

Southeast Asia Energy Outlook 2019

October 2019



Foreword

This is the fourth edition of the *Southeast Asia Energy Outlook* and it reflects very clearly the deepening relationship that the International Energy Agency (IEA) enjoys with the countries of the Association of Southeast Asian Nations (ASEAN).

The analysis covers energy markets, energy security, climate change and air pollution in a comprehensive way. It also responds directly to the priorities for co-operation that were agreed between ASEAN energy ministers and the International Energy Agency at our meeting in Singapore in October 2018. At this meeting, we focused in particular on the importance of regional power system interconnection, renewables integration, energy efficiency for cooling, investments and digitalisation.

Less than a year later, at the meeting of the ASEAN Ministers of Energy in Bangkok in September 2019, I was able to report back with some of the key findings from this *Southeast Asia Energy Outlook*. The report not only covers the broad outlook for the region to 2040, but also contains insights from the additional in-depth IEA work on our priority topics.

As ministers recognised in Bangkok, this underlines the role of the IEA as a key strategic partner of ASEAN, helping the region tackle its energy challenges across all fuels and all technologies.

This report also reflects the IEA's three main priorities under my leadership. Our strong and expanding engagement with the key players in global energy as they seek to meet growing energy demand in a secure, affordable and sustainable manner. Our attention to new risks to energy security even as we remain vigilant about traditional hazards. And our position as a global hub for expertise on clean energy transitions, notably on energy efficiency. Our emphasis – in this report and elsewhere in IEA work – is on real-world solutions to our energy dilemmas and needs.

This *Southeast Asia Energy Outlook* was a collaborative effort under the overall direction of Tim Gould and the *World Energy Outlook* team, with major contributions from colleagues working on energy efficiency, renewable energy and system integration. I take this opportunity to thank all those, inside and outside the IEA, whose support and expertise helped make it possible.

Dr. Fatih Birol
IEA Executive Director

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Introduction

The Southeast Asia Energy Outlook 2019 is the fourth edition of this World Energy Outlook Special Report. Reflecting its growing partnership with Southeast Asia, the International Energy Agency (IEA) has conducted these in-depth studies every two years since 2013. The studies highlight the opportunities and risks facing the ten member countries of the Association of Southeast Asian Nations (ASEAN) – Brunei Darussalam, Cambodia, Indonesia, Lao People’s Democratic Republic (PDR), Malaysia, Myanmar, Philippines, Singapore, Thailand and Viet Nam - as they look to meet rising energy demand in a secure, affordable and sustainable manner.

This report does not forecast what the energy sector will look like in Southeast Asia. The aim is to consider different possible futures, and the ways that they could come about. The report considers two main scenarios.

The **Stated Policies Scenario** (STEPS) assesses where today’s policy frameworks and ambitions, plus continued evolution of known technologies, might take Southeast Asia’s energy sector in the period to 2040. This scenario only takes into account policies that have been announced (“stated”) and does not take a position on how these policies might evolve in future. The aim is to hold up a mirror to the energy ambitions of today’s decision makers and provide a

candid assessment of their implications for energy markets, security and emissions.

The **Sustainable Development Scenario** (SDS) takes a different approach. Instead of setting out the starting conditions, it fixes the outcomes and works back to the present to see how they can be achieved. The outcomes are the key energy-related components of the United Nations Sustainable Development Goals: delivering on the Paris Agreement, achieving universal access to modern energy by 2030, and dramatically reducing energy-related air pollution.

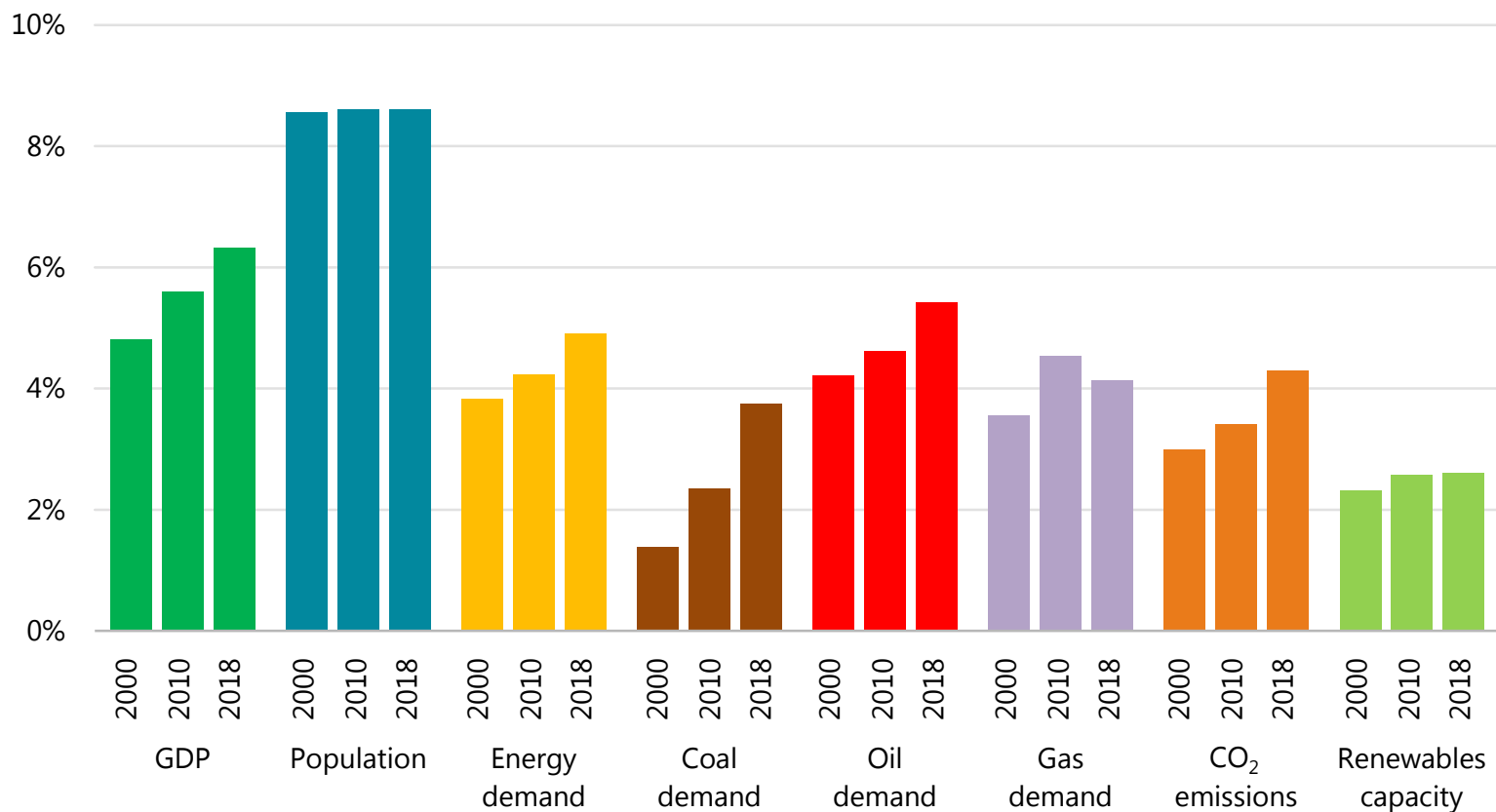
Whereas the Stated Policies Scenario describes “where the region is heading”, the Sustainable Development Scenario shows “where it would need to go” to meet these internationally agreed goals. This gap between these outcomes can be narrowed, but it will require much stronger policy actions.

After a scene-setting discussion in the first chapter, the scenario projections across all fuels and technologies are described in detail in Chapter 2. In Chapter 3, we analyse in detail three key areas: the future of cooling in the region; the scope to expand regional electricity trading, and the prospects for investment in the electricity sector.

Key findings

Southeast Asia's economic and energy influence is growing...

Share of selected global economic and energy indicators in Southeast Asia



Note: GDP = gross domestic product (\$2018, power purchasing parity [PPP]); CO₂ = carbon dioxide.

... and the region's rise so far has been underpinned by fossil fuels

Any assessment of the outlook for global energy has to reckon with the growing weight of Southeast Asia. Home to nearly one-in-ten of the world's population, the rapidly growing economies of the region are shaping many aspects of the global economic and energy outlook.

