG, especially from the United States and potentially later from East Africa, which are expected to be made available without the traditional commitment of delivery to specific destinations. In addition to further developing and expanding its LNG import, regasification and export capacity, since 2008 Singapore has restructured its domestic gas market with the aim of fostering competition, including the separation of the transportation segment and providing open and non-discriminatory access to its onshore gas pipeline network and to the LNG Jurong terminal.

While Singapore's LNG activities are expected to contribute to bringing more flexibility to the Asia Pacific LNG market, it remains to be seen if the modest size of the Singapore domestic market will represent a serious obstacle to the ambition of developing an LNG price setter for the Asia Pacific region, as the limited amount of gas traded may be insufficient to create a liquid market with transparent pricing. Also, Singapore is not the only country in Asia with aspirations to develop an LNG hub: Japan, South Korea, China and Malaysia have stated similar plans. In the case of Malaysia and Singapore, the two countries may potentially work together to scale up an integrated gas market that can help enhance energy security in Southeast Asia and facilitate transparent pricing and price discovery in the Asian LNG market more generally. Particularly in light of Singapore's land scarcity, the expansion of Singapore's storage and bunkering facilities – whether for oil or for LNG – will eventually hit a limit and traders will have to look beyond Singapore's borders to develop additional storage and service facilities.

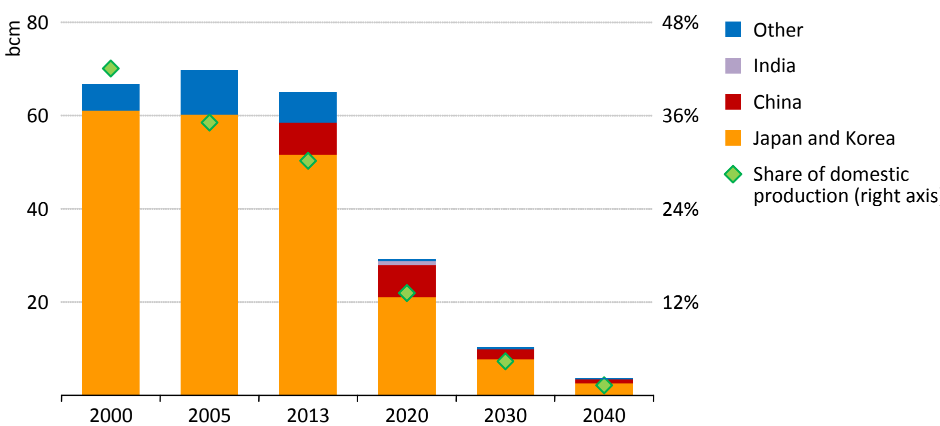
Figure 3.13 ⊳ Destination of Southeast Asia natural gas production



*Includes buildings, agriculture, non-energy use, other energy sector and bunkers.

This projected trend has significant implications beyond the borders of Southeast Asia, mainly for the largest purchasers of Southeast Asia LNG supply. Japan and Korea have traditionally absorbed the majority of the region's LNG exports, which accounts for a significant part of their domestic gas consumption.[21] Japan and Korea together imported almost 51 bcm of LNG from Southeast Asia in 2013, equivalent to about 79% of its total LNG exports. While Japan and Korea are set to remain the key destination markets, the picture changes over time due to the steady decline of gas resources available for export, and partially due to the rising competition with other emerging LNG buyers in the Asia Pacific area, notably China and India (Figure 3.14).

Figure 3.14 ⊳ Southeast Asia LNG exports by destination



Note: The chart shows inter-regional trade, i.e. trade between countries and regions as included in the World Energy Model (more information at: *www.worldenergyoutlook.org/model*). The chart does not include intra-regional trade, i.e. trade between countries in Southeast Asia.

[21] In 2013, LNG imports from Southeast Asia covered 29% of Japan's gas demand and 27% of Korea's domestic gas consumption.

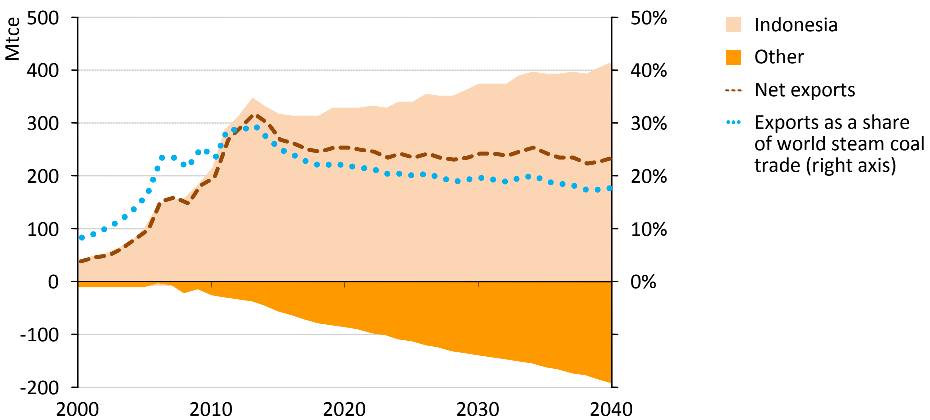
Coal trade

In the New Policies Scenario, Southeast Asia remains a net coal exporter. However, net exports steadily decline to around 230 Mtce by 2040 as domestic demand surges and coal demand growth on international markets slows.

The dynamics in the Southeast Asia coal market are set to significantly change over time. The emergence of coal as a fuel of choice for meeting rising domestic energy needs, especially due to the fast growth of power generation capacity and increasing electrification rates, prompts the region's coal industry to shift from focusing on exports to internal markets. Most countries in the region become or expand their roles as net coal importers, while the additional coal production in Indonesia is almost entirely covered by growth in its domestic demand. As a result, the share of Southeast Asia's net exports in internationally traded coal markets steadily declines throughout the *Outlook* period, going from 29% of the total in 2013 to less than 20% in 2040 (Figure 3.15).

3

Figure 3.15 ▷ Southeast Asia coal trade and share of internationally traded coal



Note: Negative values indicate imports.

By far, Indonesia remains the largest coal producer in the region over the period to 2040 (Box 3.4). Indonesia overtakes the United States by early 2030s to become the third-largest coal producer in the world behind China and India, but surrenders its role as the world's largest coal exporter before 2020 as it is overtaken by Australia. Its share of the total market for internationally traded coal declines only marginally, still remaining at around 30% throughout the projection period.

India and China are by far the largest buyers of Indonesian coal. Robust demand growth in these two countries has underpinned the strong growth in Indonesian coal production in the past. However, this relationship heavily exposes Indonesian exporters to energy policies in these countries. Over the course of the last year, China has introduced or tested a number of explicit and implicit instruments to control coal imports in an effort to protect the domestic mining industry and to improve the environmental performance of coal-fired plants. Chinese authorities have introduced import taxes for coal, banned certain types of coal from being imported and, in the last quarter of 2014, have requested the largest utilities to refrain from importing coal. Partly due to a free-trade agreement, Indonesia so far has been only marginally impacted by these measures, but remains heavily exposed to coal regulation in China. Even though these might be revised at a later stage, preliminary official data suggest that Indonesia's coal exports fell by 4% in 2014, driven by slackening demand from China.

Similarly, Indian coal policy could reduce imports of Indonesian coal. In India, coal imports fill the gap between soaring demand and sluggish growth in domestic coal output.[22] Indian coal is low cost too and if output were to exceed country's demand growth this would certainly displace large amounts of imports which come at a higher cost than domestic coal in most of India.

Another element which could have significant implication for exports of Indonesian coal is its over-exposure to potential hikes in the dry bulk shipping rates, which are largely a function of volumes carried. The dry bulk shipping market has been oversupplied for several years, resulting in very low freight rates. However, any increase in freight rates will be detrimental to exporters of low-quality coal, such as Indonesia, and beneficial to exporters with high quality coal such as Australia (even if this might be partially offset by longer travelling distance).

Box 3.4 ▹ Illegal coal mining in Indonesia

Illegal coal mining activities are a pervasive problem in Indonesia, concentrated mainly on the coal-rich islands of Kalimantan and Sumatra. No hard numbers are available on the volume of coal that is illegally produced and exported, but estimates from the Indonesian government and the Indonesian Coal Mining Association range from 20 to 70 million tonnes (Mt) per year, with the number of workers involved in illegal mining operations varying from 10 000 to 35 000.[23]

Illegal coal mining brings with it a range of severe consequences. Those include unfair competition in the country's coal industry, distortions of local and international markets and environmental damage, such as forest and land degradation as well as water and air pollution. Unauthorised coal production also causes the government to miss out on royalties. Based on current coal prices, the amount of coal that is shipped illegally translates into an overall value ranging between $1 and $4 billion per year.

[22] India's government set a target to reach 1 000 Mt of indigenous coal production by 2020, which would imply the displacement of all coal imports. This would require a major turnaround of the Indian coal sector which has been struggling to expand output in recent years.

[23] Based on an assumption of coal production of 2 000 tonnes per illegal miner per year.

Currently, Indonesia’s laws and regulations concerning coal production are not sufficiently developed to completely address illegal mining practices. A large number of operations do not comply with existing licensing regimes in part due to a lack of clarity or even conflicting government regulations, as well as deficient monitoring and enforcement capacity at local, provincial and national levels. In other cases, small-scale “people’s mining” operations by local residents in villages or community co-operatives permitted by law have proliferated far beyond government monitoring capacity.

However, the Indonesian government is scaling up its efforts to curb illegal coal exports with the adoption of several measures and the enforcement of regulation and state control of the coal industry. These include more stringent monitoring of port activities, enhanced scrutiny of cargo documentation and the construction of 14 state-controlled coal terminals (seven in Sumatra and seven in Kalimantan) to ensure more supervision of coal being exported.

Given the role of Indonesia in international coal markets, the solution of illegal coal mining would have implications going well beyond the national context. But, perhaps most importantly, lessons learned from illegal coal mining might be instrumental to address other illegal mining activities (for example in gold, tin and iron) that are both common in Indonesia and considered to be causes of severe environmental damage and the proliferation of child labour.

Focus on Malaysia

Energy demand and supply to 2040

Highlights

- Malaysia has the third-largest economy in Southeast Asia and is also the third-largest energy consumer in the region. It has high per-capita energy demand – three times the region's average – and has achieved near-universal access to modern energy services. Currently it is placing growing emphasis on increasing the deployment of renewable energy technologies and reducing energy subsidies.
- In the New Policies Scenario, Malaysia's primary energy demand almost doubles between 2013 and 2040, to 160 Mtoe. Early in the projection period, natural gas is the leading fuel in the primary energy mix, though it is surpassed before 2030 by coal, demand for which more than triples. Oil demand increases from 670 kb/d in 2014 to around 1 mb/d in 2040. The use of renewables grows rapidly, albeit from a low base, aided by government policies and incentives. Malaysia's energy-related CO_2 emissions double over the period, while the carbon intensity of its economy declines by 33%.
- Electricity generation grows 4% per year on average to reach 400 TWh in 2040. Most of the growth comes from coal-fired power plants, with coal overtaking natural gas around 2020 as the main source of power generation. By 2040, coal represents almost 60% of the power mix. Total installed power generation capacity increases from 32 GW in 2014 to about 85 GW in 2040.
- Malaysia is currently the second-largest oil producer in Southeast Asia, with output of 670 kb/d in 2014. Though oil production rises in the years to 2020 as new projects ramp up, it plateaus and begins to decline thereafter, dropping to around 600 kb/d in 2040, due to declining output in mature basins. Despite this, it surpasses Indonesia by 2040 to become the largest oil producer in the region.
- Incentives to encourage production in deepwater and marginal fields underpin a rise in natural gas production from around 69 bcm in 2013 to almost 75 bcm in 2020 in the New Policies Scenario. However, production drops back towards 60 bcm in 2040, as output from new fields fails to offset declines in mature basins.
- Malaysia's role in international energy markets is set to change as it increasingly becomes dependent on imports. It is already transitioning from a net exporter of oil to a net importer. This trend continues over the projection period and its oil import dependence rises to over 40% in 2040, by which time spending on oil imports amounts to almost $19 billion per year. Malaysia was the world's second-largest LNG exporter in 2013 (while also importing gas by pipeline), but growing domestic demand is set to steadily erode its contribution to international markets and its net gas exports decline to around 7 bcm by 2040.

Introduction

Malaysia, a parliamentary democracy with a constitutional monarchy, lies in the heart of Southeast Asia, covering almost 330 000 square kilometres of land that is divided by the South China Sea. Peninsular Malaysia (Western Malaysia) stretches from the southern end of Thailand to the island of Singapore. Eastern Malaysia is located on the island of Borneo, which it shares with Brunei Darussalam and Indonesia, and is made up of the states of Sarawak and Sabah.

Following decades of sustained economic growth, Malaysia is now an upper middle-income country and its economy is the third-largest in Southeast Asia and the 28th largest in the world. Its gross domestic product (GDP) per capita, at $23 680 (year-2014 dollars, purchasing power parity [PPP] terms) in 2013, was more than twice the Southeast Asian average (Table 4.1). Historically, the economy was dominated by agriculture and primary commodities, but it has become much more diversified due to rapid growth in the manufacturing and services sectors. The service sector currently accounts for about 50% of Malaysia's GDP followed by industry (including manufacturing, construction and mining) (around 40%) and agriculture (around 10%). The economy relies heavily on trade, particularly within Asia, with an emphasis on electronic goods, natural gas, palm oil and rubber. In the Outlook's central scenario – New Policies Scenario – Malaysia's GDP grows at an average annual rate of 3.9% in the period to 2040.[1]

Table 4.1 ▷ Key indicators for Malaysia

	Unit	2000	2013	CAAGR 2000-2013
Population	million	23	30	1.8%
GDP (PPP) per capita	$2014	16 269	23 680	2.9%
Energy demand	Mtoe	50	89	4.5%
Energy demand/capita	toe/capita	2.13	2.98	2.6%
Electricity demand	TWh	61	124	5.6%
Electricity demand/capita	kWh/capita	2 720	4 361	3.7%
Energy intensity	toe per $1 000 ($2014, PPP)	0.131	0.126	-0.3%
Net oil exports*	mb/d	0.31	-0.04	-185%
Net natural gas exports**	bcm	21	25	1.4%
CO_2 emissions***	Mt	118	211	4.6%

*Negative values indicate net imports. **In 2013, Malaysia's net gas pipeline imports amounted to almost 13 bcm, while it exported around 34 bcm of LNG. ***Excludes emissions from land use, land-use change and forestry.

Notes: CAAGR=Compound average annual growth rate; PPP = purchasing power parity; Mtoe = million tonnes of oil equivalent; toe = tonnes of oil equivalent; TWh = terawatt-hour; kWh = kilowatt-hour; mb/d = million barrels per day; bcm = billion cubic metres; Mt = million tonnes.

[1] See Chapter 1 for details of the New Policies Scenario.

The population of Malaysia was about 30 million in 2013, of which about 80% are concentrated in Peninsular Malaysia. In the New Policies Scenario, Malaysia's population increases at an average annual rate of 1.1%, reaching almost 40 million in 2040. The working age population – those aged 15 to 64 – is relatively high at 69%, a positive indicator for future growth. Malaysia's level of urbanisation has been on the rise, increasing from 62% in 2000 to 74% in 2013, and is relatively high for Southeast Asia.

Malaysia's total primary energy demand increased by almost 80% from 2000 to 2013. It has the third-largest energy demand in Southeast Asia, accounting for 15% of the region's overall demand. Malaysia's energy mix is heavily reliant on fossil fuels: natural gas (42%), oil (36%) and coal (17%). Electricity demand has been increasing even more rapidly than overall energy use, doubling since 2000. Its per-capita electricity use is among the highest in the region and it has achieved almost-universal access to electricity. Malaysia's power generation capacity of 32 gigawatts (GW) is predominately fired by natural gas, although coal has been gaining market share. Other than hydropower, the use of renewable sources in the power sector remains fairly limited but the potential is substantial and initiatives are being put in place to increase their deployment. Nuclear power does not feature in the mix, although it remains under discussion.

The oil and gas sector has long formed an important part of Malaysia's economy. Historically Malaysia has been an oil exporter, but following a trend over the last decade of rising domestic consumption and declining production, the country became a net oil importer in 2013.[2] A similar trend can be seen in natural gas trade, although Malaysia remains an important gas exporter, mainly in terms of liquefied natural gas (LNG). However, gas imports (including LNG since 2013 and pipeline imports from Indonesia) have almost doubled since 2008 to around 13 billion cubic metres (bcm) in 2013 to alleviate geographic supply-demand imbalances within the country. Malaysia produces limited amounts of coal; about 90% of coal demand is met by imports, primarily from Indonesia.