Southeast Asia is a very diverse and dynamic region, but one common element is that policy makers across different countries have been intensifying their efforts to ensure a secure, affordable and more sustainable pathway for the energy sector. This includes action to facilitate investment in fuel and power supply and infrastructure, while focusing also on efficiency. The potential benefits of a well-managed expansion of the region's energy system, in terms of improved welfare and quality of life for its citizens, are huge.

There are encouraging indications in many areas, but also some warning signs. Rising fuel demand, especially for oil, has far outpaced production from within the region. Southeast Asia as a whole is now on the verge of becoming a net importer of fossil fuels for the first time.

At the same time, Southeast Asia is well on the way to achieving universal access to electricity by 2030. Millions of new consumers have gained access to electricity since 2000, yet some 45 million people in the region are still

without it today and many more continue to rely on solid biomass as a cooking fuel.

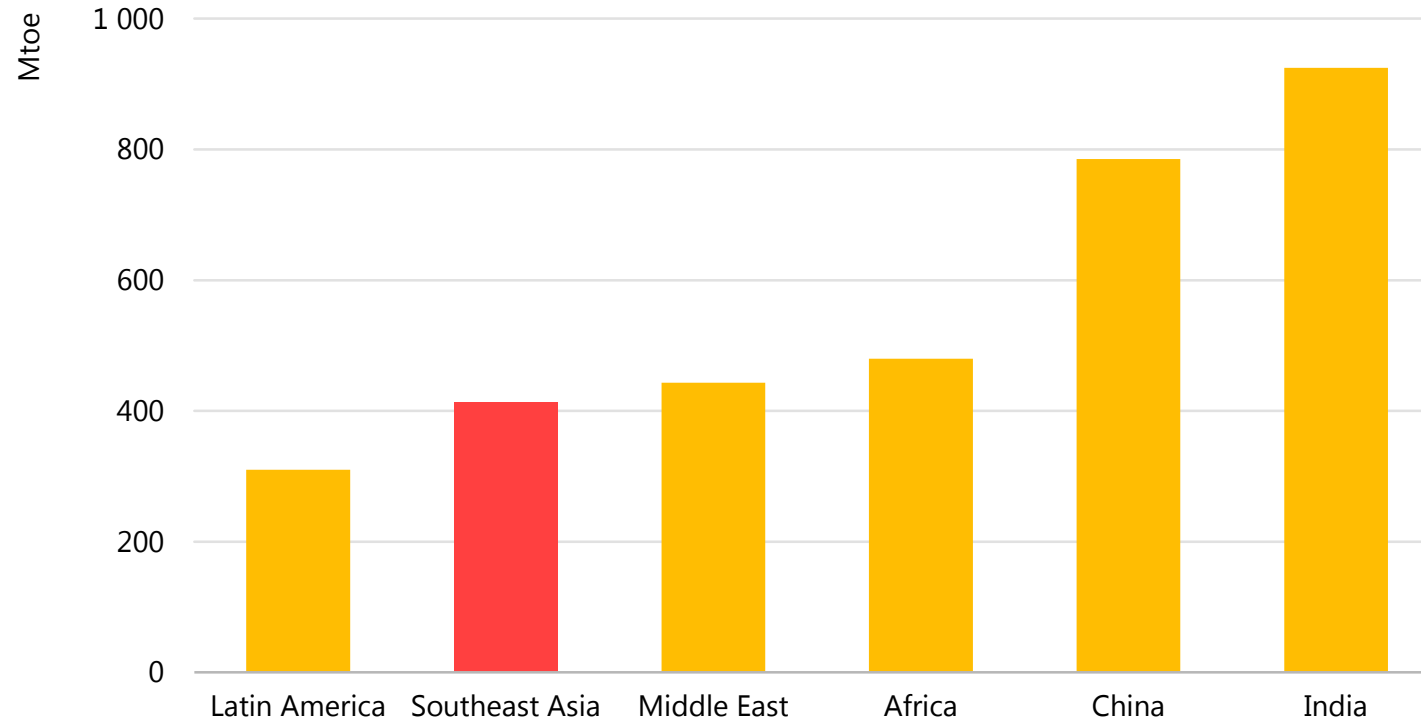
Southeast Asia's growth in electricity demand, at an average of 6% per year, has been among the fastest in the world, but a number of power systems in the region are facing significant financial strains.

Since 2000, overall energy demand has grown by more than 80% and the lion's share of this growth has been met by a doubling in fossil fuel use. Oil is the largest element in the regional energy mix and coal – largely for power generation – has been the fastest growing. This has underpinned the region's development and industrial growth, but has also made air pollution a major risk to public health and driven up energy-related carbon dioxide (CO₂) emissions.

Southeast Asia has considerable potential for renewable energy, but (excluding the traditional use of solid biomass) it currently meets only around 15% of the region's energy demand. Hydropower output has quadrupled since 2000 and the modern use of bioenergy in heating and transport has also increased rapidly. Despite falling costs, the contribution of solar photovoltaics (PV) and wind remains small, though some markets are now putting in place frameworks to better support their deployment.

With today's policy settings, energy demand continues to grow strongly to 2040...

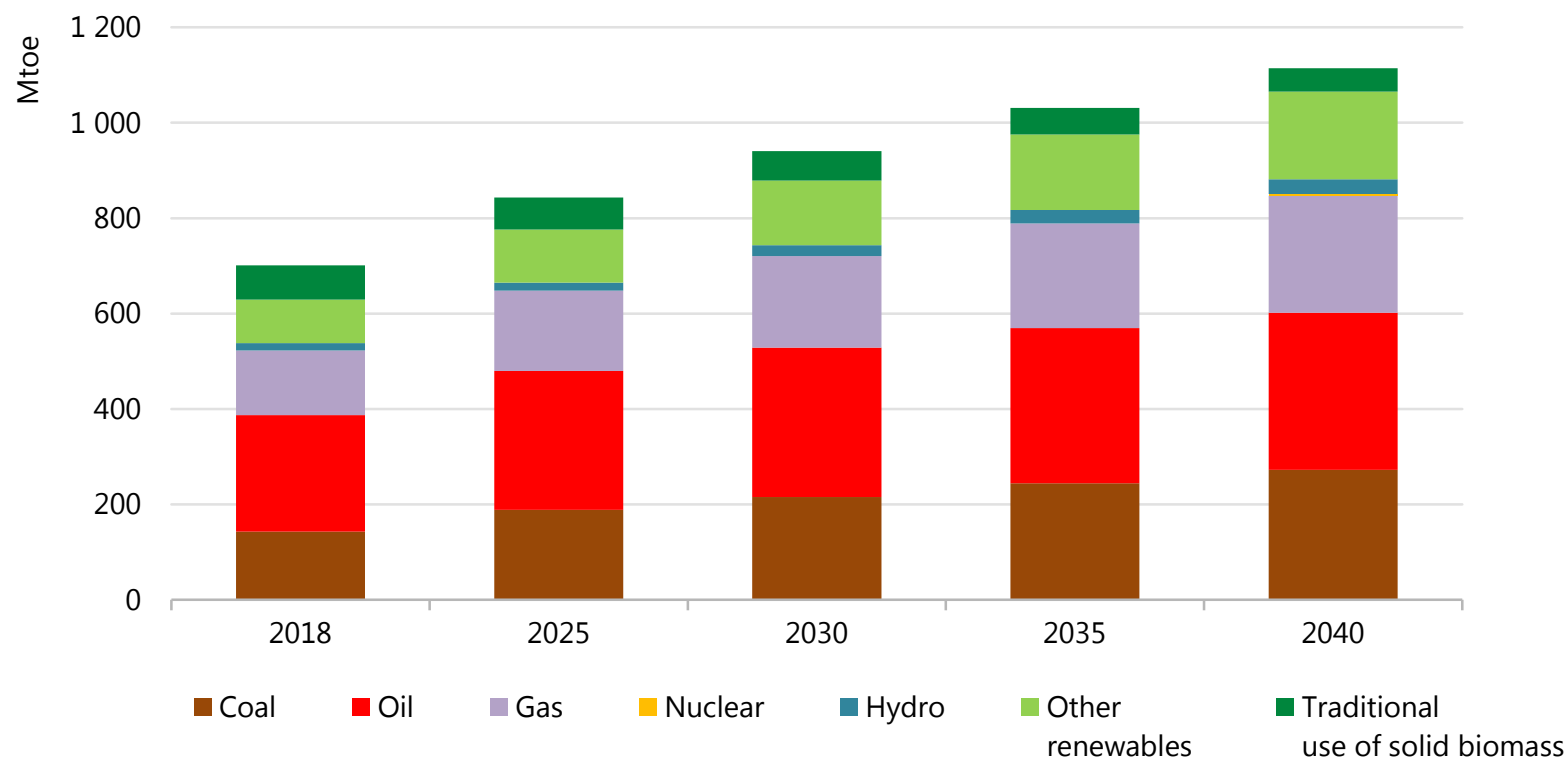
Change in total primary energy demand in selected regions in the Stated Policies Scenario



Note: Mtoe = million tonnes of oil equivalent.

... prompting Southeast Asia to mobilise all fuels and technologies in response

Primary energy demand in Southeast Asia in the Stated Policies Scenario



Notes: Mtoe = million tonnes of oil equivalent. Other renewables include solar PV, wind, geothermal and modern use of bioenergy.

Rising incomes, industrialisation and urbanisation are powerful forces behind the expansion of Southeast Asia's energy system

In the Stated Policies Scenario, which explores the implications of announced policy targets as well as existing energy policies, Southeast Asia's overall energy demand grows by 60% to 2040. The region's economy more than doubles in size over this period, and a rise of 120 million in the population is concentrated in urban areas.

The projected rate of energy demand growth is lower than that of the past two decades, reflecting a structural economic shift towards less energy intensive manufacturing and services sectors, as well as greater efficiency. Nonetheless, it still represents some 12% of the projected rise in global energy use to 2040.

All fuels and technologies play a part in meeting the growth in demand in this scenario. Southeast Asia's oil demand surpasses 9 million barrels per day (mb/d) by 2040, up from just above 6.5 mb/d today. Oil continues to dominate road transport demand, despite an increase in consumption of biofuels. Electrification of mobility, with the partial exception of two and three wheelers, makes only limited inroads. This pathway suggests little change in Southeast Asia from today's congested roads and poor urban air quality.

Southeast Asia is one of a few regions where the share of coal in the power mix increased in 2018 and, based on

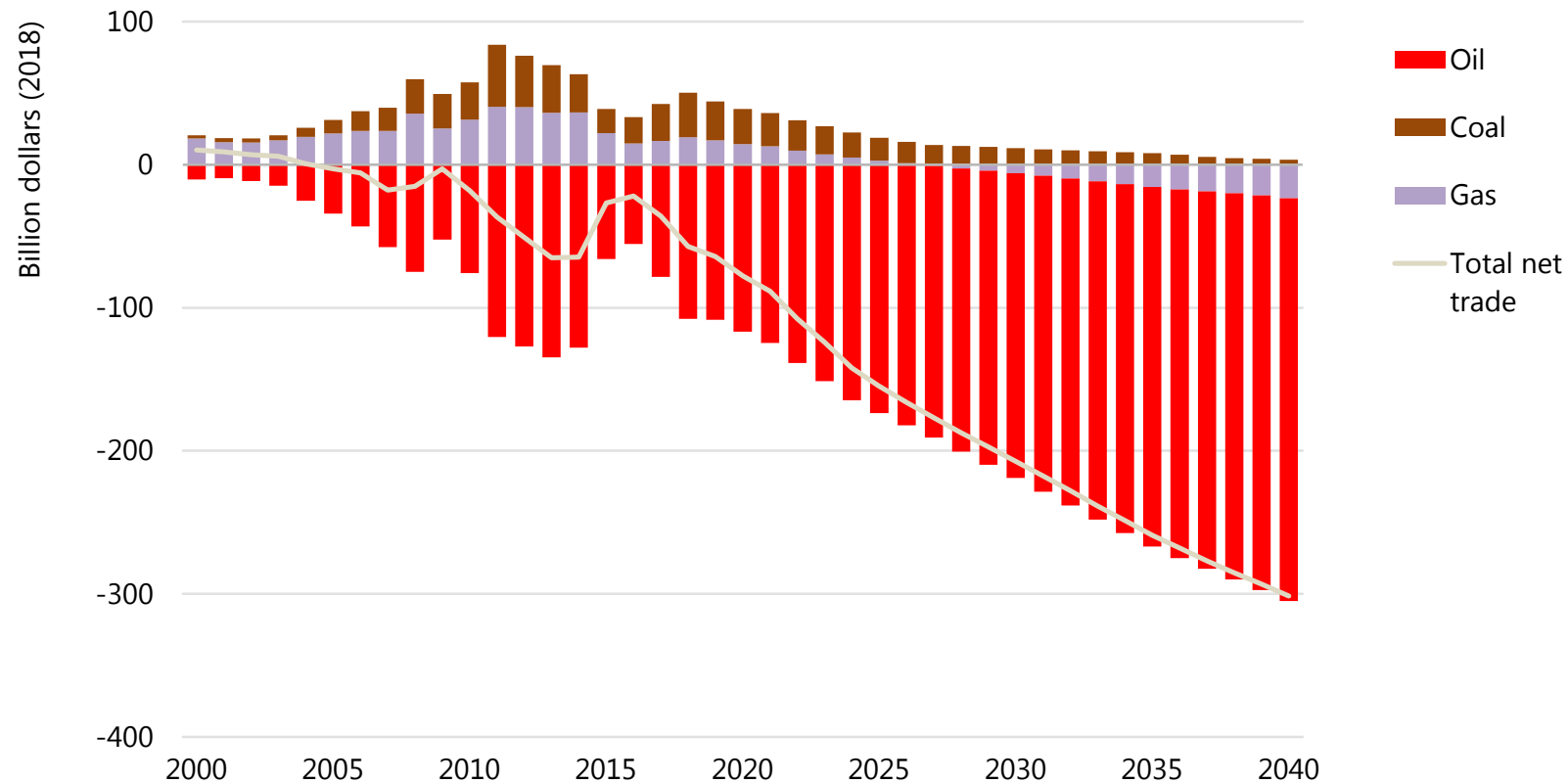
today's policy settings, coal demand is projected to rise steadily over the coming decades. This is largely to fuel new and increasingly efficient coal-fired power plants, although the headwinds facing these projects are growing – including increasing difficulty to secure competitive financing for new coal facilities.

Natural gas faces competing pressures in Southeast Asia. It appears to be a good fit for the needs of the region's fast-growing cities and lighter industries, as well as (in the form of liquefied natural gas [LNG]) a way to displace costly oil use in some island communities. However, increasing reliance on imports makes the fuel less price-competitive. In our projections, it is industrial consumers rather than power plants that are the largest source of growth in gas demand.

In the Stated Policies Scenario, the share of renewables in power generation rises from 24% today (18% of which is hydropower) to 30% by 2040, but this still lags far behind the levels reached in China, India and some other economies in Asia. Wind and solar are set to grow rapidly from today's low levels, while hydropower and modern bioenergy – including biofuels, biomass, biogas and bioenergy derived from other waste products – remain the mainstays of Southeast Asia's renewable energy portfolio.

Southeast Asia's current pathway is heading for rising energy import bills...

Fossil fuel trade balance in Southeast Asia in the Stated Policies Scenario



... as well as increasing emissions

The pathway that Southeast Asia is on includes the realisation of some major energy policy goals, including the vital task of ensuring universal electricity access and some progress with diversification of the energy mix.

Yet our Stated Policies Scenario also highlights some major potential risks. A widening gap between indigenous production and the region's projected oil and gas needs results in a ballooning energy trade deficit. By 2040, Southeast Asia is projected to register a net deficit in payments for energy trade of over \$300 billion per year, almost entirely due to imports of oil. This would also imply growing strains on government budgets, especially if subsidy policies remain in place that shield consumers from paying market-based energy prices.