Energy policy and market overview

The strategic direction of energy policy in Malaysia is set by the Economic Planning Unit, which is part of the Prime Minister's Office. Responsibility for implementing energy policy falls across a range of ministries and agencies. The Ministry of Energy, Green Technology and Water has the lead on a number of aspects, with a primary focus on electricity supply. Petroliam Nasional Berhad (PETRONAS) is responsible for the oil and gas sector, which is government-owned and under the direction of the prime minister and the single largest contributor to government revenues. PETRONAS has exclusive control of hydrocarbon resources, although foreign and private companies are able to participate in upstream activities under production sharing contracts.

[2] It considers crude oil and oil products.

SPOTLIGHT

End of the road for Malaysia's fossil-fuel subsidies?

Malaysia has a long history of subsidising energy, including gasoline, diesel, liquefied petroleum gas (LPG), kerosene, natural gas and electricity, but has been making progress recently in reforming energy pricing. The drivers for change are numerous. The cost of subsidies had been pushed higher by the combination of persistently high international energy prices and fast-growing energy demand. For example, the number of cars on Malaysia's roads more than doubled between 2000 and 2013, contributing to the budget allocation for energy subsidies growing from around Malaysian ringgit (MYR) 4-5 billion ($1.3 billion) in the early 2000s to MYR 29 billion ($9 billion) in 2013. There has also been growing recognition that subsidies have created serious problems, such as the smuggling of subsidised fuel (especially gasoline and diesel) for sale in neighbouring countries at higher prices.

In December 2014, the government ended subsidies for 95RON gasoline and diesel, with their prices now set monthly to track movements in international markets (as is also the case for 97RON gasoline). Prior to the changes, retail prices were meant to vary based on an "automatic pricing mechanism" (APM), but in practice they had rarely changed since 2009 and instead the APM determined the subsidy or sales tax exemptions required to maintain fixed retail prices. Subsidies remain in place for LPG and diesel for public transport and the fishing industry. Malaysia has also been reforming electricity prices, while making sure that power remains affordable for low income households on a targeted basis. In January 2014, a pass-through mechanism was introduced that adjusts electricity tariffs every six months to reflect changes in fuel costs and allow other fixed costs to be recovered. Prior to these reforms, utilities had racked up big losses when shortages of domestically produced natural gas supplied at regulated prices required them to switch to more expensive LNG imports, distillates or fuel oil to run power plants. Even with the increases, electricity prices in Malaysia remain low compared to many other parts of Southeast Asia.

The reforms to electricity pricing were complemented by increases in the prices paid for natural gas in various sectors. Over recent years, the gap between domestic prices for natural gas in Malaysia and international prices for LNG widened substantially (until the recent fall in international prices). This has led to PETRONAS foregoing a significant amount of potential revenue and also incurring significant losses as it had to import LNG at market rates to meet domestic demand. In 2014 the government increased natural gas prices paid by the power sector and industry. The move towards market-parity gas pricing is likely to see increasing substitution of natural gas by coal. It will also make LNG imports a more viable option, despite their generally higher cost, while also improving prospects for domestic production by providing incentives to develop costlier resources. Nonetheless, much still remains to be done: in early 2015, utilities were paying MYR 15.2 ($4.2) per million British thermal units (MBtu) for piped gas compared with MYR 46 ($12.5) per MBtu for LNG, though this has come down significantly over the course of 2015.

Malaysia's power sector is undergoing several reforms including revisions to electricity tariffs, which are expected to help finance network expansion and capacity additions, and enable more use of renewable energy technologies (see Spotlight). The power sector is dominated by three large vertically integrated utilities (one each in Peninsular Malaysia, Sabah and Sarawak). Partial liberalisation has fostered some small independent power producers (IPPs) that sell their total output to a single buyer. Regulation of the electricity and the natural gas pipeline networks is the responsibility of the Energy Commission in Peninsular Malaysia and Sabah. In Sarawak these functions are the role of the state government. Peninsular Malaysia's power grid is linked with Thailand and Singapore. A proposed interconnection with Sarawak, which would transmit hydro-based power, has been delayed until 2021. Under the Association of Southeast Asian Nations (ASEAN) Power Grid, which is an aspirational programme to establish a regional electricity network, additional interconnections are being developed between Malaysia and Singapore, Thailand and Indonesia, and between the regions of Malaysia (see Chapter 5).

In terms of energy efficiency, Malaysia's efforts have largely focussed on electricity (which accounts for about one-fifth of total final energy consumption), highlighting the scope for increased savings through a broader approach. These efforts have been complicated by the governance structure that places responsibility for energy across a number of jurisdictions. As a member of Asia-Pacific Economic Cooperation (APEC), Malaysia has committed to achieving a 45% reduction in its energy intensity between 2005 and 2035. Some notable steps it has taken include ongoing reductions in fossil-fuel subsidies, implementation of minimum energy performance standards (MEPS), a Building Sector Energy Efficiency Project (BSEEP) and a green building index that promotes the use of energy efficient appliances and retrofitting of existing buildings (Table 4.2). The proposed National Energy Efficiency Action Plan, which is in the process of being finalised, proposes a strategy for a co-ordinated and cost-effective implementation of energy efficiency measures in the industrial, commercial and residential sectors in order to reduce energy consumption and deliver economic savings. However, the plan is confined to electricity usage and does not cover other aspects of the energy sector. Under the National Automotive Policy (NAP 2014), Malaysia has a target to become the regional hub for energy efficient vehicles (EEV) by 2020.[3]

Malaysia has considerable renewable energy resources, though today they play a relatively limited role in meeting its energy needs, in part because they are often located far from demand centres. Since 2001, with the introduction of the Fifth Fuel Policy (which includes new renewables as the fifth fuel in the energy mix with natural gas, oil, hydro and coal), Malaysia has sought to expand the use of renewable forms of energy. The renewable

[3] In this context, EEVs are defined as vehicles that meet defined specifications in terms of carbon emission levels (grammes/km) and fuel consumption (litres/100 km) and include fuel-efficient vehicles, hybrids, electric vehicles and alternative-fuel vehicles, e.g. compressed natural gas, liquefied petroleum gas, biodiesel, ethanol, hydrogen and fuel cells.

technologies that hold the most potential include biomass, biogas, small-scale hydro and solar photovoltaic (PV). As an APEC member, Malaysia has committed to double the share of renewables in its overall energy mix by 2030 from 2005 levels. Targets have been set to increase renewables-based power generation capacity to 2 080 megawatts (MW) by 2020 and 4 000 MW by 2030 (these targets exclude the contribution from large hydro). Various financial incentives, including feed-in tariffs (FiT) and tax exemptions, have been put in place to attract the needed investment (Box 4.1). Malaysia is also targeting an expanded role for biofuels in transport, primarily through the use of palm oil. A requirement for diesel to include 5% palm oil was raised to 7% in late 2014 and in mid-2015 plans were announced to allow blending of up to 10%.

Table 4.2 ▹ Key energy targets and policy measures in Malaysia

	Target	Policy measures
Energy efficiency	The proposed policy to reduce electricity consumption by 6% in 10 year period.	Promotion of 5-Star rated appliances; MEPS, energy audits in industry and buildings, energy efficient building design.
Renewables	2 080 MW or 11% of total power capacity by 2020. 4 000 MW or 17% of total power capacity by 2030.	Feed-in tariffs (FiT). Establishment of the Sustainable Energy Development Authority. Tax incentives. Net metering and utility-scale solar (under study).

Sources: Economic Planning Unit (2015); Ministry of Energy, Green Technology and Water (KeTTHA).

Malaysia has committed to reduce its carbon dioxide (CO_2) emissions per unit of GDP by up to 40% by 2020, from 2005 levels, conditional upon receiving the transfer of technology and adequate financing from developed countries. Data suggest that it is making some progress towards meeting the target, in part due to structural changes in its economy with a shift from manufacturing to the less energy-intensive services sector and higher-value industrial activity. A greenhouse-gas reporting programme has been established, with a particular focus on monitoring and reducing emissions from private sector entities. In the power sector, the Renewable Energy Act, which provides feed-in tariffs for renewables-based electricity, is one of the key policy instruments being utilised to reduce carbon emissions. In the transport sector, a key initiative is the development of a new mass transit system to reduce congestion and save energy.

Nuclear power does not feature in Malaysia's energy mix. The country has, however, investigated its potential introduction, though previously announced plans to build two nuclear plants are not being actively pursued. The 11th Malaysia Plan 2016-2020, states that the use of nuclear power as an alternative energy resource will be explored further and that an independent atomic energy regulatory commission will be established (Economic Planning Unit, Prime Minster's Department Malaysia, 2015). Any future development of nuclear power would probably be limited to Peninsula Malaysia (where a majority of the electricity demand is concentrated) as part of a strategy to overcome natural gas shortages, which in recent years have led to increased use of coal and oil in power generation.

Box 4.1 ▻ Pushing renewables into the Malaysian mix

Implemented by the Sustainable Energy Development Agency (SEDA) in December 2011, the feed-in tariff (FiT) scheme is a key policy instrument for accelerating the deployment of renewable energy set out in Malaysia's Renewable Energy Act 2011. The FiT scheme covers biogas, biomass (including solid waste), solar PV and small hydropower with a maximum on-grid capacity of 30 MW per installation. Power utilities in Malaysia must purchase all electricity generated by approved renewable energy producers at a set tariff via long-term power purchasing agreements (PPAs) effective for 16 years for biomass and biogas, and 21 years for solar PV and small hydro.

Due to long financing agreements and limited funding for the FiT scheme from the dedicated Renewable Energy Fund, SEDA sets installed capacity quotas for each round of FiT applications. Tariffs vary according to the type and size of installed capacity. As of April 2015, the basic FiT rates were: Malaysian ringgit (MYR) 0.27-0.30 per kilowatt-hour (kWh) ($0.06-0.07/kWh) for biomass, MYR 0.27-0.32/kWh ($0.06-0.08/kWh) for biogas, MYR 0.49-0.92/kWh ($0.12-0.22/kWh) for solar PV and MYR 0.23-0.24/kWh ($0.05-0.06/kWh) for small hydro. Bonus FiT rates are awarded when producers also meet specific criteria such as the use of landfill waste or locally manufactured technologies.[4] Digression rates can be applied to projects approved since 2013, though presently they only apply to solar PV installations.

The terms of the FiT scheme proved to be particularly attractive especially for solar PV, with application consistently exceeding quotas. As of April 2015, almost 98% of the 6 752 approved applications under the FiT scheme were for solar PV. Of the 283 MW of operating renewables capacity under the FiT scheme, nearly 68% (192 MW) are solar PV installations, with most of the remaining being biomass (63 MW).

While the popularity of solar PV in the FiT scheme sends a strong signal to support the achievement of Malaysia's ambitious solar capacity targets, it has also compelled the Malaysian government to reconsider application quotas as well as financing options. Currently retail customers whose consumption exceeds 300 kWh pay a 1.6% premium to support the the Renewable Energy Fund that finances the FiT scheme, though it is insufficient to support the expansion of the Fund. However, raising electricity tariffs further would be difficult. As a consequence, the government is considering abolishing the FiT for solar PV in 2017 and plans to introduce net metering over the period of the 11th Malaysia Plan 2016-2020. As well, the government is considering the implementation of utility-scale solar. FiT schemes are expected to remain in place for biogas, biomass and small hydro, which have seen comparatively lower uptake.

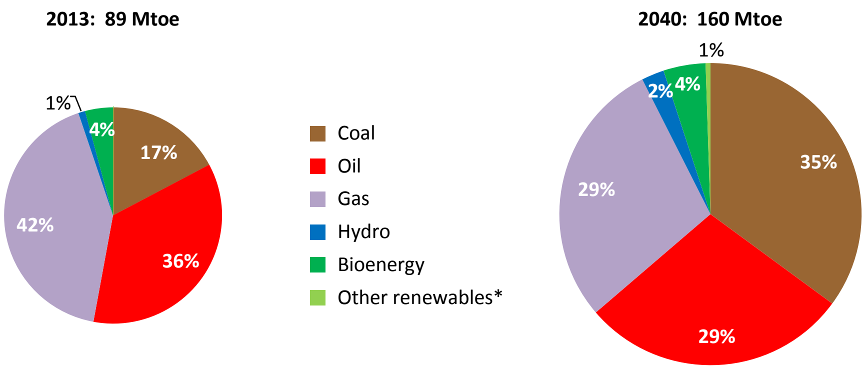
[4] In 2014, Malaysia became the world's third-largest producer of photovoltaic modules and components after China and Chinese Taipei, as several of largest solar manufacturing companies expanded their production capacity.

Energy demand to 2040

Primary energy demand

Malaysia's total primary energy demand almost doubles over the *Outlook* period in the New Policies Scenario, from 89 million tonnes of oil equivalent (Mtoe) in 2013 to 160 Mtoe in 2040 (Figure 4.1). Demand grows at an average annual rate of 2.2% per year. Demand increases for each of the primary energy sources, but their rates of growth are markedly different. Fossil fuels remain dominant, their share falling only slightly by 2040 from 95% of total primary energy demand in 2013. Though natural gas is the leading fuel at the start of the *Outlook* it loses significant market share to coal and in the medium term to oil. By 2040, coal is the largest fuel in the mix, having overtaken natural gas before 2030 and oil shortly thereafter. As Malaysia has faced challenges in sustaining production of oil and natural gas, it has sought to diversify its energy mix, introducing policies such as the Fifth Fuel Policy, National Biofuels Policy, and National Renewable Energy Policy and Action Plan among others to ensure effective use of its energy resources. These policies underpin rapid growth in the use of renewables, though as they build from today's low base they still constitute a small share of total energy demand in 2040.

Figure 4.1 ▷ Fuel shares in primary energy demand in Malaysia



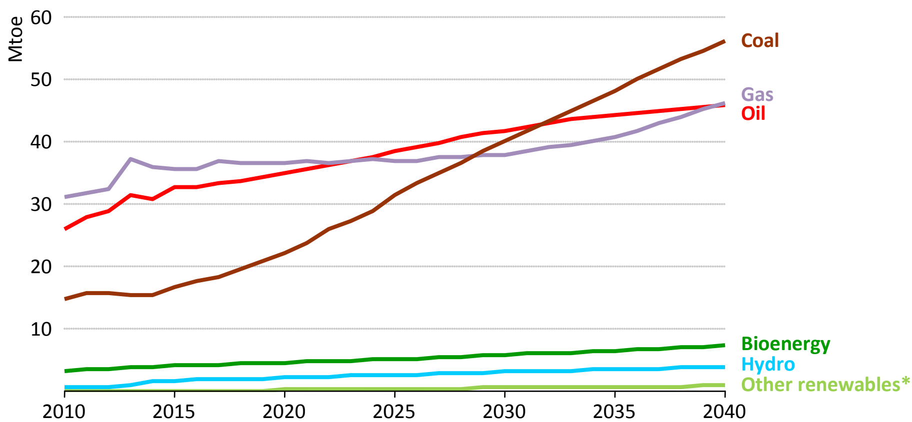
*Includes solar PV and wind.

Malaysia's energy intensity – measured as the amount of energy used to produce a unit of GDP – falls by 40% over the *Outlook* period. This in part results from improvements in energy efficiency brought about by the implementation of dedicated measures that stem from Malaysia's commitment as a member of APEC to reduce its energy intensity, shifts in the drivers of economic growth from energy-intensive industries towards services and higher-value manufacturing, and further reforms to fossil-fuel subsidies. Malaysia's per-capita energy demand rises 35% from 2.98 tonnes of oil equivalent (toe) in 2013 to 4.0 toe in 2040, by which time it is almost three times the Southeast Asian average (overtaking the OECD average around 2035).

Outlook by fuel

In the New Policies Scenario, Malaysia's natural gas demand grows from 44 billion cubic metres (bcm) in 2013 to 55 bcm in 2040, an average of 0.8% per year. Natural gas use is constrained by the steady decline in production from maturing fields and rising prices as remaining subsidies are phased out, and imports (both pipeline and LNG) increase. While natural gas holds the largest share of total primary energy demand at the start of the *Outlook* (42%), its share drops to 29% by 2040, roughly equal with oil (Figure 4.2). Imports supply a growing share of Malaysia's gas demand, as its domestic production declines and demand increases.

Figure 4.2 ▷ Primary energy demand by fuel in Malaysia, 2010-2040



*Includes solar PV and wind.

Demand for oil grows at 1.4% per year on average, rising from 670 thousand barrels per day (kb/d) in 2014 to 760 kb/d in 2020 and around 1 mb/d in 2040. Its share of the mix drops from 36% to 29% on improvements in efficiency and more use of biofuels in transport, increased investment in public transport and to a lesser extent the continued switching away from oil in power generation.

Coal demand more than triples to reach almost 80 million tonnes of coal equivalent (Mtce) in 2040, growing at 4.9% per year on average. This rapid increase mirrors trends seen in other parts of Southeast Asia and is driven by the relatively attractive economics of coal-fired power generation and the need to meet rising electricity demand in the context of growing imports of natural gas. Additionally, with the gradual removal of subsidies for natural gas, coal's competitive advantage versus gas increases. Coal's share of total primary energy demand rises by 18 percentage points to 35% in 2040. Malaysia has limited coal resources and they are primarily located in remote and environmentally sensitive parts of Sarawak and Sabah. It currently relies on imports to meet 90% of its coal demand (sourced primarily from Indonesia, and to a lesser extent from Australia, South Africa and Viet Nam).

Use of renewable energy sources (bioenergy, hydropower, solar PV and wind) almost triples in the New Policies Scenario, rising to 12 Mtoe by 2040. The development of renewable energy is being actively promoted through policies backed by FiT and other incentives. The use of modern renewable energy (which includes all renewable sources except traditional use of biomass) is concentrated in the power sector. Hydropower, the largest source, grows an average 5.5% per year and sees its share of electricity generation rise from 8% in 2013 to 11% by 2040. Given that much of the available large hydro potential has already been developed on Peninsular Malaysia, this growth is concentrated in Sarawak through the further expansion of the Sarawak Corridor of Renewable Energy.[5]

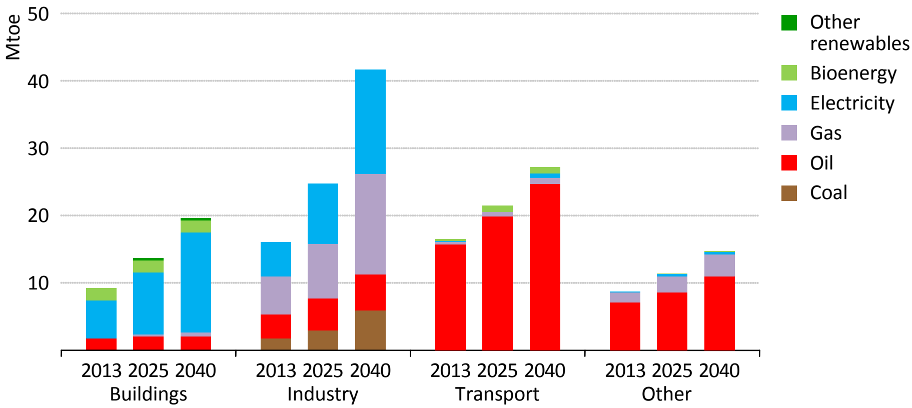
Compared with Southeast East Asia as a whole, where bioenergy (comprising solid biomass, biofuels and biogas) use is quite high, mostly for cooking, the use of bioenergy is limited in Malaysia. Its share of the energy mix grows slightly from 4% in 2013 to 5% by 2040 in the New Policies Scenario. Use of bioenergy in Malaysia in the power sector grows, as biomass residues (primarily from palm oil and rice) are utilised to generate electricity. It is also increasingly used in the transport sector. Malaysia is one of the world's largest producers of palm oil, although most of it is used in food rather than in biofuels and is exported. Currently the domestic use of biofuels is limited, but new blending mandates and increased production in Sarawak are set to increase both local production and consumption. There are several challenges that could constrain the use of bioenergy including uncertainty about the availability of supply and its quality, and concerns about the environmental sustainability of production.

Outlook by sector

Malaysia's total final energy consumption (TFC) increases 2.7% per year, from 50 Mtoe in 2013 to more than 100 Mtoe in 2040 (Figure 4.3). This is slower than the rate experienced over the previous two decades when TFC growth averaged 5.1% a year. Transport is the largest energy-consuming sector, and at 16 Mtoe in 2013, accounted for 33% of TFC. Over the *Outlook* period, transport energy use grows at a more modest rate (1.9%) than other end-use sectors and by 2020 it is overtaken by industry as the largest consuming sector. Road transport accounts for almost all of the energy demand in the transport sector. A distinguishing feature of the transport sector in Malaysia is that it is already mature. Malaysia's high level of ownership, 293 passenger light-duty vehicles (PLDVs) per 1 000 inhabitants in 2013, is largely due to its relatively high per-capita income, history of subsidised fuel and limited public transportation systems. While its car ownership grows to reach 450 PLDVs per 1 000 inhabitants by 2040, average annual growth slows after 2020 because of progressive saturation of the market and the expansion of public transport options (Box 4.2).

[5] The Sarawak Corridor of Renewable Energy is a development corridor launched in 2008 that emphasises ten key industries for development including tourism, oil, aluminum, metals, fishing, livestock, and palm oil among others.

Figure 4.3 ▷ Total final energy consumption by fuel in Malaysia



Notes: Buildings sector includes residential and services. Other includes agriculture and non-energy use. Other renewables includes solar PV and wind.

Box 4.2 ▷ Public transport development

Economic development, population growth and rising living standards have spurred demand for mobility in Malaysia. Over the last two decades, the number of PLDVs has more than quadrupled contributing to traffic congestions and rising levels of emissions and air pollutants, especially in the Klang Valley which represents a significant share of Malaysia's economy (an area including Kuala Lumpur, Selangor district of Petaling, Klang, Gombak and Hulu Langat).

As urbanisation is set to continue, with the Klang Valley expected to host around one-third of the entire Malaysian population by 2020, the government has taken important steps to encourage a shift towards more use of public transport systems. The most important project is the Klang Valley Mass Rapid Transit Project (KVMRT), the largest public transport infrastructure project to date in Malaysia. It aims to develop an efficient public transport network with construction of three rail lines covering 145 kilometres. The first phase of the project has begun and is expected to be completed by 2017.

In addition to KVMRT, the Malaysian government has undertaken other public transport projects such as the extension of the current light rapid transit (LRT) lines and the Bus Rapid Transit, an initiative to establish a special corridor for buses on major highways. This should bring the percentage of users taking public transport (compared to those using private vehicles) to 40%, up from 17% in 2014. Additionally, these efforts are expected to streamline the public transport system by reducing traffic jams, moderating energy consumption with a modal shift to public transport, as well as reducing air pollutants and carbon emissions and thus improving air quality.

Oil accounts for more than 90% of energy use in Malaysia's transport sector throughout the projection period despite efforts to promote the use of alternatives. Through its natural gas vehicle (NGV) programme, which is a partnership between PETRONAS and the government, Malaysia had nearly 70 000 natural gas vehicles on the road in 2013, mostly taxis. While the price of natural gas has been kept well below that of petrol to encourage adoption, limited access to refilling stations has slowed expansion of the NGV fleet (Malaysian Gas Association, 2014). By 2040, natural gas and bioenergy account for 8% of total transport energy demand, up from 3% in 2013.

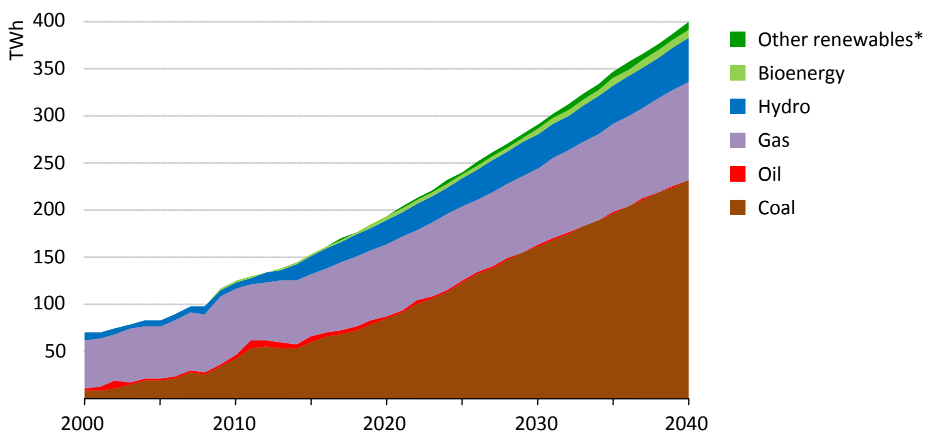
Industrial energy demand increases by more than two and a half times by 2040, growing an average of 3.6% per year, much faster than the other end-use sectors. Manufacturing and processing facilities and construction operations help drive demand as does the continued expansion of the Sarawak Corridor of Renewable Energy. It is also a result of Malaysia's Economic Transformation Programme, which aims to turn the country into a high-income economy and stimulate investment in as areas such as metal smelters, high-tech manufacturing and petrochemical plants. Natural gas and electricity dominate the industrial energy mix, each accounting for roughly 36% of industrial demand by 2040. The growth in industrial energy demand to 2040 is less than the rise in the value of overall industrial output (which roughly triples), reflecting an improvement in the energy intensity of industrial production. These gains are linked to energy efficiency measures to help manage the increase in demand and an assumed shift towards higher-value industrial activities. Nonetheless, Malaysia's industrial energy intensity remains higher than the Southeast Asia average in part because it continues to export energy-intensive commodities.

The buildings sector (residential and services) consumed over 9 Mtoe of energy in 2013, accounting for 18% of final consumption, a share that remains relatively constant to 2040. While energy demand in the buildings sector is less than transport and industry sectors, it grows an average 2.9% per year, and accounts for 40% of the growth in Malaysia's electricity demand over the *Outlook* period. Electricity demand in the buildings sector increases from 65 TWh in 2013 to more than 170 TWh by 2040, an annual average growth rate of 3.7% per year. Rising living standards and higher incomes drive this high growth rate. In addition, Malaysia's hot and humid climate encourages the use of cooling year-round. Together cooling equipment and appliances account for around half of electricity demand buildings in 2013 and 57% by 2040. As a result, electricity's share of energy use in the buildings sector rises from 61% in 2013 to 76% by 2040, and oil's share decreases from 19% to 11% (LPG is used for cooking in households). The share of biomass in the buildings sector energy consumption, 20% in 2013 falling to 9% in 2040, is much lower than the average in Southeast Asia (61% in 2013 and 33% in 2040). Other energy demand, which includes agriculture and non-energy use (primarily oil and gas feedstock for the petrochemical industry) constitute the smallest share of total final consumption throughout the *Outlook* period.

Power sector

In the New Policies Scenario, electricity demand grows at 4% per year on average from 2013 to 2040 in keeping with continued economic growth and prosperity. Peninsular Malaysia accounts for more than 90% of the country's electricity demand. For the country as a whole, electricity demand per capita more than doubles, passing the European Union per-capita level soon after 2020 and reaching almost 9 500 kWh per capita by 2040. Malaysia has one of the highest overall electrification rates in the region, though the rates vary by location: Peninsular Malaysia is almost at full electrification, Sabah is at 93% and Sarawak is at 88%.[6] The last stage before universal access is the most difficult, as the remaining population without access is the hardest to reach, often located in remote areas (SE4ALL, 2014). This typically prompts authorities to focus on decentralised systems, including small hydro and solar, to meet the challenge.

Figure 4.4 ▷ Electricity generation by fuel in Malaysia, 2000-2040



*Includes solar PV and wind.

Electricity generation increases by almost a factor of three, growing on average 4% per year to reach 400 TWh in 2040. To meet rising demand, all fuels except oil increase in the sector (Figure 4.4). Today natural gas accounts for the largest share of generation, but by 2020, coal overtakes it. Coal grows an average of 5.6% per year and by 2040 it accounts for 58% of fuel used for power generation (having already grown from 11% in 2000 to nearly 40% in 2013). While coal and gas together account for almost 85% of electricity generation in 2040, the mix diversifies as bioenergy, hydro and other renewables gain small shares. An emphasis by the government on policies aimed at increasing the amount of renewables in the energy mix helps drive their growth in the power sector. On average, other renewables (which includes solar PV and wind) grows almost 16% per year, while bioenergy grows 8%

[6] 11th Malaysia Plan 2016-2020.

per year and hydro 5.5%. While these technologies start from a low base (with the exception of hydropower), their share of the generation mix grows seven percentage points to reach 16% in total by 2040 (11% for hydro, 2% each for bioenergy and other renewables).

To keep up with growth in electricity demand, Malaysia's installed generation capacity expands from 32 GW in 2014 to 85 GW in 2040 (Table 4.3). The gross capacity addition of 64 GW in Malaysia over the *Outlook* period is roughly one-sixth of the total gross capacity additions in the Southeast Asian region. Coal and gas continue to dominate Malaysia's power sector, accounting for about 75% of gross capacity additions. Other capacity additions are: hydro at 13%; other renewables (solar PV and wind) at 8%; bioenergy at 3% and oil at 2%.

Table 4.3 ▷ Installed generation capacity by fuel in Malaysia

	Electrical capacity (GW)						Shares		CAAGR*
	2014	2020	2025	2030	2035	2040	2014	2040	2014-2040
Coal	8	12	17	23	28	33	25%	39%	5.7%
Oil	4	3	3	3	2	2	11%	2%	-2.4%
Gas	15	19	21	24	28	30	46%	36%	2.8%
Hydro	5	7	9	10	12	13	16%	16%	3.6%
Bioenergy	0.4	1	1	1	2	2	1%	2%	5.9%
Other renewables**	0.2	1	2	3	4	5	1%	5%	13.5%
Total	**32**	**44**	**54**	**64**	**75**	**85**	**100%**	**100%**	**3.8%**

*Compound average annual growth rate. **Includes solar PV and wind.

Coal adds the most gross capacity over the *Outlook* period (26 GW), which is reflected in the increase in its share of electricity generation, which rises almost 20 percentage points from 2013 to reach 58% in 2040. Though natural gas adds 22 GW of gross capacity over the *Outlook* period, its share of electricity generation declines as coal's price relative to natural gas and Malaysia's diversification goals help drive coal's expansion.

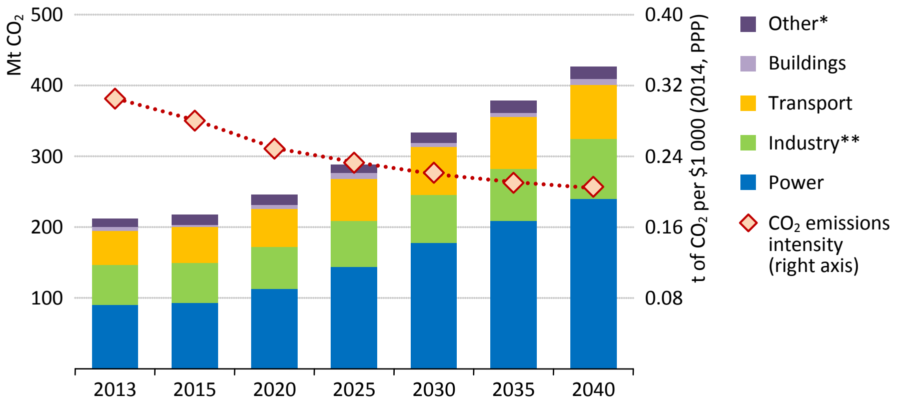
Given the importance of coal to Malaysia's energy mix, the use of more efficient technologies will be critical to reducing emissions of local air pollutants and CO_2. A step in that direction was achieved in early 2015 when Malaysia's first ultra-supercritical coal-fired power plant, Manjung 4, came online. A shift towards more efficient coal plants over the projection period increases the overall efficiency of Malaysia's coal fleet by a remarkable 6 percentage points, to roughly 40% in 2040.

Energy-related CO_2 emissions

Given the continuing dominance of fossil fuels in Malaysia's energy mix, its energy-related CO_2 emissions double in the New Policies Scenario, increasing from 211 million tonnes (Mt) in 2013 to almost 430 Mt by 2040 (Figure 4.5). Coal use in the power sector is responsible for two-thirds of the increase in emissions over the *Outlook* period. The carbon intensity of

Malaysia's economy is one-and-a-half times greater than the average in Southeast Asia. Malaysia's carbon intensity declines by 33% over the *Outlook* period due to structural changes in its economy and the implementation of measures and policies, such as the Renewable Energy Act, though it remains well above the Southeast Asian average in 2040.

Figure 4.5 ▷ Energy-related CO_2 emissions by sector in Malaysia



*Includes agriculture and non-energy use. **Includes transformation industries from other energy sector.

Malaysia currently accounts for over one-sixth of Southeast Asia's total energy-related CO_2 emissions, a share that remains stable until 2040. Its per-capita CO_2 emissions are more three times higher than the Southeast Asian average over the *Outlook* period and more than one-and-a-half times higher than the OECD average by 2040, which has been declining since 2007 and is expected to continue.