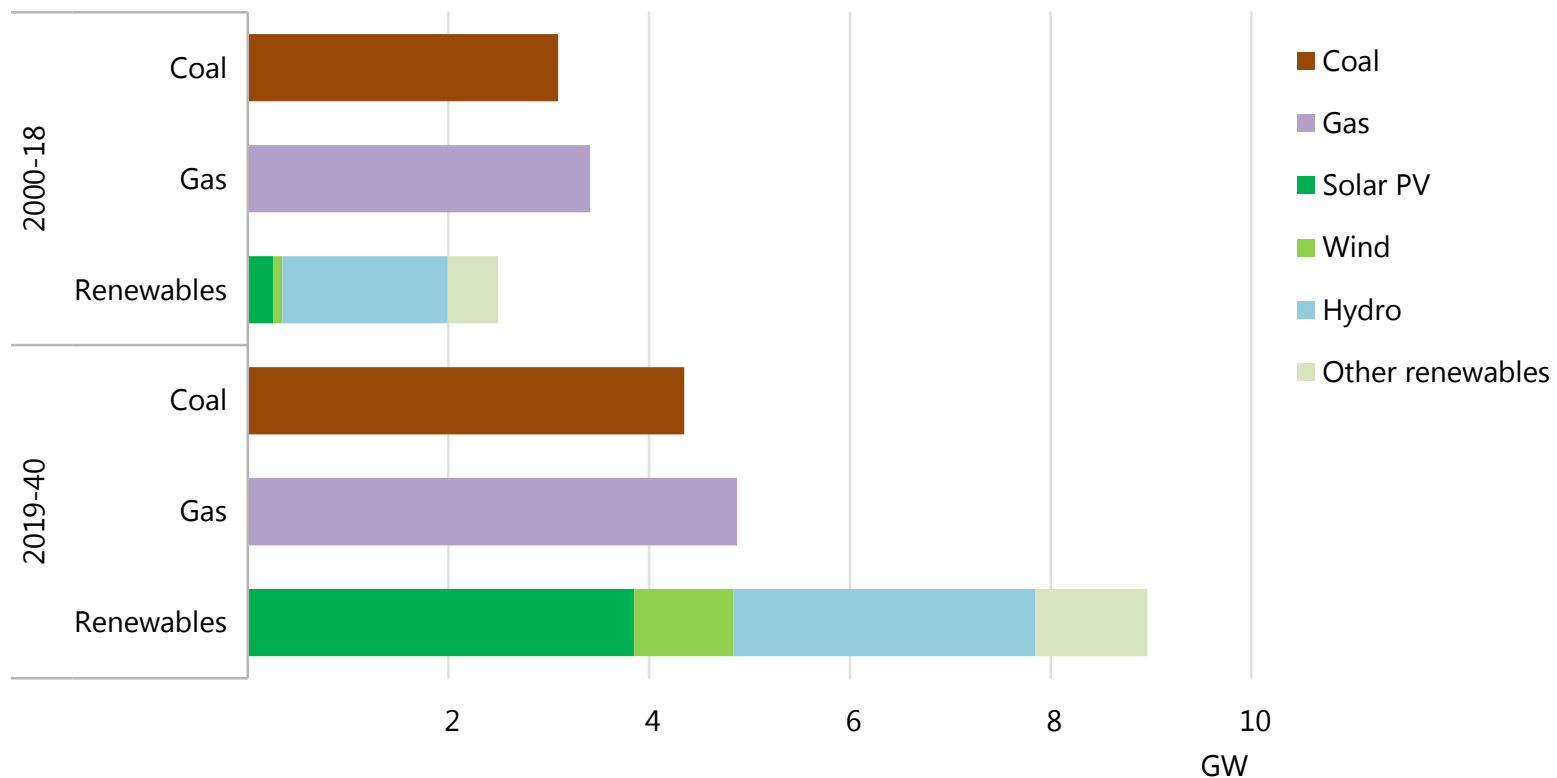
The large increase in imports also raises energy security concerns. In the case of oil, the region's overall dependence on imports exceeds 80% in 2040, up from 65% today.

The consequences of energy-related air pollution on human health remain severe. The number of annual premature deaths associated with outdoor and household air pollution in Southeast Asia rises to more than 650 000 by 2040, up from an estimated 450 000 in 2018. Some 175 million people across the region still remain dependent on the traditional use of solid biomass for cooking in 2040.

The projected increase in fossil fuel consumption, particularly the continued rise in coal demand, is felt in a two-thirds rise in CO₂ emissions to almost 2.4 gigatonnes (Gt) in 2040. In most other parts of the world, the power sector's share of total energy-related emissions falls to 2040 even as electricity expands its role in final consumption. However, the relatively high carbon intensity of an expanding generation fleet in Southeast Asia means that the region's power sector is responsible for just under half of CO₂ emissions in 2040, up from 42% today.

Emerging signs of change in the region's power mix

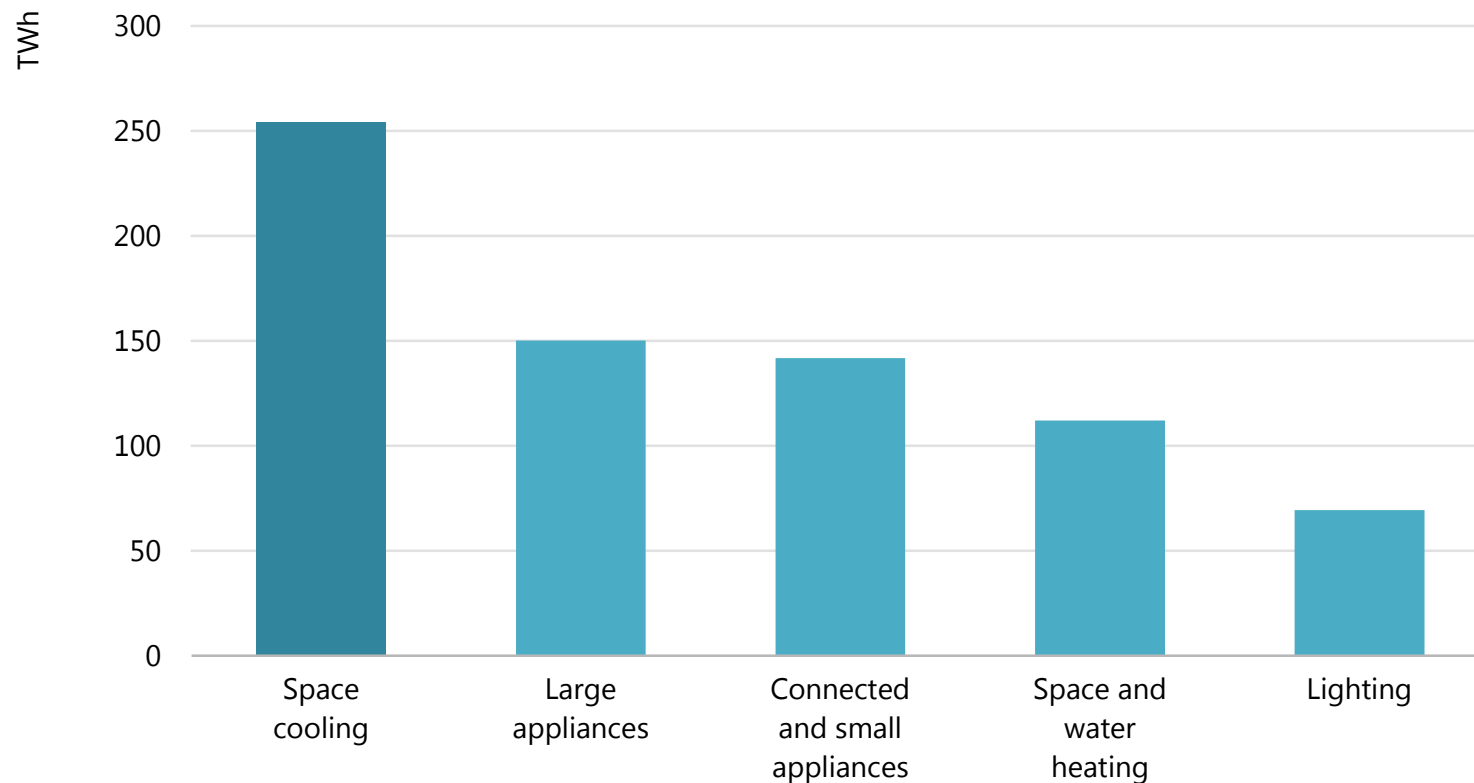
Southeast Asia's average annual capacity additions by type in the Stated Policies Scenario



Note: GW = gigawatts.

Rising demand for cooling could exacerbate strains on the power system

Sources of electricity demand growth in buildings to 2040 in Southeast Asia in the Stated Policies Scenario



Note: TWh = terawatt-hours.

The future is electrifying in Southeast Asia

Southeast Asia's electricity sector is in a very dynamic phase of development, both for supply and demand.