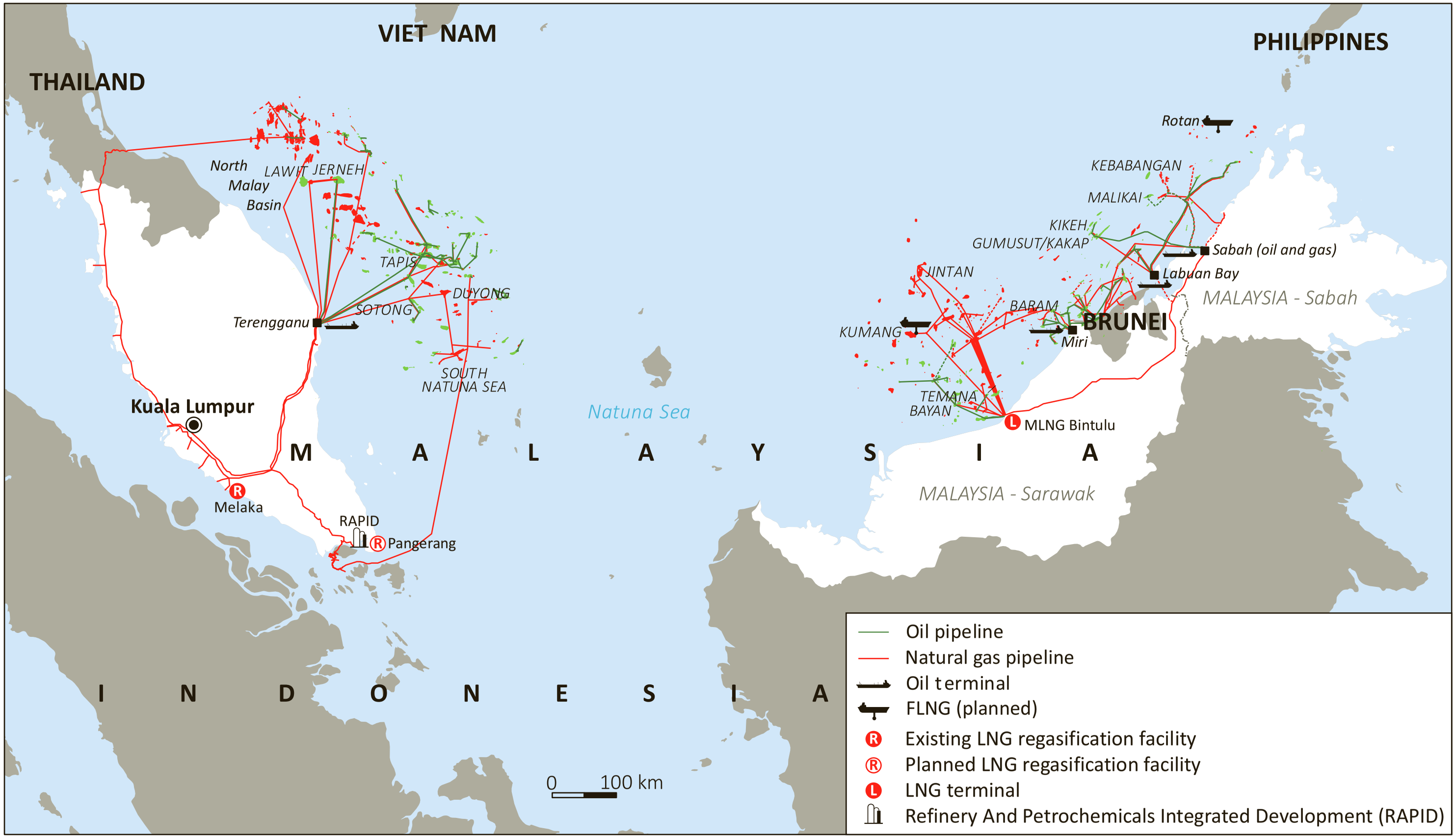
The power sector's share of total CO_2 emissions grows by 14 percentage points, to reach 56% by 2040 as fossil fuels retain their dominance. Industry's share increases from 15% to 17% reflecting an expansion of industrial output, while the transport and the buildings sectors' shares decline, owing to already high levels of vehicle ownership and increased public transit options and energy access coupled with improvements in efficiency.

Energy supply to 2040

Oil supply

Malaysia ranks second among Southeast Asia countries in terms of proven oil reserves, with 4 billion barrels at the end of 2014, and is the second-largest oil producer in the region. Its remaining recoverable resources are about four-times larger, amounting to about 16 billion barrels. The country's oil sector started with the exploitation of fields located in the shallow waters offshore Terengganu in Peninsular Malaysia and Baram Delta in Sarawak, which are now in decline. Future oil production will come mainly from deep offshore Sarawak and Sabah where large oil discoveries, such as the Kikeh and Gumusut-Kakap fields, have been found and there is significant potential for future discoveries (Figure 4.6).

Figure 4.6 ▷ Oil and gas infrastructure in Malaysia



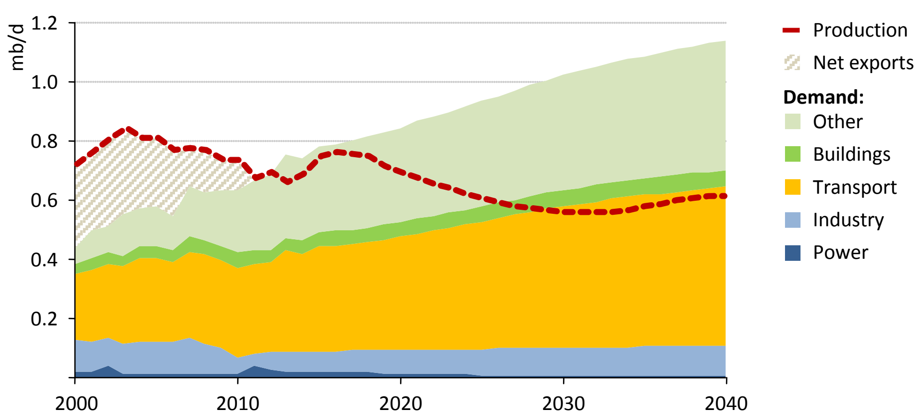
This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries, and to the name of any territory, city or area.

Malaysia's total oil output at 670 thousand barrels per day (kb/d) in 2014 was down 19% from its peak of 830 kb/d in 2003. Recognising that a significant portion of the country's remaining proven reserves are marginal fields, the government expanded fiscal incentives to encourage investment in marginal fields and enhanced oil recovery (EOR) projects in mature areas as part of the Economic Transformation Programme implemented in 2011. PETRONAS has signed EOR agreements with foreign oil companies and introduced a new type of risk service contract to encourage the development of marginal fields. In 2014, ExxonMobil and PETRONAS commenced EOR work by implementing water-alternating-gas techniques on Tapis, one of several mature fields offshore Peninsular Malaysia that is hoped will sustain the country's production. In 2012, Shell and PETRONAS signed two production sharing contracts to develop six oil fields in the Baram Delta offshore in Sarawak and three oil fields in the North Sabah development area.

In the New Policies Scenario, Malaysia's oil production rises to above 700 kb/d in the years leading up to 2020 before declining slightly to just over 670 kb/d in 2020. The increase is linked to the ramp up in production from new projects operated by Shell offshore Sabah, including the Gumusut-Kakap oil field, where production started in late 2014 (with expected peak production of 135 kb/d in a few years), and the Malikai field (with expected peak output in the order of 60 kb/d by 2017-2018). Despite this increase and subsequent plateau in the medium term, over the longer term domestic production declines, falling to around 600 kb/d by 2040. The contribution from EOR projects and new fields in largely underexplored areas in offshore Sabah only partly offset the decline in production in mature basins.

Malaysia became a net oil importer in 2013 and after 2020 its dependence on oil imports rises steadily, slowing after 2030 reaching 400 kb/d by 2040 (Figure 4.7). This equates to an import dependence of over 40% and an oil import bill of almost $19 billion.

Figure 4.7 ▻ Oil balance in Malaysia, 2000-2040



Notes: Net imports are required when demand exceeds production. Demand includes bunkers (projected at around 0.2 mb/d by 2040).

Malaysia has significantly expanded its oil refinery capacity and now has five refineries with an overall capacity of roughly 600 kb/d, which is sufficient to almost meet its current demand for oil products. However, the introduction of more stringent fuel standards, starting with the adoption of Euro 4 standard for gasoline[7] from September 2015, means that it will need to import low-sulphur gasoline until the new PETRONAS 300 kb/d RAPID (Refinery and Petrochemicals Integrated Development) refinery in Johor comes online in a few years. Expanding refining capacity will increase the dependence on imported crude oil for refinery runs, but will allow for reduced product imports.

Natural gas supply

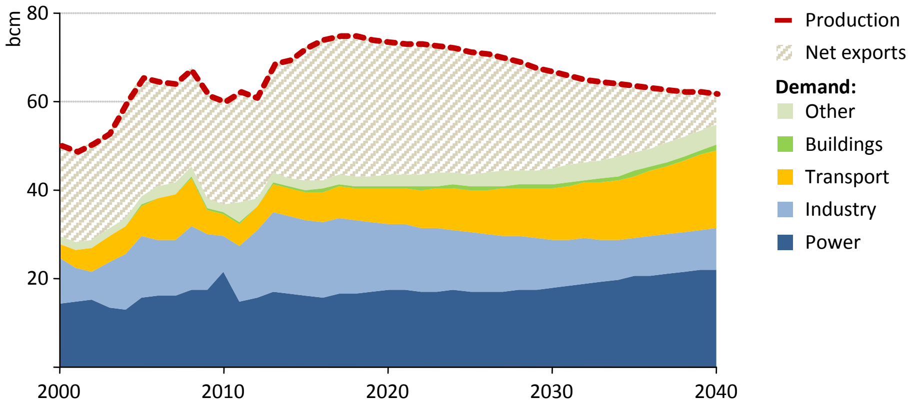
Malaysia holds 2.6 trillion cubic metres (tcm) of proven natural gas reserves (and about 5.5 tcm of remaining recoverable gas resources), ranking second in Southeast Asia, behind Indonesia, and 18th in the world. It produced around 69 bcm in 2013 (with preliminary data indicating that gas production in 2014 remained around 2013 levels). Most of the gas produced in Peninsular Malaysia (which is predominantly associated with oil production) is used locally, while output in Sabah and Sarawak is converted to LNG mainly for export to international markets.

Malaysia has been one of most successful countries in the region in recent years in terms of new gas discoveries, with almost 500 bcm found since 2000 in the Sarawak East-Natuna Basin, mainly by PETRONAS and Shell. There has been renewed interest from international and local operators following new incentives introduced in 2011, including lower tax rates and waivers on export duties, aimed at sustaining activities in deepwater and improving the economics of marginal fields that were not previously considered to be viable. Such measures have led to the development, for example, of the North Malay Basin project, made up of nine stranded gas fields situated in waters northeast of Peninsular Malaysia. These fields are expected to reach peak production of 3 bcm per year in 2015.

In the New Policies Scenario, Malaysia's gas production rises to 74 bcm in 2020; the increase is underpinned by the ramp up of new projects, mainly located offshore East Malaysia that supply the LNG complex in Bintulu, and the exploitation of smaller reserves that until recently had been considered stranded. The Kebabangan gas project offshore Sabah, which was brought onstream in late 2014, is another significant source of output and is expected to produce more than 8 bcm by 2017. In the longer term, Malaysia's gas industry is expected to face several challenges that could increase the cost and complexity of production, including the management of depleting fields and the exploitation of deepwater reserves that contain high levels of CO_2 and other impurities. As a result, in the New Policies Scenario, Malaysia's gas production is projected to gently fall starting later this decade, reaching 62 bcm in 2040, as output from the new fields is insufficient to offset the decline in more mature basins (Figure 4.8).

[7] Euro 4 is a globally accepted European emission standard for vehicles that requires fuel to be low in sulphur (0.005% or 50 parts per million) and benzene (maximum 1% by volume).

Figure 4.8 ▷ Natural gas balance in Malaysia, 2000-2040



In 2013, Malaysia was the world's second-largest LNG exporter, counting Japan, Korea and China as its biggest customers (IGU, 2015). Malaysia's gross LNG exports amounted to just under 34 bcm in 2013, accounting for more than 8% of the country's total export by value (Malaysian Gas Association, 2014). The geographical mismatch between Malaysia's gas demand centres and resources has driven the development of regasification terminals on Peninsular Malaysia.[8] The first terminal, at Melaka, started operating in 2013 and a second, at Pangerang, is expected to come online in 2019. In 2014, LNG imports were estimated at 2 bcm. By contrast, in Sabah and Sarawak there is limited demand and the bulk of production feeds export markets through the LNG complex at Bintulu in Sarawak, whose capacity is 33 bcm. Malaysia's export capacity will soon increase with the addition of two small floating LNG (FLNG) plants (Kanowit, offshore Sarawak, and Rotan, offshore Sabah), expected by 2016-2018, with capacity totalling 3.6 bcm.

The development of gas importing and exporting infrastructure points to an increase of LNG trade within the country, with a growing amount of LNG from a wide range of international sources as well as trade between offshore Borneo, where most future production will come from, and Peninsular Malaysia.[9] As a result, Malaysia's net contribution to international gas markets, already barely half its gross LNG exports, is set to progressively decline throughout the projection period. Its increasing domestic demand coupled with the slight decline in its production means that Malaysia moves from being a significant exporter to exporting just 7 bcm by 2040. Any policy changes affecting local gas demand, such as greater gas use coupled with more renewables in the power sector, could further reduce its net gas exports.

[8] Peninsular Malaysia is also supplied by piped gas from Indonesia's fields in Natuna Sea. In 2013, pipeline gas imports from this source exceeded 13 bcm.

[9] At the time of writing it remains uncertain to what extent Malaysia will use its own LNG. Different sources indicate that the price formula set for the sale of Borneo LNG to Peninsular Malaysia is such that it is nearly at export parity. This implies that the origin of LNG consumed in Peninsular Malaysia will be influenced also by international market factors, plus PETRONAS equity positions in other LNG projects, e.g. in Australia.

Priorities for energy policy-makers

Four actions to improve the Southeast Asian energy landscape

Highlights

- Countries in Southeast Asia have made considerable progress in many aspects of their energy policy. In particular, they have focused on four priority issues that, depending on how they develop, will have important impacts on the region's energy landscape: expanding regional power grid interconnections; attracting investment to develop energy infrastructure; improving access to modern energy services; and phasing out fossil-fuel subsidies.
- Six cross-border power grid interconnections are currently in operation with many more under construction or planned. Enhanced grid interconnections could stimulate economic development by providing more efficient, reliable and resilient electricity service across the region. Plentiful renewable energy resources represent an important catalyst for expansion of a regional electricity market. However, important technical, financial and institutional barriers will need to be addressed to develop a regional power market.
- Attracting sufficient investment will enhance Southeast Asia's energy security and sustainability. In the New Policies Scenario, $2.9 trillion of investment in energy is needed in the period to 2040, of which about half is for the power sector. In a scenario to curb GHG emissions growth in the near term, investment requirements are reduced, with a greater share of the total directed to energy efficiency improvements.
- In Southeast Asia, 120 million people lack access to electricity. Moreover, 276 million people continue to rely on biomass in traditional stoves for cooking, which causes health problems and premature deaths. But progress is evident. For the region as a whole, the number of people without access to electricity has declined by two-thirds since 2000 and half of the countries have achieved or are very close to achieving universal access.
- Southeast Asia stands out as one of the world's most proactive regions in phasing out or reducing fossil-fuel subsidies. Yet, much remains to be accomplished. Fossil-fuel subsidies in the region are estimated at $36 billion in 2014. They often result in wasteful energy consumption, create serious market distortions, deter investment and fail to meet their intended objectives. Reforms in recent years have been primarily driven by the combination of an extended period of high international energy prices between 2008 and mid-2014 and increasing reliance on imports, resulting in subsidy programmes becoming a significant economic burden on government budgets.

Overview

This chapter examines four priority areas for energy policy-makers in Southeast Asia: (i) expanding inter-regional power grid interconnections; (ii) attracting investment to develop energy infrastructure; (iii) improving access to modern energy services; and (iv) phasing out fossil-fuel subsidies. While much remains to be done in each of these areas across many parts of Southeast Asia, it is evident that notable progress has been made in recent years towards reaching the various objectives that have been set. While the four areas can be viewed as rather distinct challenges, they are also interlinked. Progress in one area can facilitate advances in the others. Moreover, each can contribute to improving the region's energy security, environmental sustainability and economic development.

Power grid interconnection

Historically the pattern of development of electricity systems across Southeast Asia has had a distinctly national focus. Recently, the perspective has shifted towards integrating the power grids supplied by a variety of resources including coal, natural gas, hydropower and other renewables to meet various demand profiles. Such integration has the potential to deliver benefits that include increased energy security and power system reliability, economic advantages and opportunities to enhance access and sustainability, especially by integrating higher shares of renewables. There has been particular interest in tapping the hydropower potential in Cambodia, Lao PDR and Myanmar for domestic use and cross-border interconnections to supply growing demand in Thailand, Malaysia, Singapore and Viet Nam, as a means of facilitating trade and underpinning development of a regional power market. Further momentum towards enhancing and expanding interconnections throughout the region could come from the creation of a proposed ASEAN Economic Community (AEC) in late 2015, which aims to strengthen regional ties by promoting inter-regional trade.

Current status and future prospects

The Association of Southeast Asian Nations (ASEAN) member countries have long supported the concept of interconnecting their power grids to facilitate cross-border electricity trade and to improve access to energy services. Interconnection of electricity systems in the region began in 1971 with commissioning of the Nam Ngum 1 hydropower project between Lao PDR and Thailand. The first utility-to-utility power exchange agreement was made in 1978 between Thailand, Malaysia and Singapore, which involved two interconnections: Malaysia – Thailand and Malaysia – Singapore. Today, six cross-border power interconnections are in operation across Southeast Asia. Many more are under construction and planned (Table 5.1).

In 1981, the power utilities and authorities of five ASEAN countries established the Heads of ASEAN Power Utilities and Authorities (HAPUA) whose objective is to co-ordinate development of the ASEAN Power Grid (APG) network. HAPUA set out a master plan in 2003 and selected 11 key grid interconnection projects to be developed by 2020. Planned projects were expanded to 16 in 2011. HAPUA is working towards the realisation of various interconnection projects for the APG: initially on cross-border, bilateral terms, with a view to expand to a sub-regional basis, particularly in Cambodia, Lao PDR, Myanmar and Viet Nam, and eventually to an integrated Southeast Asian power grid system.

Table 5.1 ▹ Cross-border power interconnections in Southeast Asia (existing, under construction and planned)

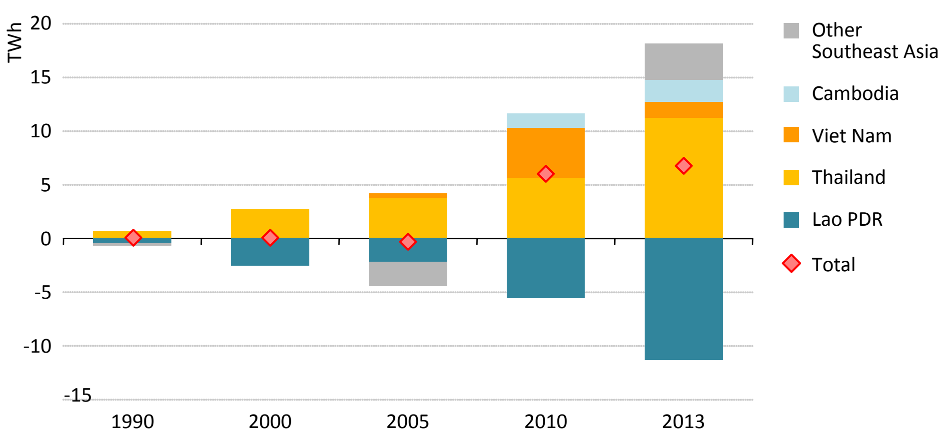
	Countries		Capacity (MW)	Interconnections
Existing	Thailand	Lao PDR	2 205	Nam Theun 2 - Roi Et 2, Nam Ngum - Na Bong - Udon Thani 3, Theun Hinboun - Thakhek - Nakhon Phanom, Houay Ho - Ubon Ratchathani 2
	Malaysia	Singapore	450	Plentong - Woodlands
	Viet Nam	Cambodia	400	Chau Doc - Takeo - Phnom Penh, Tai Ninh - Kampong Cham
	Thailand	Malaysia	380	Sadao - Chuping, Khlong Ngae - Gurun
	Lao PDR	Viet Nam	248	Xekaman 3 - Thanhmy
	Thailand	Cambodia	120	Aranyaprathet - Banteay Meanchey - Siem Reap - Battambang
Under construction	Thailand	Lao PDR	3 352	Hong Sa - Nan 2 - Mae Moh 3, Xayaburi - Loei 2 - Khon Kaen 4, Xe Pien Xe Namnoi - Pakse - Ubon Ratchathani 3, Nam Ngiep 1 - Na Bong - Udon Thani 3
	Lao PDR	Viet Nam	2 510	Luang Prabang - Nho Quan, Ban Hat San - Pleiku, Nam Mo - Ban ve
	Malaysia	Indonesia	830	Melaka - Pekan Baru, Sarawak - W. Kalimantan
	Lao PDR	Cambodia	300	Ban Hat - Stung Treng
	Malaysia	Brunei	200	Sarawak - Brunei
	Thailand	Malaysia	100	Su-ngai Kolok - Rantau Panjang
Planned	Thailand	Myanmar	11 709	Ta Sang - Mae Moh 3, Mong Ton - Sai Noi 2, Hutgyi - Phitsanulok 3, Mai Khot - Mae Chan - Chiang Rai
	Thailand	Lao PDR	3 095	Nam Ou - Tha Wang Pha - Nan 2, Xekong 4-5 - Pakse - Ubon Ratchathani 3, Nam Theun 1- Na Bong - Udon Thani 3, Nam Kong 1 & Don Sahong - Pakse - Ubon Ratchathani 3, Nong Khai - Khoksa-at, Nakhon Phanom - Thakhek, Thoeng - Bo Keo
	Thailand	Cambodia	2 200	Pluak Daeng - Chantaburi 2 - Koh Kong, Prachin Buri 2 - Battambang, Trat 2 - Stung Meteuk (Mnum)
	Lao PDR	Viet Nam	1 889	Ban Sok - Pleiku, Xekaman 1- Thanhmy, Sekamas 3 - Vuong - Da Nang
	Singapore	Indonesia	1 200	Batam - Singapore, Sumatra - Singapore
	Malaysia	Singapore	600	Malaysia - Singapore
	Philippines	Malaysia	500	Philippines - Sabah
	Viet Nam	Cambodia	465	Sambor CPEC - Tan Dinh
	Thailand	Malaysia	300	Khlong Ngae - Gurun (additional)
	Malaysia	Indonesia	200	Sabah - E. Kalimantan

Source: ERIA, 2014.

Another initiative, the Greater Mekong Sub-region (GMS) aims to facilitate a sub-regional market with interconnections and electricity trade among five nations and one Chinese province (Cambodia, Lao PDR, Myanmar, Thailand, Viet Nam and China's Yunnan province). Proposed by the Asian Development Bank (ADB) in 1992, the GMS initiative expects that more than 16% of the power supply in the sub-region will cross borders by 2025. The GMS initiative is currently at the stage of trading electricity between an independent power producer in one country and utilities in another using dedicated transmission lines, but the plan is to eventually enable electricity trade between any two countries using the transmission facilities of a third.

The construction of cross-border transmission lines has facilitated increased electricity trade in Southeast Asia. For example, Lao PDR more than quadrupled electricity exports from 2.8 terawatt-hours (TWh) in 2000 to 12.5 TWh in 2013. While it exports to most neighbouring countries, currently almost 80% of Laotian exports go to Thailand. Net electricity imports in Thailand more than quadrupled from 2000 to 2013. Electricity trade between Lao PDR and Thailand expanded in 2010 with the start of commercial operation of the Nam Theun 2 Hydropower station. Only Lao PDR is a net exporter on an intra-regional basis. Malaysia was a net electricity exporter in the 2000s, but now imports power to meet growing demand as well as providing back-up capacity in the case of potential power emergencies. Southeast Asia as a whole is a net electricity importing region, with the imports coming from China (Figure 5.1).

Figure 5.1 ▷ Net electricity imports in Southeast Asia, 1990-2013



Sources: IEA energy statistics; Ministry of Energy and Mines of Lao PDR.

Potential benefits and challenges

Power system interconnection provides the opportunity for Southeast Asia to reap multiple benefits, because of its regional resource diversity, but this will require adequate infrastructure as well as co-operative and complementary operational frameworks. For example, displacing the use of hydrocarbons to meet demand with hydropower – domestic or imported – could reduce costs and would cut local air pollution and greenhouse-gas (GHG) emissions. While investing in and operating cross-border transmission networks are costly, savings from lower demand for fossil fuels and avoided investment in new power capacity can render the investment in network integration economically viable.

The establishment of a regional power system can also offer improved conditions for development of variable sources of renewable energy in the region, such as solar and wind. For example, aggregating output over larger geographic regions and deploying a mix of renewable energy technologies can reduce the variability of renewables in aggregate. Expanding the balancing area of the power system may also provide for tapping the flexibility of a greater number of conventional power plants in order to accommodate the remaining variability of renewables output (IEA, 2014a).

A recent study by the Economic Research Institute for ASEAN and East Asia (ERIA) on investment in grid interconnections highlights multiple energy benefits if the projects presently under construction and planned are realised (see Spotlight). The study also showed potential shifts in the power mix of ASEAN countries and electricity trade flows with expanded cross-border transmission capacity, in which Myanmar, Lao PDR and Cambodia, with their large hydropower potential, could be major exporters within the region (Figure 5.2). There are several technical, financial and institutional barriers that Southeast Asia will need to overcome in order to strengthen the interconnections of the region's electricity networks. Existing technologies are available to provide solutions for technical issues related to operations including voltage, frequency and load changes. Financing cross-border transmission lines will require conditions that allow large investment costs to be recovered. Investment is a key uncertainty in the expansion of interconnected power grids in Southeast Asia. So far, investors in the region have focused on expanding power generation capacity. Average annual investment in power plants more than doubled over the decade from the early 2000s, while the average annual investment in transmission and distribution (T&D) systems remained almost flat (IEA, 2014b).

Significant efforts also will be needed to tackle institutional barriers such as harmonisation of technical and reliability standards and effective regulatory frameworks, including key features of market design, across the various countries, which can be complicated by differences in policies and interests of stakeholders ranging from industries to consumers. A case in point is the pilot project among Lao PDR, Thailand, Malaysia and Singapore that is now underway and could be an important milestone to assess the feasibility of more cross-border connections in the region given the different natures of their domestic wholesale markets. A broad agenda to be addressed includes licensing for electricity importers and exporters, handling of imported electricity in the domestic wholesale market and sharing benefits with consumers.

Figure 5.2 ▷ ERIA findings on the potential implications and benefits of enhanced power grid interconnections

This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries, and to the name of any territory, city or area.

S P O T L I G H T

Can investment in power grid interconnections be a game changer for Southeast Asia?

On the assumption that the power interconnection projects currently under construction and planned in Southeast Asia are realised, a 2014 Economic Research Institute for ASEAN and East Asia (ERIA) study forecasts that the share of hydropower generation in the region's power mix could increase to 24% by 2035.[1] This would come mainly at the expense of natural gas and coal. ERIA estimates that net savings for the power system as a whole in the region would reach around $6.6 billion over the period 2010 to 2035 (ERIA, 2014).

Looking at major impacts of expanded power grid interconnections on a country-by-country basis, the ERIA study indicates significant shifts in their power mix. For example, in Thailand electricity imports could curb consumption of natural gas for power generation. Malaysia could reduce the amount of new coal-fired generation capacity which is planned in order to meet growing electricity demand.

In terms of electricity trade flows, the ERIA study suggests that Myanmar, Lao PDR and Cambodia would be the main exporters while Thailand, Malaysia, Viet Nam and Singapore would be the main importers. Thailand is expected to emerge as a trading hub, importing electricity from Myanmar, Lao PDR and Cambodia and exporting it to Malaysia. A mutually complementary relationship could be established between Malaysia and Indonesia, with Peninsula Malaysia importing electricity from Indonesia and Sarawak exporting electricity to Indonesia.

Among the current cross-border transmission projects, the ERIA study estimates that an interconnection between Lao PDR, Thailand, Malaysia and Singapore could bring large economic benefits, as the cost of constructing new power plants and new grids could be reduced. Recently these four countries started a pilot project to trade electricity from Lao PDR to Singapore. The ERIA study also indicates potential for economic benefits with further interconnections between Thailand-Cambodia, Viet Nam-Cambodia and Indonesia-Malaysia.

It takes time to harmonise institutional frameworks. Europe's long experience of electricity market integration could provide some useful lessons (Box 5.1). While economic, political and social conditions in Southeast Asia are very different from those in Europe, there are some parallels in the steps the Southeast Asian countries have been taking to better connect their electricity networks. HAPUA co-ordinates activities to address economic, market and technical issues for cross-border power exchanges in close consultation with

[1] The research was conducted independently by ERIA based on different assumptions from this report. In addition, note that the forecasted power generation mix includes data for China (Yunnan Province) and India (Northeast region) and thus is not directly comparable with our projection.

governments. Considering the fact that, in Europe, the most active electricity transactions occurred between countries or companies with a history of co-operation and mutual trust (World Bank, 1995), the success of expanding Southeast Asia's power grid interconnections may depend on how the countries and companies co-operate and deepen their relevant relationships within the region.

Box 5.1 ▹ Does Europe's experience offer insights for Southeast Asia power system integration?

The need for reliable power supply played a leading role in Europe's power grid interconnections during the initial stages of the sector's development. The first cross-border electricity trade was in 1929 between Germany and Austria. After the Second World War, cross-border transmission capacity in Europe was developed as part of the Marshall Plan and investment in a western Europe regional grid was a priority to achieve self-sufficiency in electricity supply (OECD, 2013).

The increase in cross-border electricity exchanges led eight European countries (Austria, Belgium, France, Germany, Italy, Luxembourg, Netherlands and Switzerland) to establish a co-ordination body in 1951 in accordance with a recommendation of the Organisation for European Economic Co-operation (the predecessor of the OECD). A key component of the co-ordination body was to optimise the operation of power plants among countries, which led to savings in coal consumption. Thanks to joint efforts by European governments and industries, foreign exchange control in electricity trade was abolished in 1959 (UCTE, 2009), which was important as it enabled timely and flexible electricity supply by liberalising cross-border electricity trade.

Prior to the restructuring of European electricity markets in recent decades, many governments developed and operated electricity supply through vertically integrated, state-owned companies. Grid development tended to follow national boundaries, with few large-scale cross-border interconnections. Cross-border electricity trade – mainly exchanges for baseload, emergency back-up supply and marginal exchanges for spinning reserves – was often conducted through bilateral long-term contracts. Occasional exchanges also offered benefits to interconnected partners to use excess capacity at marginal costs (World Bank, 1995).

However, real progress in electricity and gas market reform would only follow from 1996, with the EU's first energy market liberalisation package. Subsequent reform packages have been introduced, with the third package making important reforms in unbundling transmission networks from generation, and in creating much more independence among national system operators in both gas and electricity, as well as important mechanisms for co-ordination across national boundaries. Unbundling and restructuring of power generation and transmission models, and increased competition has led distribution companies to look for the most affordable power supply which may be across a border. This has required more cross-border grid interconnections. Market integration has made substantial progress. Transmission system operators have established a single body to develop infrastructure, interconnection rules and to harmonise grid codes. European Union member states are taking measures to meet a target of achieving interconnection of at least 10% of their installed generation capacity by 2020 and striving for 15% by 2030 (EC, 2015). However, despite these reforms, and two decades of focussed political effort, power generation remains concentrated in large national incumbents, and although the region is more interconnected than most other regional electricity markets globally, pockets of islanded markets remain.

Energy investment

Currently more than $70 billion is spent annually on energy supply investment in Southeast Asia. Energy supply projects that contributed to the total include fossil-fuel extraction, the construction of gas pipelines, oil refineries, biofuel facilities, thermal generating plants, hydropower stations, wind turbines and solar installations as well as electricity transmission and distribution lines. The level of energy investment has increased by almost 60% over the last decade in real terms (Box 5.2). The power sector accounted for more than half of the increase in investment over the period, reflecting the rapid increase in the region's electricity demand, the high investment intensity of power supply and expanding electricity access. Investment in natural gas supply was also a large contributor, driven by growing demand for electricity generation and rising capital costs. By contrast, investment in oil supply fell by more than one-third, as most of the producing countries in the region face declines in their large mature fields and have few new prospects to expand production.