Relatively low generation costs and indigenous supply have traditionally given coal a prominent place in power sector planning. This is maintained in the Stated Policies Scenario – our measured assessment of planned additions means that the share of coal-fired generation in the region's power mix remains broadly flat at near 40% over the next two decades, Natural gas-fired plants, based on domestic supply as well as imported liquefied natural gas are also set to maintain a strong foothold in Southeast Asia.

However, the declining costs of renewables and concerns over emissions and pollution are starting to alter the balance of future additions to the power mix. Recent revisions to policy planning documents have tended to boost the long-term share of renewables, typically at the expense of coal.

Moreover, a switch is visible in near-term project developments, with a significant slowdown in decisions to move ahead with new coal-fired capacity and a rise in additions of solar and wind. In the first-half of 2019, approvals of new coal-fired capacity were exceeded by capacity additions of solar PV for the first time.

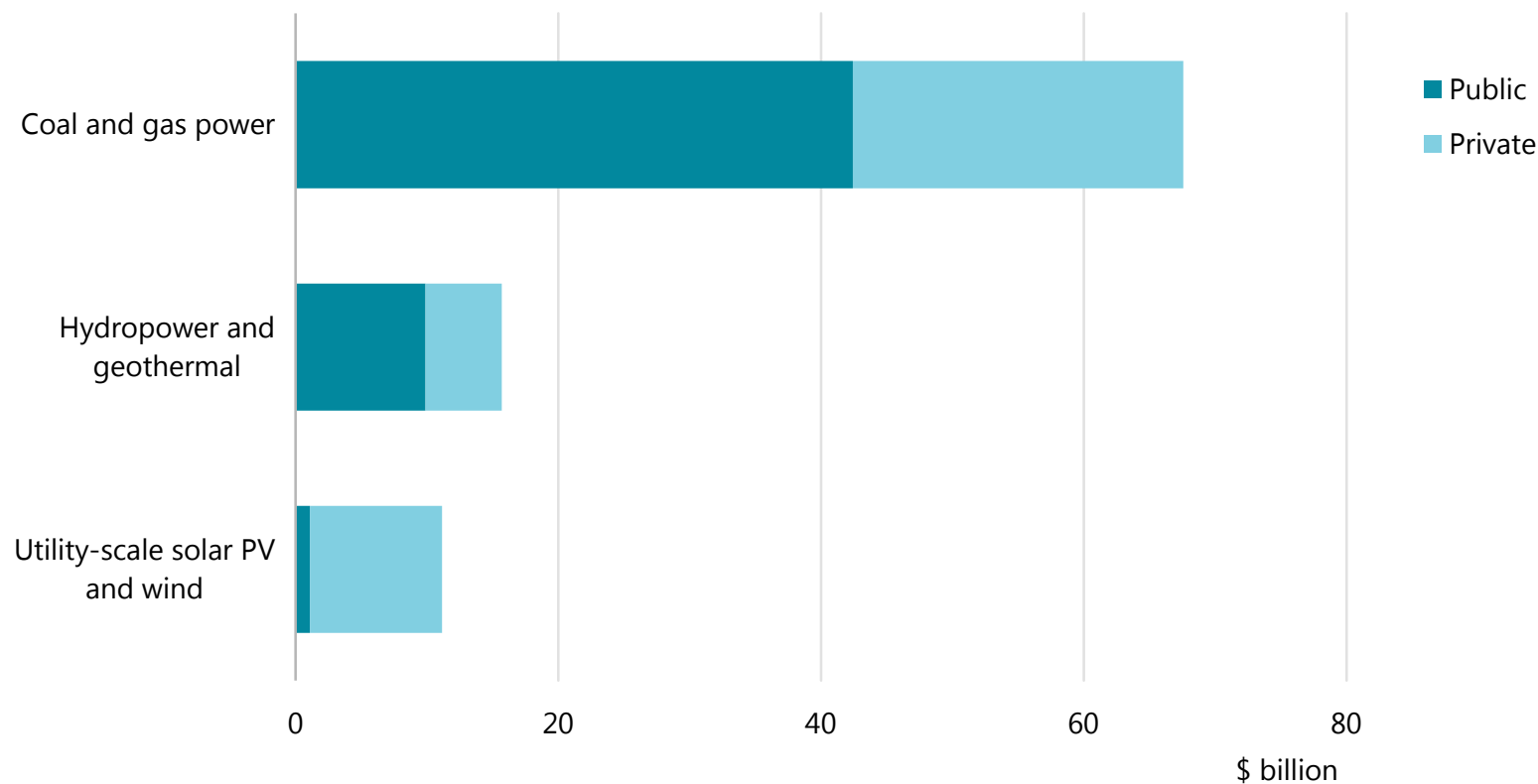
On the demand side, electricity consumption in Southeast Asia doubles to 2040; the annual growth rate of nearly 4% is twice as fast as the rest of the world. The share of electricity in final energy consumption is 18% today but this rises rapidly to 26% in 2040 and reaches the global average.

Space cooling is one of the fastest growing uses of electricity to 2040, propelled higher by rising incomes and high cooling needs. For the moment, less than 20% of households across the region have air conditioning: in Indonesia, the most populous ASEAN country, around 10% do. In our projections, appliance ownership and cooling demand skyrocket, not only raising overall electricity demand but accentuating strains on power systems as the share of cooling in peak power demand rises towards 30%.

There are real opportunities for efficiency policies to reduce some of these projected strains: our detailed market analysis shows that the average efficiency of air conditioning units sold today is well below the global average, even though much more efficient units, including those manufactured locally, are available at comparable cost. Enhanced efforts to improve building and equipment efficiency (as in the Sustainable Development Scenario) would be sufficient to reduce the growth in cooling demand in 2040 by around half.

Governments have a determining influence over the flow of energy investments...

Sources of finance for power generation investment in Southeast Asia (by year of FID, 2014-2018)



Notes: FID = final investment decision. Includes only utility-scale projects ≥ 25 megawatts. Public finance includes the participation of state-owned enterprises, development finance institutions, export-credit agencies and other public entities.

... and they also set the pace and direction of progress towards more integrated regional power markets

Whichever pathway the region takes, meeting Southeast Asia's energy needs and policy priorities will require higher levels of investment. The need to step up investment is particularly acute in the power sector. Today's investment levels fall well short of the projected needs in the Stated Policies Scenario and are more than 50% lower than what would be required in the Sustainable Development Scenario

Mobilising investment requires broad participation from the private sector, as well as the targeted use of public funds. Public sources have thus far played a very important role in financing thermal power plant projects and large-scale renewables (such as hydropower or geothermal) with sizeable upfront capital needs. By contrast, wind and solar PV projects have relied much more on private finance, spurred by specific policy incentives.

There is a critical need in Southeast Asia to attract additional private sources of capital. This would require governments to address the risks that affect the bankability of projects; we highlight four priority areas for action:

- enhancing the financial sustainability of utilities;
- improving procurement frameworks and contracting mechanisms, especially for renewables;
- creating a supportive financial system that brings in a range of financing sources

- promoting integrated approaches that take the demand-side into account.

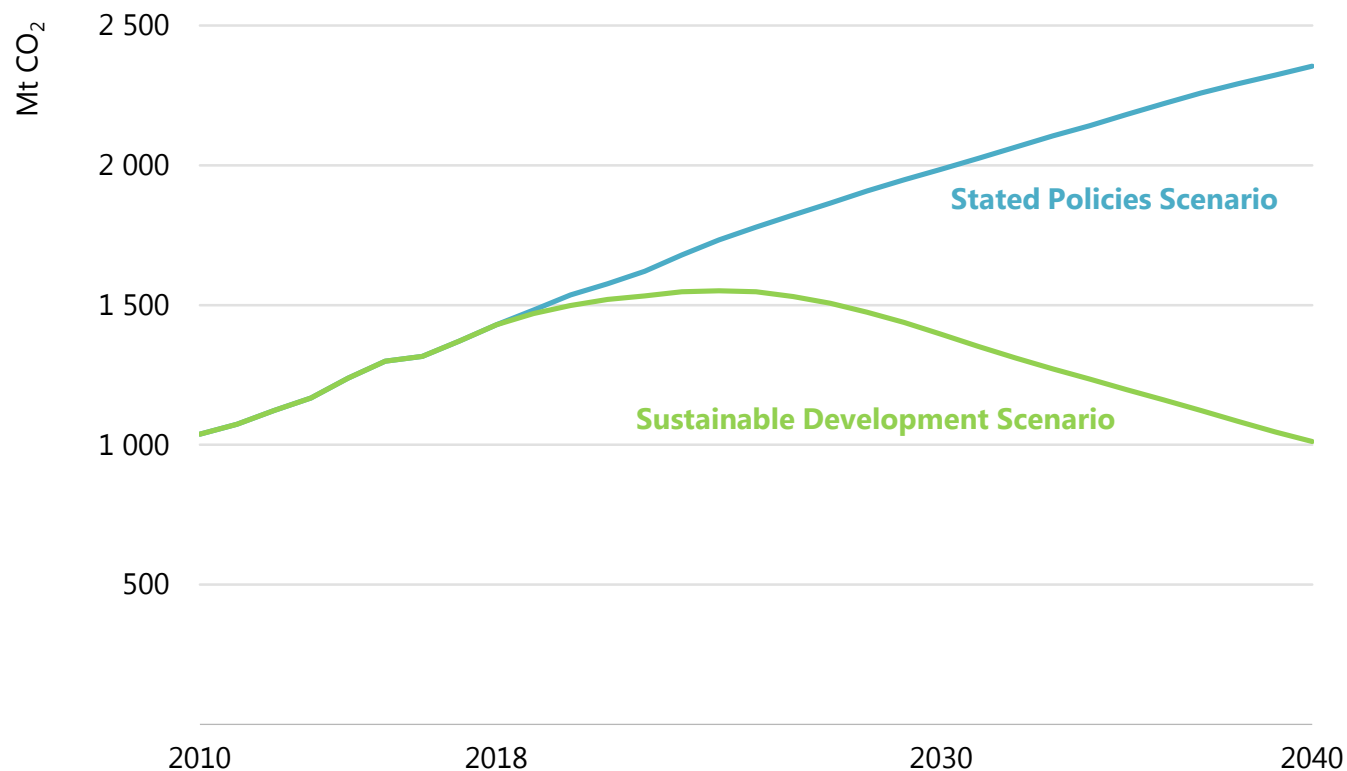
The types of investment that go ahead will also depend on the extent of regional cooperation and integration, especially progress with the ASEAN Power Grid – an ambitious project to interconnect the power systems in the region and establish multilateral power trading.

Regional power system integration is vital to facilitate growth in renewable sources of generation, in particular from wind and solar PV. Integration allows access to a larger and more diverse pool of flexible resources on the supply side (from sources such as hydro or gas-fired power) as well as the demand side. Interconnecting with neighbouring grids also reduces the system variability of wind and solar output, which is smoother when individual plants are aggregated over larger geographic areas.

Our detailed case study shows that multilateral power trading and an expansion of cross-border transmission bring major cost savings in building and operating the region's power systems. They also bring significant environmental gains when they accompany and enable an expansion of renewables-based power.

A wide range of technologies and approaches would be required to turn the emissions trend around

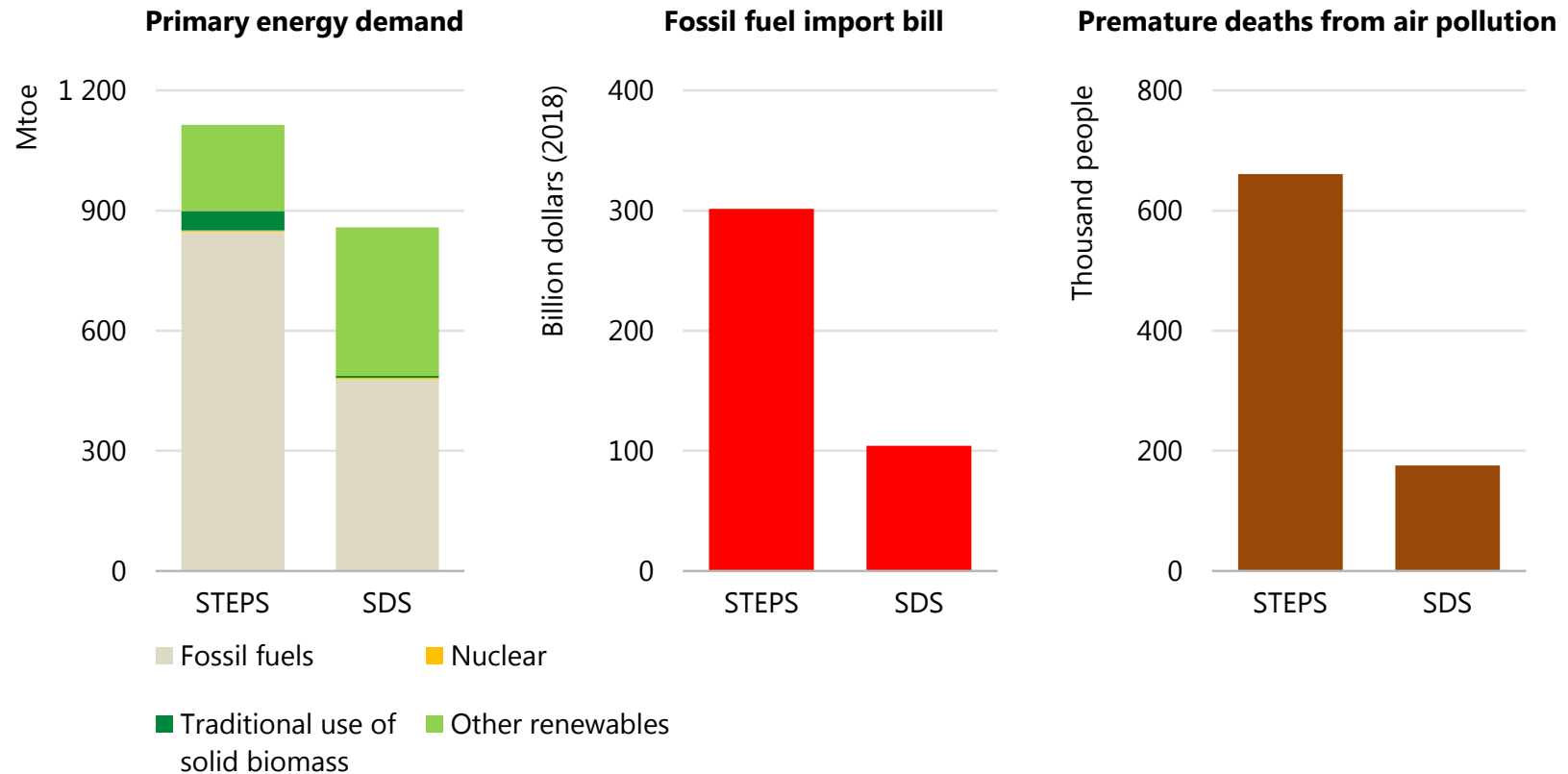
CO₂ emission reductions in the Sustainable Development Scenario relative to the Stated Policies Scenario



Note: Mt CO₂ = million tonnes of carbon dioxide.

...and secure the multiple benefits of the Sustainable Development Scenario

Comparison of selected energy indicators in the Stated Policies and Sustainable Development scenarios, 2040



Note: Mtoe = million tonnes of oil equivalent; STEPS = Stated Policies Scenario; SDS = Sustainable Development Scenario

Crucial choices ahead for Southeast Asia

This *World Energy Outlook* special report does not provide a forecast of what will happen in Southeast Asia's energy sector. Our aim is rather to provide a set of scenarios that explore different possible futures and the actions or inactions that bring them about.

Moving towards the Sustainable Development Scenario for Southeast Asia would require concerted action across all parts of the energy sector, deploying multiple technologies and approaches. There are no simple solutions, but energy transitions in other parts of the world offer valuable guidance as well as making the various policy and technology options more affordable.

Initiatives from individuals, civil society, companies and investors can all make a difference, but the greatest capacity to shape Southeast Asia's energy destiny lies with governments. We highlight four areas in particular that would be essential to move the region beyond the outcomes in the Stated Policies Scenario:

Scaling up the deployment of renewables. This is the largest single element of Southeast Asia's transition (in contrast to other parts of the world, where 'stated policies' are already more favourable towards renewables). In the Sustainable Development Scenario, the share of

renewables in power generation almost triples from today's level by 2040, reaching 70%. Inside and outside the power sector, Southeast Asia has large potential for the sustainable use of modern bioenergy, both in terms of today's technologies and in the development of advanced biofuels to improve the sustainability of the transport sector.