Box 5.2 ▹ A surge in foreign direct investment in Southeast Asia

Economic development and reform efforts have contributed to a big inflow of foreign direct investment (FDI) in Southeast Asia. According to the United Nations Conference on Trade and Development (UNCTAD), total FDI (including non-energy investment) in Southeast Asia in 2013 reached an all-time record of $125 billion, meaning that it has more than quadrupled over the last decade and for the first time is even higher than FDI to China. The region has been the world's top performer in terms of FDI over the last five years with its share of global FDI expanding from 3% in 2008 to almost 9% in 2013 (UNCTAD, 2014). The largest share of FDI in 2013 was from the European Union, followed by Japan, Southeast Asia (itself), China and the United States. The prospects for continued investment are good, underpinned by a robust economic outlook and the launch of the ASEAN Economic Community. However, a drop in international commodity prices might reduce the incentive for investment in fossil-fuel projects, mainly in Indonesia and Malaysia.

Energy investment in the New Policies Scenario

In Southeast Asia, cumulative investment in energy supply is more than $2.4 trillion over the period to 2040 in the New Policies Scenario (Figure 5.3). This represents around 5% of the global total, or one-third of China's investment. Annual investment in energy supply in Southeast Asia increases steadily over the coming decades, from an average of $75 billion up to 2020 to $113 billion in the 2030s (Table 5.2). Annual investment in the power sector grows the most in absolute terms, driven by an expansion of renewables, followed by investment in the natural gas sector.

Table 5.2 ▷ Average annual energy investment in Southeast Asia in the New Policies Scenario ($2014 billion)

	2015-2020	2021-2030	2031-2040	2015-2040
Total energy supply	**75**	**86**	**113**	**94**
Oil	17	15	20	17
Gas	16	20	25	21
Coal	2	2	3	2
Power	38	48	64	52
Plants (all fuels)	17	22	31	24
T&D	21	26	33	27
Biofuels	1	1	2	1
Energy efficiency	**8**	**15**	**23**	**16**
Total	**83**	**102**	**136**	**110**

In addition, around $420 billion is needed to improve end-use energy efficiency, which has a direct impact on supply-side investment (Figure 5.4). Though energy-efficient equipment often requires more up-front spending, these costs can be recovered by savings in energy use over its lifetime. Southeast Asia's investment in energy efficiency in the period to 2040 accounts for just 1.9% of the global total investment in energy efficiency. Through the introduction of more stringent policies, the region has made some progress in scaling up its efforts in energy efficiency, but there remains significant potential that needs to be exploited (see Box 2.2 in Chapter 2 for more details). In the New Policies Scenario, annual efficiency investment in Southeast Asia countries increase by about three-times from today's level (faster than growth experienced by annual investment in energy supply), to about $23 billion in 2030s, mainly due to a more widespread adoption of mandatory energy management programmes in the industrial sector.

The share of fossil fuels supply in total energy investment is on a declining trend, falling from 43% in the late 2010s to one-third by late 2030s (Figure 5.5). This reflects faster growth in investment in power plants, electricity T&D as well as energy efficiency.

Figure 5.3 ▷ Cumulative energy supply investment in Southeast Asia in the New Policies Scenario, 2015-2040 ($2014 billion)

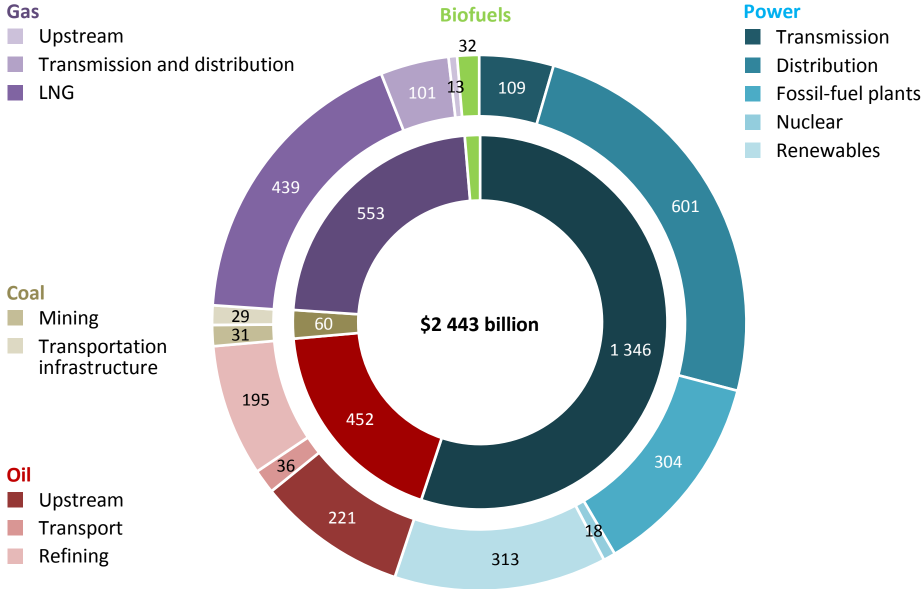


Figure 5.4 ▷ Cumulative energy efficiency investment in Southeast Asia in the New Policies Scenario, 2015-2040 ($2014 billion)

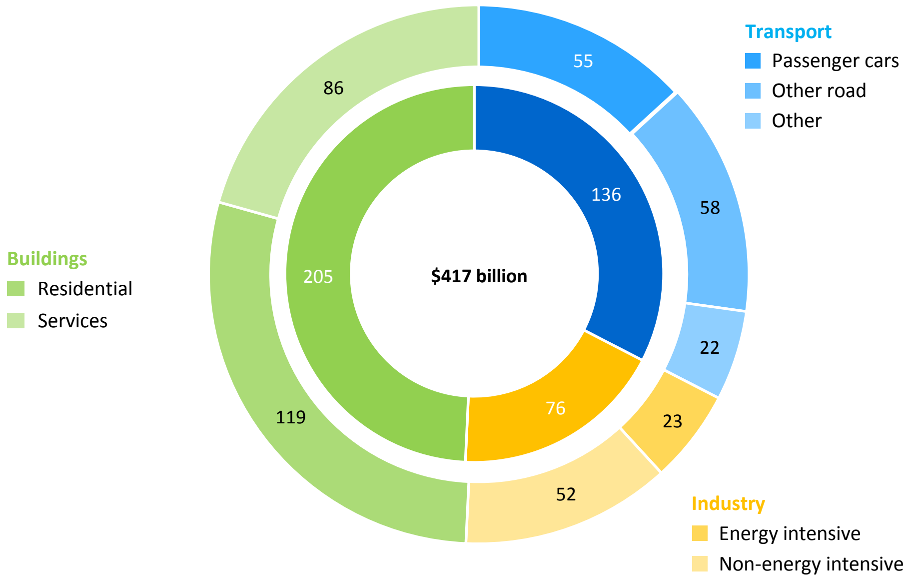
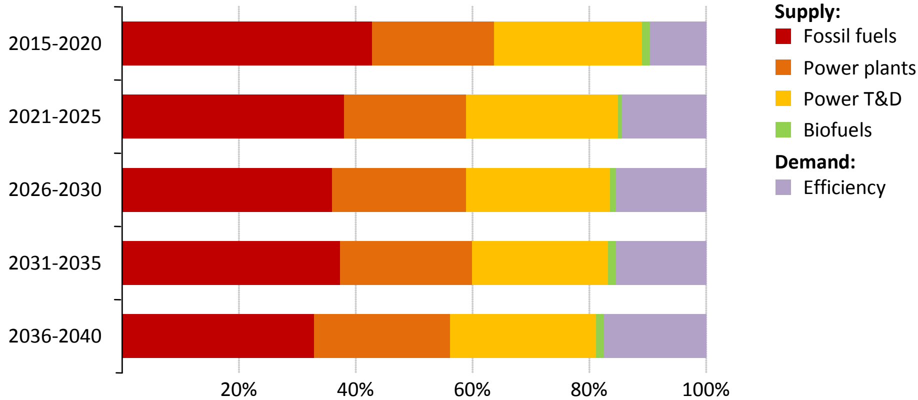


Figure 5.5 ▷ **Profile of total annual average energy investment in Southeast Asia in the New Policies Scenario**



Policy-makers will play a critical role in attracting and mobilising energy investment in Southeast Asia's regulated power markets. It is important to ensure that regulatory frameworks are effective. In this respect, recent reforms to domestic energy prices to bring them more in line with international levels in several countries is an encouraging sign for private companies and international investors and helps ensure more appropriate choices in terms of energy sources, location and timing (see next section on fossil-fuel subsidies). It will also allow governments to redirect funds to other priorities, such as infrastructure development to improve energy access and environmental performance.

Recent decisions by some lending institutions to withdraw or limit funding for new coal-fired power plants might impact investment in Southeast Asia, as some countries lack the domestic financial resources and have limited capital markets to be able to build the plants on their own (see Chapter 2, Spotlight). On the other hand, China and India are playing increasing roles in financing coal-supply infrastructure and coal-fired plants in Southeast Asia. New institutions, such as the Asian Infrastructure Investment Bank (AIIB), could potentially represent an alternative source of funding.

Investment by sector

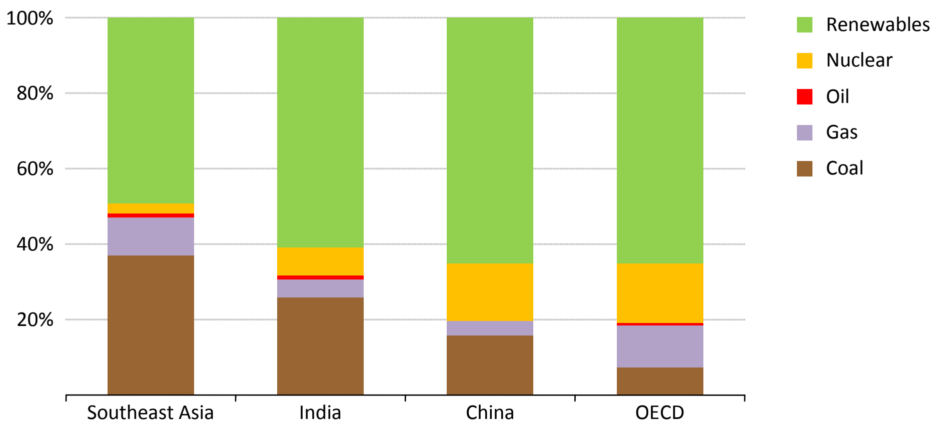
In the New Policies Scenario, the power sector accounts for more than half of energy supply investment over the period to 2040 (Figure 5.3). Cumulative investment of $710 billion in electricity T&D, is larger than investment in power plants ($635 billion) due to increasing demand and expanding electricity access. This feature makes Southeast Asia different from China and India where more capital is required for power plants than in T&D.

About half of cumulative investment in the region's power sector is for low-carbon technologies. This share is noticeably lower than other world regions (Figure 5.6). Moreover, investment needed in non-hydro renewables is 31% higher than investment in hydro power. Of the almost $180 billion invested in non-hydro renewables, more than 50% is for solar photovoltaic (PV) capacity, 22% for wind and 16% for bioenergy. Investment in coal-fired capacity accounts for 37% of cumulative investment in power plants. There is a shift to coal underway in the region's power sector and by 2030 coal overtakes natural gas to become the largest source of installed generation capacity (see Chapter 2).

Natural gas accounts for the largest share of investment in fossil-fuel supply, a total of more than $550 billion, almost 80% of which is upstream. Prospects for producing natural gas in the region are brighter than those for oil, although an increasing share of production is set to come from more complex and costly resources, often located in deepwater and with high concentrations of impurities.

Cumulative investment in the oil sector amounts to over $450 billion, with almost 50% concentrated in the upstream sector. Nearly $200 billion of investment is needed in the refining sector (of which 60% is for greenfield expansion and the remainder for maintenance and upgrades at existing plants), with more than a quarter in Indonesia. In the upstream oil and gas sector, many of the most profitable fields have been in production and are now declining. This brings new challenges for attracting the capital and expertise needed to exploit additional resources.

Figure 5.6 ▷ Share of cumulative investment in power sector by source and region, 2015-2040



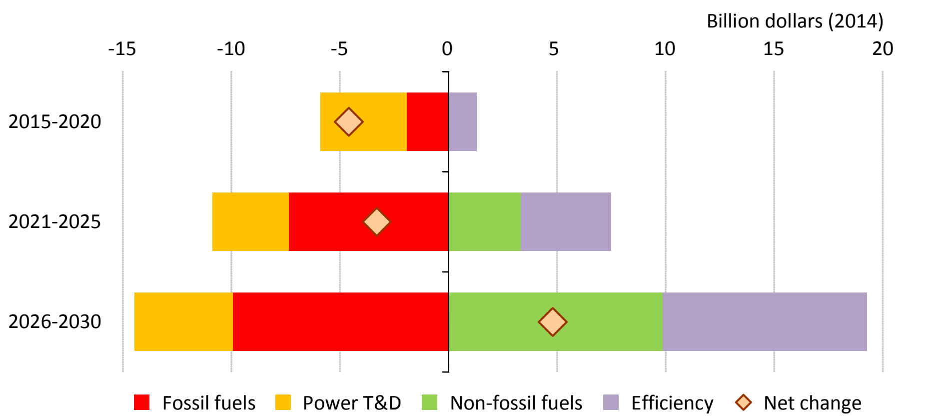
Total cumulative investment in coal amounts to $60 billion, just 2.4% of total supply investment. Indonesia accounts for the bulk of this spending, reflecting its status as the largest coal producer in the region. A significant share of coal investment in Indonesia is required to develop infrastructure, such as roads and harbours, in order to bring inland production to export facilities.

Of the cumulative $417 billion in energy efficiency investment to 2040, around half goes to improving energy efficiency in the buildings sector. The introduction of more stringent efficiency standards, such as minimum energy performance standards (MEPS), leads to about 70% of the energy efficiency investment in the buildings sector being directed to appliances such as refrigerators and washing machines. More investment is required in residential use ($119 billion) than in services ($86 billion) as incomes and ownership of large appliances increase in the region. A further one-third of cumulative investment in energy efficiency is in transport, largely in the road sector. About half of the efficiency investment in the road sector is used to improve the fuel efficiency of passenger cars, and the reminder in trucks and buses. The share of energy efficiency investment in industry is less than 20%, though it grows faster than investment in other sectors.

Energy investment in the Bridge Scenario

In the Bridge Scenario, the scenario developed for the *Energy and Climate: World Energy Outlook Special Report* (IEA, 2015), cumulative investment in energy supply in the period between today and 2030 is 7% less than in the New Policies Scenario.[2] By contrast, investment in improving end-use energy efficiency is more than 40% higher. Taking both components together, total investment in the Bridge Scenario is lower than the New Policies Scenario by around $20 billion. Though average annual total investment in the Bridge Scenario is lower than in the New Policies Scenario in the first decade, it is higher around 2030 due to additional investments required in renewables and efficiency (Figure 5.7). To achieve the full potential presented in the Bridge Scenario, additional policy measures and a variety of approaches for investment would be needed in the period up to 2030, particularly in terms of energy efficiency and renewable-based power generation.

Figure 5.7 ▹ Average annual investment differentials between the Bridge and New Policies Scenarios in Southeast Asia, 2015-2030



Note: Positive values shows higher investment in the Bridge Scenario relative to the New Policies Scenario during the indicated period.

[2] See *Energy and Climate Change, World Energy Outlook Special Report* (IEA, 2015) for details of the measures assumed and the effects projected.

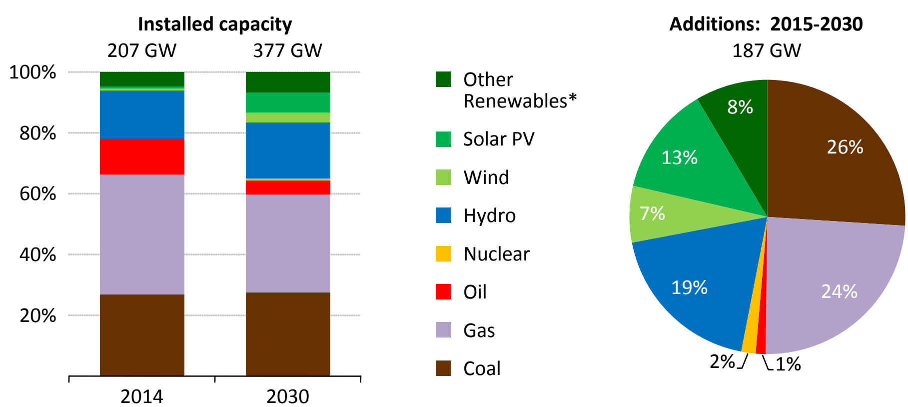
Energy efficiency

The proposed energy efficiency measures in the Bridge Scenario include the introduction of MEPS for electric motor systems in the industry sector and household appliances in the buildings sector, and fuel-economy standards for vehicles. Early adoption of such policies is important because savings increase over time as the proportion of more efficient technologies in the stock rises, in particular for road vehicles and electric motors in industry, where the average lifetime is typically 10 to 15 years. The adoption of more stringent energy efficiency requirements boosts investment in energy efficiency in Southeast Asia by more than 40% by 2030, compared with the New Policies Scenario. The buildings sector accounts for more than half of this incremental investment.

Power sector

In the Bridge Scenario, Southeast Asian countries lower their dependence on coal compared with the New Policies Scenario. They achieve a more environmentally sustainable power generation mix with a large-scale introduction of renewables, supplemented by the flexibility from gas-fired electricity generation. To achieve this, Southeast Asia would need to increase investment in renewables-based capacity by more than 50% by 2030 compared with the New Policies Scenario. Over half of this incremental investment goes to non-hydro renewables, particularly wind and solar PV, while about 30% is for hydropower development.

Figure 5.8 ▷ Power generation capacity mix and capacity additions in the Bridge Scenario in Southeast Asia



*Includes bioenergy and geothermal.

Compared with the New Policies Scenario, the average amount of subcritical coal-fired power capacity installed per year falls by 1.4 gigawatts (GW) in the Bridge Scenario, while the share of renewables in total electricity generation increases by 8 percentage points by 2030. This shift implies that cumulative coal-fired capacity additions by 2030 are less than 50 GW (Figure 5.8), 30 GW lower than in the New Policies Scenario, reducing investment in coal-fired power plants by one-third. As a result, the power sector in the region saves 230 million tonnes of carbon dioxide equivalent of GHG emissions in 2030, relative to the

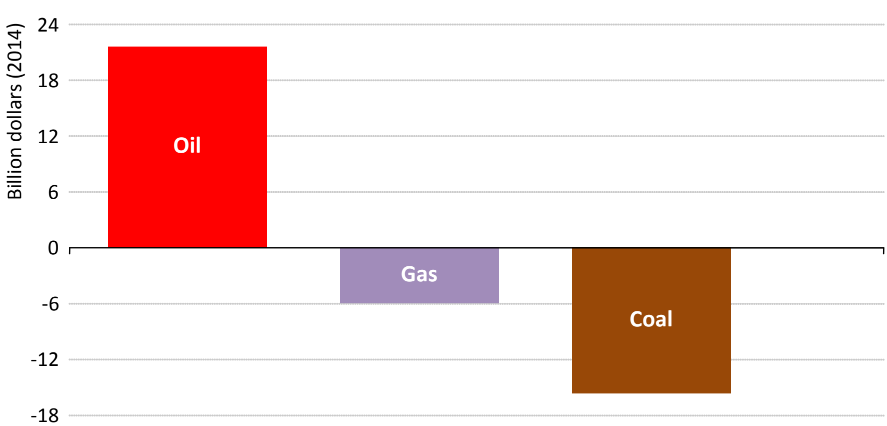
New Policies Scenario. The gradual reduction in the use of the least-efficient coal-fired power plants results from three key steps. The first is a ban on the construction of inefficient coal-fired plants (typically conventional subcritical units), with some exceptions for small power systems that cannot accommodate large supercritical or ultra-supercritical coal-fired power plants. The second is a gradual reduction in the level of operation of the least-efficient plants that are currently under construction (ensuring that they can still recover the investment costs). The third stage is the retirement or idling of all ageing inefficient coal-fired power plants that have already repaid their investment costs to the full extent possible without affecting power system reliability.

Economic implications of the Bridge Scenario

The economic effect of each policy measure adopted in the Bridge Scenario varies. However, the adoption of all of the five measures in the Bridge Scenario does not impact the overall regional prospects for economic growth and development. The increase in energy efficiency investment limits the ability of households (which are responsible for a large part of the investment made) and firms to invest in other activities. But the reduction in their fuel bills outweighs the additional investment needed, freeing up additional resources to such an extent that, overall, action on energy efficiency boosts economic growth. The increased energy efficiency of appliances and lighting, for example, helps to reduce household energy bills in 2030 in the Bridge Scenario by 7%.

The Bridge Scenario benefits fossil-fuel importing countries with savings on import bills, relative to the New Policies Scenario. For exporting countries, lower global demand for fossil fuels leads to a reduction in their export revenues in the Bridge Scenario, compared with the New Policies Scenario. For Southeast Asia as a whole, a loss in earnings from the export of coal and natural gas is offset by a reduction in spending on oil imports (Figure 5.9).

Figure 5.9 ▷ Changes in fossil-fuel trade bills of the Southeast Asian region in the Bridge Scenario relative to the New Policies Scenario, 2030



Note: Positive values are net savings in trade bills, relative to the New Policies Scenario.

Energy access

Extent and magnitude

Modern energy is a critical enabler for development. Access to modern energy improves economic growth and productivity, but also has broader benefits for health and education. A lack of access to modern energy services often results in households having to rely on inefficient and hazardous alternative fuels. Although the number of people in Southeast Asia without access to electricity has declined by two-thirds since 2000, 120 million people, or 20% of the population, are still living without electricity, while another 276 million (or 45% of the population) rely on solid fuels such as fuelwood and charcoal for cooking (Table 5.3). While the issue of clean cooking access is often given less attention than that of electricity access, it is serious and needs to be addressed. Recent estimates show that each year 4.3 million premature deaths worldwide can be attributed to household air pollution resulting from the traditional use of solid fuels (WHO, 2014).

Table 5.3 ▷ Number of people without access to modern energy services in Southeast Asia, 2013

	Without access to electricity		Traditional use of biomass for cooking*	
	Population (Million)	Share of population	Population (Million)	Share of population
Brunei Darussalam	0	0%	0	0%
Cambodia	10	66%	13	88%
Indonesia	49	20%	98	39%
Lao PDR	1	13%	4	65%
Malaysia	0	1%	0	0%
Myanmar	36	68%	49	93%
Philippines	21	21%	53	54%
Singapore	0	0%	0	0%
Thailand	1	1%	15	23%
Viet Nam	3	3%	42	47%
Total Southeast Asia	**120**	**19%**	**276**	**45%**

*Based on World Health Organization (WHO) and IEA databases.

The switch away from solid biomass to cleaner fuels involves multiple challenges. Solid biomass in the form of fuelwood or animal waste is "free" compared to alternative fuels, meaning that rising incomes do not necessarily trigger a switch to modern solutions. Costs related to deforestation, land degradation or hours spent to collect fuelwood are important but often do not have an immediate impact on fuel choice for the poorest. There is some evidence that households attach a fairly low priority to cleaner cooking options when deciding how to spend additional income. Cultural factors also play an important role as in many regions cooking meals on a traditional three-stone fire is a habit that households may not want to quit. For these reasons, policies and programmes will play a major role in Southeast Asia if it is to achieve similar progress on clean cooking as it has achieved on electricity access.

Progress in achieving universal access

Five countries in Southeast Asia – Brunei Darussalam, Malaysia, Singapore, Thailand and Viet Nam – have achieved universal electricity access or are very close to reaching the target. Viet Nam in particular can claim a remarkable achievement in recent decades, having increased its rural electrification rate from an estimated 10% in the late 1980s to 97% today. However, a significant portion of the population in the rest of Southeast Asia remains without access to electricity. Levels of access are particularly low in Cambodia and Myanmar, where around two-thirds of the people have no household electricity.

Electrification programmes and innovative business models have shown some success in a number of Southeast Asian countries. In Myanmar, for example, a fee-for-service model allows the poorest to pay for a very small amount of electricity. Customers can choose various packages, for example, for just enough electricity to power two fluorescent light bulbs for about $4/month. This "pay-as-you-go" scheme has successfully provided first-level electricity access to low-income households. In Cambodia, a Rural Electrification Fund was created with the goal of providing electricity access to 70% of the population by 2030. The fund provides interest-free loans to households to help increase connections and also provides financial support for solar home systems. The development of mini-grid and off-grid systems is particularly important in rural areas and small islands in the region. In Indonesia, for instance, the "1 000 Islands" programme aims to expand electricity access in the outer islands with solar-diesel hybrid systems.

While the electricity access situation has improved notably in Southeast Asia in recent years, the picture is bleaker for access to clean cooking. Large parts of the populations in Cambodia, Indonesia, Lao PDR, Myanmar, Philippines and Viet Nam still use solid biomass in traditional stoves for cooking. A few successful programmes have been implemented, but there is still a need for greater political and financial commitment to ensure all households in the region switch to clean fuels (Box 5.3).

Box 5.3 ▷ Kerosene to LPG conversion programme in Indonesia

Indonesia's Kerosene to LPG conversion programme sought to convert more than 50 million users of kerosene to liquefied petroleum gas (LPG).[3] It is one of the world's largest efforts to promote clean and safe cooking. From its inception in 2007 to 2011, more than one-third of households switched to LPG (from 11% to 46%), while the proportion of kerosene users declined by two-thirds (from 37% to 12%) (World Bank, 2013). By mid-2012, the programme had distributed LPG stoves and 3 kilogramme LPG

[3] Kerosene can be considered as a cleaner fuel than solid biomass in a number of ways, however, it involves risks of burns, fires, intoxication and household air pollution.

cylinders to more than 54 million households, and small and medium industries. The programme has been particularly successful in East, West and Central Java where household use of LPG has increased by more than a factor of five since 2007. This initiative provided households with clean cooking fuels, with associated benefits in cleanliness and convenience. The switch from kerosene to LPG also alleviated the fiscal burden of subsidies for the government as compared with kerosene as less LPG is needed for the same service. Indeed, the calorific value of LPG is higher than that of kerosene and the efficiency of an average LPG stove is about 10% higher than that of a kerosene stove.

Despite this progress, providing access to clean fuels for rural households remains a challenge as almost 100 million people in Indonesia (some 40% of the population) continues to rely on the traditional use of solid biomass for cooking. While some households simply cannot access LPG because they are too far from the distribution network, others use solid biomass along with LPG. This phenomenon, known as "fuel stacking", is common when affordability and reliability of supply of alternative fuels fluctuate over time. In order to ensure a complete switch from fuelwood and other solid fuels, accessibility to affordable clean alternatives should be ensured at all times, notably through scaled-up distribution networks and well-targeted financial support for the poor.

Fossil-fuel subsidies

Extent and magnitude

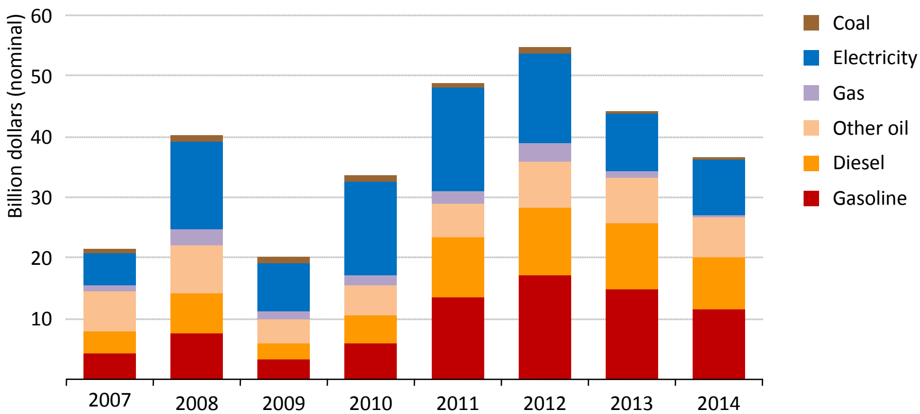
Countries in Southeast Asia have a long history of providing subsidies to fossil fuels that lower end-use prices below international levels or below the full cost of supply in the case of fossil-fuelled generated electricity. The main objective of subsidising fossil fuels is usually to hold down the cost of energy for poor households for social reasons or to redistribute national resource wealth. In practice, however, subsidies often fail to bring much benefit to the ones really in need and rather benefit those who can afford to consume more of the subsidised fuel (IEA, 2011). Subsidies incentivise excessive use of energy, hinder investments in low-carbon technologies and energy-efficient equipment and contribute to greenhouse-gas emissions. Fossil-fuel subsidies can also cause financial losses to energy suppliers as a consequence of under-pricing of energy commodities that result in under-investment in energy supply.

Six of the ten countries in Southeast Asia subsidise the consumption of fossil fuels: Indonesia, Thailand, Viet Nam, Brunei Darussalam, Myanmar and Malaysia.[4] The majority of these subsidies are directed to gasoline, followed by electricity generated from fossil fuels, diesel, LPG and kerosene. Based on IEA estimates, the economic value of these

[4] For more coverage of fossil-fuel subsidies in Malaysia, see Chapter 4.

subsidies totalled $36 billion in 2014, with gasoline and diesel each contributing around $11 billion and $8 billion respectively (Figure 5.10). Indonesia had the highest level of subsidies estimated at around $28 billion, followed by Malaysia at $5 billion.

Figure 5.10 ▷ Economic value of fossil-fuel consumption subsidies in Southeast Asia by fuel, 2007-2014



For many years, **Indonesia** subsidised consumption of gasoline (RON88), LPG, kerosene, electricity and the so-called "solar" grade of diesel. In 2014, the values of these subsidies amounted to $9 billion for gasoline, $8 billion for electricity, $6 billion for diesel and $4 billion for LPG. Persistently high international oil prices, as well as other factors such as the need to allocate more funds to other sectors of the economy and a depreciation of the Indonesian rupiah (IDR) against the US dollar, led Indonesia to take a series of measures to reduce the heavy financial burden of these subsidies. A first step was an increase in gasoline and diesel prices in June 2013. The price of premium gasoline was increased by IDR 2 000 ($0.17) to IDR 6 500 ($0.55) per litre, and the price of solar diesel by IDR 1 000 ($0.08) to IDR 5 500 ($0.46) per litre. In November 2014, gasoline and diesel prices were increased by a further IDR 1 000 ($0.08) per litre. On the 1st January 2015, Indonesia completely abolished subsidies on gasoline (although its distribution is still subsidised outside Java) and capped the subsidy on solar diesel at IDR 1 000 ($0.08) per litre. Under the new policy, the government now adjusts prices of these fuels on a monthly basis. However, in April and May 2015, the government's price increases did not fully reflect the fluctuations of international markets, resulting in financial losses for the state-owned company, PT Pertamina. Indonesia has implemented a very successful kerosene to LPG conversion programme, as highlighted in Box 5.3, which not only provided a significant part of the population (around a quarter of households) with access to clean cooking facilities, but also significantly reduced spending on subsidies for kerosene and LPG in the early years following the implementation of the programme.

Thailand subsidises the consumption of compressed natural gas (CNG) for vehicles, diesel and electricity and – up until recently – LPG. In 2014, the estimated value of these subsidies was $2.1 billion, of which 80% was for LPG. Subsidies for LPG were abolished in December 2014, a move which saw retail prices for LPG increase by Thai Baht (THB) 1.03 ($0.03) to THB 24.16 baht ($0.73) per kilogramme (for social reasons, subsidised LPG is still available for some low-income groups and street-food vendors registered with the Energy Ministry). As LPG subsidies were the largest portion of the overall value, a significant reduction is expected in 2015 subsidies expenditure. CNG for vehicles is subsidised through a price set below the cost of production, with the resulting losses being incurred by PTT, the state-owned oil and gas company. In October 2014, subsidies for CNG were reduced by increasing its price by THB 1 ($0.03) per kilogramme.

In **Viet Nam**, fossil-fuel subsidies totalled $1.0 billion in 2014, directed mainly to natural gas and electricity. Prices for oil products are now above international benchmarks, but are still regulated in a bid to minimise the volatility in international prices being directly passed through to consumers. **Brunei Darussalam** subsidises oil products and electricity and these amounted to almost $400 million in 2014, the highest in the region when measured on a per-capita basis. As the country is a significant energy exporter, these subsidies represent opportunity costs and have no direct budgetary impact. In **Myanmar**, the under-pricing of electricity to end-users is the main form of subsidisation. While a revision of electricity tariffs took place in March 2014, they are still among the lowest in the region and below the cost of generation.

Progress in reforming subsidies

Globally, Southeast Asia stands out as one of the regions that have been most active in making reforms to its fossil-fuel subsidy programmes (Table 5.4).