A major focus on improving energy efficiency. This is not only a pillar of sustainable energy use but also eases energy security concerns by curbing import growth, while keeping consumer energy bills in check. Efficiency plays a role across all sectors, but is especially important in fast-growing sectors such as cooling and road transport.

Getting prices right by phasing out fossil fuel subsidies. Southeast Asia has made progress on reducing fossil fuel consumption subsidies, but this process is not complete. Seeing it through is essential to spur more sustainable energy consumption and investment decisions.

Tackling the legacy issues, starting with the least-efficient coal plants. Among the policy options, carbon capture, utilisation and storage is a vital technology to reduce emissions from the power sector and from industry.

Energy in Southeast Asia

Today's energy trends

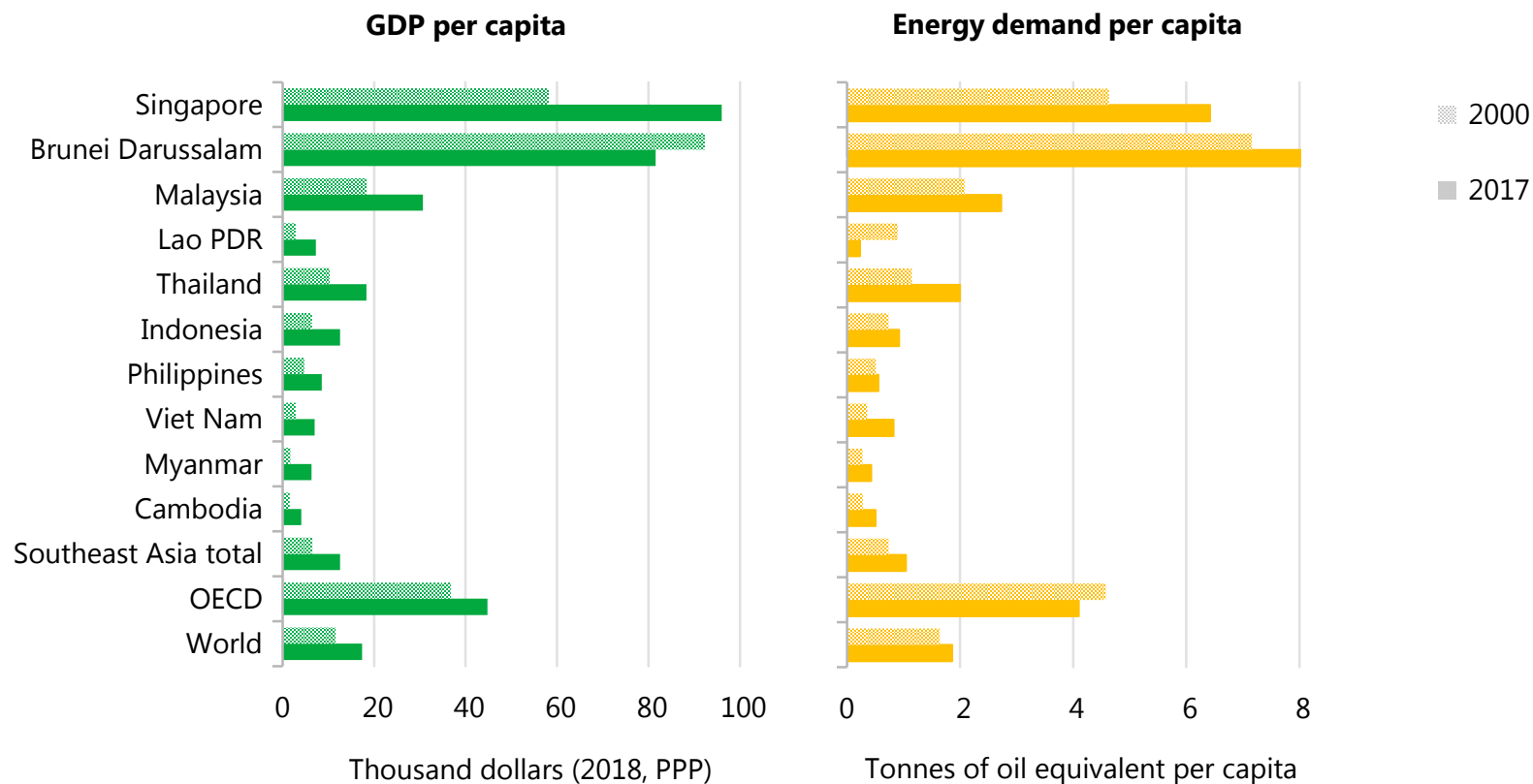
Energy demand (23-30)

Electricity and energy supply (31-36)

Focus on mobility (37-40)

Circumstances vary across the region, but Southeast Asia's economic and energy role is growing fast

GDP and energy demand per capita in Southeast Asia



Notes: GDP = gross domestic product; ASEAN = Association of Southeast Asian Nations; OECD = Organisation for Economic Co-operation and Development; PPP = purchasing power parity. Lao PDR = Lao People's Democratic Republic. Energy demand per capita of Lao PDR is 2015 data.

Southeast Asia's development story takes centre stage...

Home to nearly one-out-of-ten people in the world, the burgeoning economies in Southeast Asia increasingly shape many aspects of the global economic and energy outlook. The region today accounts for nearly 5% of global energy demand and this share has been rising steadily. Urbanisation and industrialisation are gathering pace. Around seven million people are added to the region's urban population each year. Industrial growth, underpinned in many cases by foreign direct investment, means that Southeast Asia supports a breathtaking diversity of global value chains.

This dynamism masks underlying disparities in income and development levels and areas where progress has been lagging behind. Rapid economic growth has often outpaced the expansion of infrastructure and connectivity. Policy reforms have proceeded slowly in some countries, inhibiting potentially much higher levels of private investment.

Thus far, the region's energy development path has been largely based on fossil fuels and thermal-based power supply to meet rapidly growing energy demand. This

approach has supported growth, but it has also created some major challenges.

Rapidly rising oil demand has resulted in growing import dependence and exposure to price swings. Southeast Asia is one of a few regions where the share of coal in the power mix increased in 2018, underlining the region's exposure to the environmental costs of local air pollution as well as its rising share in global carbon dioxide (CO₂) emissions. A number of power systems in the region are facing severe financial strains, while access to reliable and affordable energy remains beyond the reach of some remote communities.

Southeast Asia region has a unique geography, with islands, peninsulas and pockets of very densely populated regions separated by uplands and mountainous areas. These specifics all affect the pathway that energy systems in the region will follow.

...as decision makers try to put the region on a more secure and sustainable energy pathway