Table 5.4 ▷ Recent fossil-fuel subsidy reforms in Southeast Asia

Country	Main fuels subsidised	Recent developments
Indonesia	Diesel, electricity	On the 1st January 2015, subsidies to gasoline (88 RON) were abolished and the diesel subsidy capped at IDR 1 000 ($0.08)/litre.
Malaysia	LPG, natural gas, electricity	In December 2014, subsidies for gasoline (RON95) and diesel were abolished. Now prices for both are set monthly to track international levels. In January 2014, electricity tariffs were increased by 15% on average to MYR 0.38 ($0.12) per kilowatt-hour. Fuel cost pass-through, based on international gas price movements, was resumed. In May 2014, natural gas prices increased by up to 26% for certain categories of users.
Myanmar	Electricity	In 2014, a new block electricity tariff scheme for households and industry was approved, though tariffs are still among the lowest in Asia.
Thailand	LPG, natural gas, electricity	In October 2014, the price of CNG for vehicles was increased by THB 1 ($0.03) per kilogramme. In December 2014, subsidies for LPG were ended, leading to price increases of THB 1.03 ($0.03) to THB 24.16 ($0.73) per kilogramme.

Many of the reforms have, in large part, been triggered by persistently high energy prices between 2008 and mid-2014, which pushed the cost of subsidies to very high levels, particularly as many of the countries have been experiencing fast growth in energy demand. However, in a number of cases, it was not until the drop in oil prices from mid-2014 that countries took action, realising they had an opportunity to make the necessary reforms without having a major upward impact on end-user prices – or inflation – or provoking public opposition. However, the durability of such reforms may be challenged if and when international markets move back into a higher price environment. The likelihood of long-term success can be improved if the move from subsidised (typically fixed) pricing follows general best practice guidelines, e.g. the adoption of an automatic pricing mechanism that adjusts consumer prices according to changes in international fuel prices (Box 5.4).

Box 5.4 ▷ Common elements to successful subsidy reform

National circumstances and changing market conditions mean that there is no single path to follow when reforming fossil-fuel subsidies. However, experience has shown that the prospects for success can be enhanced by adherence to some simple guidelines:

- **Get the prices right –** One of the basic pillars of successful subsidy reform is to ensure that prices reflect the full economic cost of the energy that is being supplied. Prices before tax should be set with reference to international market prices and be adjusted as necessary to reflect inflation and currency volatility. This process is more complicated with electricity than, say, oil products: it is necessary to ensure that tariffs are sufficient to cover not only the costs of the fuel inputs but also of transmission and distribution, while also giving utilities a return on their capital. Public authorities need to ensure that pricing systems are transparent, well-monitored and enforced. Government controls on pricing may be warranted in certain situations, for example, to ensure that the poorest households have access to clean cooking fuels and electricity, but other forms of social support are often more efficient and effective.
- **Implement reforms in steps –** Subsidy reforms should typically be introduced in small steps; to do otherwise risks abrupt and large price rises that may crystallise strong opposition. As a country makes the transition away from subsidies, it is advisable to introduce a formula-based pricing system that ensures retail prices track international benchmarks. To de-politicise the process, an independent body should be set up to oversee energy pricing, helping consumers understand and accept the reasons for price changes.
- **Manage the effects –** Subsidy reform can have undesirable consequences for some groups, and social reforms may need to be implemented in parallel to protect vulnerable groups, such as the poorest households. For example, conditional cash transfers to those with the lowest income may be required; but the effectiveness of such measures must be regularly monitored and evaluated.

- **Consult and communicate at all stages –** A comprehensive communication strategy is essential to convince citizens of the need for reform and the justice of its implementation. Such a strategy must speak to all energy users, but especially those most affected by the reforms. Public inquiries, speeches, debates, workshops and printed material can all contribute.

Going forward

The ten countries that comprise Southeast Asia face an exciting and dynamic energy future. Rising incomes and greater energy access will continue to drive energy demand growth and energy trade patterns will continue to shift, with greater inter-country and intra-regional trade in many energy commodities, including power. Securing the necessary investment to ensure energy supplies and infrastructure are developed in the right timeframe, in an optimal regional fashion, using a diverse mix of technologies, responding to locational price signals and new technologies will not be straightforward. A stable policy landscape and greater regional co-operation will be critical as the region faces the difficult task of balancing different policy objectives, including energy security, energy price and access, and environmental impacts of energy production and use. Continued development will hinge on the strategic direction of the region's and individual country's energy policies.

Recognizing the importance of this task, governments in Southeast Asia have already taken important steps in the right direction. Energy access has improved markedly, and subsidies are being scaled back to target those most in need. An energy emergency preparedness policy is being developed. The undoubted benefits of greater energy efficiency are being tapped, though significant potential remains. Recognizing the dual benefits of energy security and sustainability, many countries have adopted medium- and long-term targets for renewables and have been active participants in international climate negotiations, with some countries setting national targets to reduce GHGs. However the continued shift towards coal will necessitate the utilization of more efficient technologies in order to manage the rise of local pollution and CO_2 emissions.

The obvious geographic mismatch between the location of resources and demand centres means that energy trade will grow. While the archipelagic nature of much of the region is a barrier to the type of large-scale power and gas grid interconnection seen in North America and Europe, other solutions present themselves. For example, greater maritime LNG trade that utilizes quickly deployed floating storage and regasification units (FSRU) or converted LNG export terminals, and small scale grid development, could complement the potential transmission power grid interconnects between countries and regions, providing important and cost-effective flexibility to regional energy supplies. Co-operation could be especially important when exploiting the complementarity of the region's differing and sometimes remote energy resources, to provide economies of scale for example, and improving everyone's energy diversity, security and affordability.

Collective efforts to transform the Southeast Asian energy landscape in a more efficient and sustainable manner have already been initiated across the region, and further collaborative efforts to enhance the benefit of individual countries' measures will be necessary to ensure the challenges posed by the dynamic economic and demographic changes in the region are met.

Southeast Asia projections

General note to the tables

The tables detail projections for *energy demand*, gross *electricity generation* and *electrical capacity*, and *carbon-dioxide (CO_2) emissions* from fuel combustion in ASEAN member countries, which include Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, the Philippines, Singapore, Thailand and Viet Nam. The tables present historical and projected data for the New Policies Scenario.

Data for *fossil-fuel production*, *energy demand*, *gross electricity generation* and *CO_2 emissions* from fuel combustion up to 2013 are based on IEA statistics, published in *Energy Balances of OECD Countries*, *Energy Balances of non-OECD Countries*, *CO_2 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 2015 version) and the International Atomic Energy Agency PRIS database.

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 CO_2 includes emissions from other energy sector in addition to the power generation and TFC sectors shown in the tables. CO_2 emissions and energy demand from international marine and aviation bunkers are not included. CO_2 emissions do not include emissions from industrial waste and non-renewable municipal waste.

Southeast Asia: New Policies Scenario

	Energy demand (Mtoe)							Shares (%)		CAAGR (%)
	1990	2013	2020	2025	2030	2035	2040	2013	2040	2013-40
TPED	**233**	**594**	**716**	**800**	**891**	**983**	**1 070**	**100**	**100**	**2.2**
Coal	13	91	151	188	228	266	309	15	29	4.6
Oil	89	213	247	267	285	302	309	36	29	1.4
Gas	30	133	149	163	178	199	220	22	21	1.9
Nuclear	-	-	-	1	6	8	8	-	1	n.a.
Hydro	2	9	10	13	16	19	22	2	2	3.1
Bioenergy	93	122	127	129	130	132	134	21	13	0.4
Other renewables	7	25	32	39	47	56	67	4	6	3.8
Power generation	**39**	**184**	**251**	**299**	**352**	**406**	**463**	**100**	**100**	**3.5**
Coal	7	66	117	147	179	208	244	36	53	5.0
Oil	17	11	9	8	7	7	7	6	1	-1.9
Gas	6	69	75	79	81	88	93	37	20	1.1
Nuclear	-	-	-	1	6	8	8	-	2	n.a.
Hydro	2	9	10	13	16	19	22	5	5	3.1
Bioenergy	0	5	8	12	16	19	23	3	5	5.9
Other renewables	7	25	32	39	46	55	66	13	14	3.7
Other energy sector	**34**	**58**	**61**	**64**	**70**	**80**	**88**	**100**	**100**	**1.5**
Electricity	*2*	*8*	*11*	*13*	*16*	*19*	*22*	*13*	*25*	*3.9*
TFC	**173**	**420**	**500**	**554**	**608**	**662**	**711**	**100**	**100**	**2.0**
Coal	6	27	35	41	47	52	56	6	8	2.7
Oil	67	190	224	243	260	274	283	45	40	1.5
Gas	8	35	49	60	73	87	101	8	14	4.0
Electricity	11	62	85	104	124	146	170	15	24	3.8
Bioenergy	82	106	107	105	103	101	99	25	14	-0.2
Other renewables	-	-	0	0	1	1	2	-	0	n.a.
Industry	**43**	**120**	**152**	**175**	**198**	**223**	**246**	**100**	**100**	**2.7**
Coal	6	26	34	40	45	50	54	21	22	2.8
Oil	15	22	26	27	28	28	29	18	12	1.0
Gas	3	27	37	46	56	67	78	23	32	4.0
Electricity	5	26	34	40	46	53	60	22	24	3.2
Bioenergy	14	20	21	22	23	24	25	16	10	0.9
Other renewables	-	-	0	0	0	0	0	-	0	n.a.
Transport	**32**	**113**	**136**	**151**	**164**	**174**	**181**	**100**	**100**	**1.8**
Oil	32	107	127	140	151	160	165	95	91	1.6
Electricity	0	0	0	0	1	1	1	0	0	4.8
Biofuels	-	3	5	7	7	8	9	2	5	5.0
Other fuels	0	3	4	5	5	5	5	3	3	2.1
Buildings	**84**	**138**	**151**	**160**	**172**	**185**	**199**	**100**	**100**	**1.4**
Coal	0	1	2	2	2	2	1	1	1	0.1
Oil	10	17	18	18	18	17	17	12	9	0.0
Gas	0	0	1	2	4	5	7	0	3	10.7
Electricity	6	35	50	62	76	92	108	26	54	4.2
Bioenergy	68	84	80	76	72	69	65	61	33	-1.0
Other renewables	-	-	0	0	0	1	1	-	0	n.a.
Other	**14**	**49**	**61**	**68**	**74**	**80**	**85**	**100**	**100**	**2.1**

Southeast Asia: New Policies Scenario

	Electricity generation (TWh)							Shares (%)		CAAGR (%)
	1990	2013	2020	2025	2030	2035	2040	2013	2040	2013-40
Total generation	**154**	**789**	**1 104**	**1 342**	**1 610**	**1 901**	**2 212**	**100**	**100**	**3.9**
Coal	28	255	482	623	775	920	1 097	32	50	5.6
Oil	66	45	36	31	28	27	24	6	1	-2.2
Gas	26	349	406	445	470	524	578	44	26	1.9
Nuclear	-	-	-	4	24	32	32	-	1	n.a.
Hydro	27	110	119	148	184	225	255	14	12	3.2
Bioenergy	1	10	22	34	48	62	75	1	3	7.7
Wind	-	0	5	10	18	29	46	0	2	18.6
Geothermal	7	19	27	34	41	49	58	2	3	4.2
Solar PV	-	1	7	13	23	34	47	0	2	14.4

	Electrical capacity (GW)						Shares (%)		CAAGR (%)
	2013	2020	2025	2030	2035	2040	2013	2040	2013-40
Total capacity	**196**	**277**	**333**	**400**	**474**	**550**	**100**	**100**	**3.9**
Coal	47	88	108	134	163	201	24	37	5.6
Oil	24	23	23	22	20	17	12	3	-1.3
Gas	80	103	118	132	146	158	41	29	2.6
Nuclear	-	-	1	3	4	4	-	1	n.a.
Hydro	34	44	54	66	80	90	18	16	3.6
Bioenergy	6	8	10	12	14	16	3	3	3.6
Wind	0	2	5	8	13	21	0	4	16.4
Geothermal	3	4	5	6	8	9	2	2	4.0
Solar PV	1	5	10	17	25	33	0	6	14.0

	CO_2 emissions (Mt)							Shares (%)		CAAGR (%)
	1990	2013	2020	2025	2030	2035	2040	2013	2040	2013-40
Total CO_2	**355**	**1 175**	**1 522**	**1 741**	**1 962**	**2 177**	**2 394**	**100**	**100**	**2.7**
Coal	54	374	614	762	916	1 053	1 212	32	51	4.5
Oil	254	510	579	621	659	695	711	43	30	1.2
Gas	47	292	330	358	387	430	471	25	20	1.8
Power generation	**97**	**459**	**673**	**802**	**936**	**1 069**	**1 220**	**100**	**100**	**3.7**
Coal	29	264	469	592	722	838	980	57	80	5.0
Oil	53	34	29	25	23	23	21	7	2	-1.7
Gas	15	161	176	186	191	208	219	35	18	1.1
TFC	**215**	**640**	**772**	**864**	**952**	**1 032**	**1 095**	**100**	**100**	**2.0**
Coal	25	110	145	170	194	214	231	17	21	2.8
Oil	183	459	532	575	613	644	661	72	60	1.4
Transport	*98*	*321*	*379*	*418*	*451*	*479*	*494*	*50*	*45*	*1.6*
Gas	7	71	95	119	145	174	202	11	18	3.9

Units and conversion factors

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

Units

Coal	Mtce	million tonnes of coal equivalent (equals 0.7 Mtoe)
Emissions	ppm	parts per million (by volume)
	Gt CO_2-eq	gigatonnes of carbon-dioxide equivalent (using 100-year global warming potentials for different greenhouse gases)
	g CO_2/km	grammes of carbon dioxide per kilometre
	g CO_2/kWh	grammes of carbon dioxide per kilowatt-hour
Energy	Mtoe	million tonnes of oil equivalent
	MBtu	million British thermal units
	Gcal	gigacalorie (1 calorie x 10^9)
	TJ	terajoule (1 joule x 10^{12})
	kWh	kilowatt-hour
	MWh	megawatt-hour
	GWh	gigawatt-hour
	TWh	terawatt-hour
Gas	bcm	billion cubic metres
Mass	kg	kilogramme (1 000 kg = 1 tonne)
	kt	kilotonnes (1 tonne x 10^3)
	Mt	million tonnes (1 tonne x 10^6)
	Gt	gigatonnes (1 tonne x 10^9)
Monetary	$ million	1 US dollar x 10^6
	$ billion	1 US dollar x 10^9
	$ trillion	1 US dollar x 10^{12}
Oil	b/d	barrel per day
	mb/d	million barrels per day
Power	kW	kilowatt (1 watt x 10^3)
	MW	megawatt (1 watt x 10^6)
	GW	gigawatt (1 watt x 10^9)

Energy conversions

Convert to:	TJ	Gcal	Mtoe	MBtu	GWh
From:	multiply by:				
TJ	1	238.8	2.388×10^{-5}	947.8	0.2778
Gcal	4.1868×10^{-3}	1	10^{-7}	3.968	1.163×10^{-3}
Mtoe	4.1868×10^{4}	10^{7}	1	3.968×10^{7}	11 630
MBtu	1.0551×10^{-3}	0.252	2.52×10^{-8}	1	2.931×10^{-4}
GWh	3.6	860	8.6×10^{-5}	3 412	1

Currency conversions

Exchange rates (2014)	1 US Dollar equals:
Euro	0.75
Indonesian Rupiah	11 863.75
Malaysian Ringgit	3.27
Japanese Yen	105.69

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Southeast Asia Energy Outlook

World Energy Outlook Special Report

The ten countries that make up the Association of Southeast Asian Nations (ASEAN) are exerting an increasingly important influence on global energy trends. Underpinned by rapid economic and demographic growth, energy demand in the region has more than doubled in the last 25 years, a trend that is set to continue over the period to 2040. Given Southeast Asia's role as a global growth engine, understanding what is shaping energy markets in this vibrant region and the implications for energy security and the environment is vital for policy makers and anyone with a stake in the energy sector.

The International Energy Agency, in collaboration with the Economic Research Institute for ASEAN and East Asia (ERIA), has prepared the *Southeast Asia Energy Outlook 2015* in response to a request from ministers at the 7th East Asia Summit Energy in Bali, Indonesia in 2013. Drawing on the latest data, and policy and market developments, this report examines the current status and future prospects for energy markets in the region and their implications for energy security, the environment and economic development.

The report highlights:

- Trends in domestic energy demand and supply prospects to 2040, broken down by fuel and sector.
- The outlook for the power sector and the increasing share of coal in the region's electricity generation.
- The role that Southeast Asia will play in international energy trade and the implications for its energy expenditures.
- The potential energy and environmental benefits of implementing pragmatic measures that would help limit the rise in the region's greenhouse-gas emissions.
- An in-depth analysis of energy prospects in Malaysia to 2040.
- A focus on four key issues that will shape the direction of the region's energy system: power grid interconnection, energy investment, energy access and fossil-fuel subsidies.