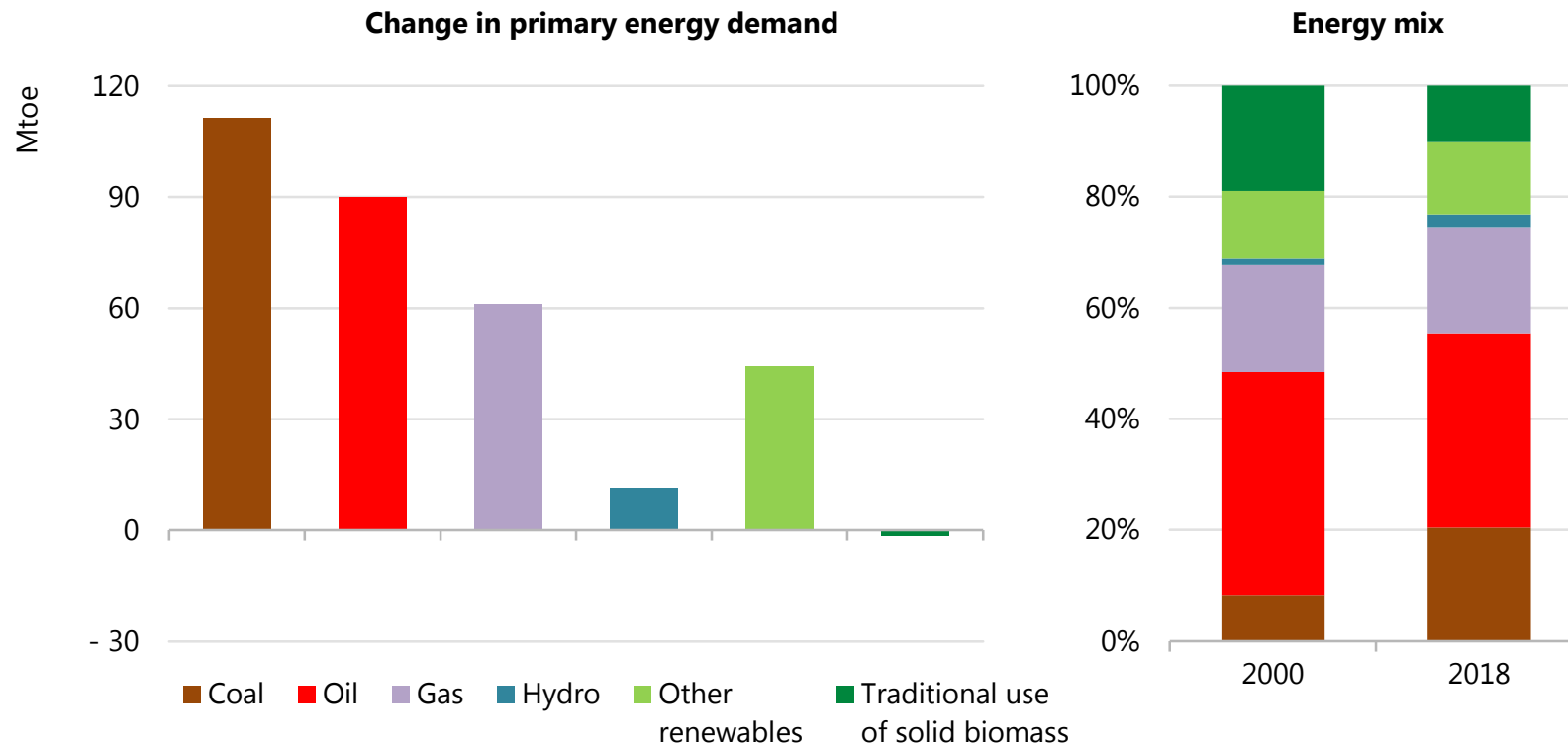
Energy demand levels on a per-capita basis in a number of Southeast Asian countries are still relatively low by international comparison. The scope for further demand growth is enormous. As such, the region faces the perennial question of how best to accommodate higher levels of economic activity and energy consumption without provoking a deterioration in the reliability and affordability of energy services, or aggravating the environmental consequences of energy use.

Rapid global technology developments, in particular the falling cost of renewable energy technologies, are combining with the region's own policy goals to open up a new set of opportunities for Southeast Asia to shape its energy future. ASEAN member countries have collectively endorsed ambitious targets that seek to improve the rate of energy efficiency improvement, limit emissions from fossil fuels and expand the role of renewables in the energy mix.

The prospects of building a more sustainable and secure energy system in a cost-effective way depend on strengthening policy commitments and implementation, including appropriate pricing along the energy value chain, frameworks to attract adequate investment, a supportive environment for innovation and integrated approaches to energy development that encompass both supply and demand side measures.

Coal has led primary energy demand growth since 2000

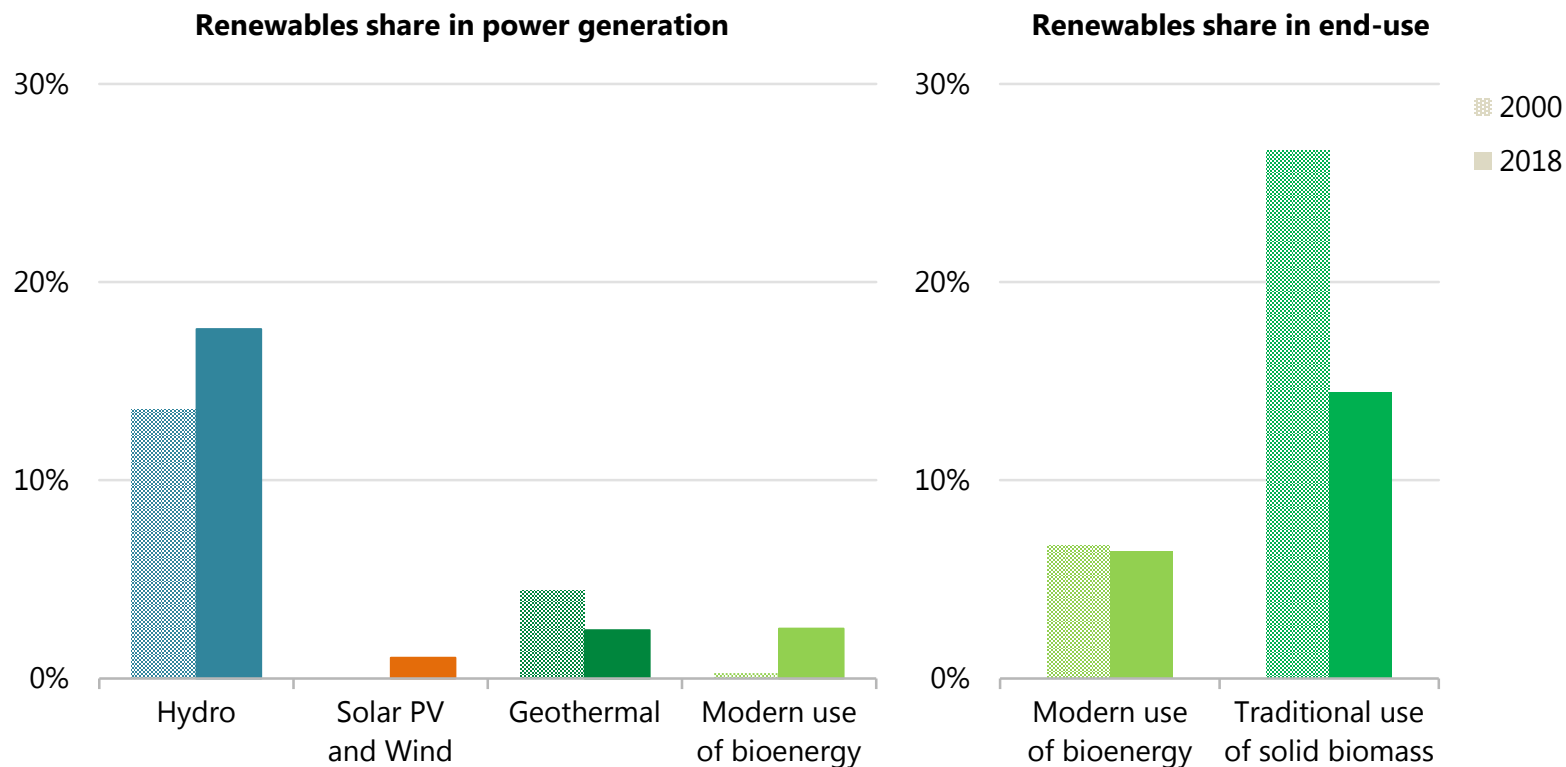
Change in Southeast Asia's total primary energy demand and energy mix, 2000-18



Notes: Mtoe = million tonnes of oil equivalent. Other renewables include solar photovoltaics, wind, geothermal and modern use of bioenergy. Traditional use of solid biomass refers to the use of solid biomass with basic technologies, such as a three-stone fire, often with no or poorly operating chimneys.

Modern renewables only contribute modestly relative to their potential

Renewables share in power generation and total final consumption in Southeast Asia, 2000-18



Notes: Solar PV = solar photovoltaics. Modern use of bioenergy refers to use of bioenergy excluding traditional use of solid biomass.

Absent widespread measures to support efficiency and low carbon supply, the energy to fuel economic growth has largely come from fossil fuels

Primary energy demand in Southeast Asia has increased by more than 80% since 2000, an average of 3.4% per year, far outpacing the global annual average of 2.0% over the period. This reflects Southeast Asia's rapid economic expansion as well as the insufficiency of measures to encourage more efficient patterns of energy consumption.

Since 2000, the use of relatively cheap and abundant fossil fuels doubled to meet nearly 85% of the incremental demand growth. Fossil fuels now account for three-quarters of primary energy demand in the region. In some cases, pricing policies for fossil fuels shielded consumers from changes in their international market value (see slides 50-51).

The development of the region's infrastructure and industrial base, together with higher incomes and the emergence of a burgeoning consumer class, have pushed up demand for coal and natural gas, notably for power generation.

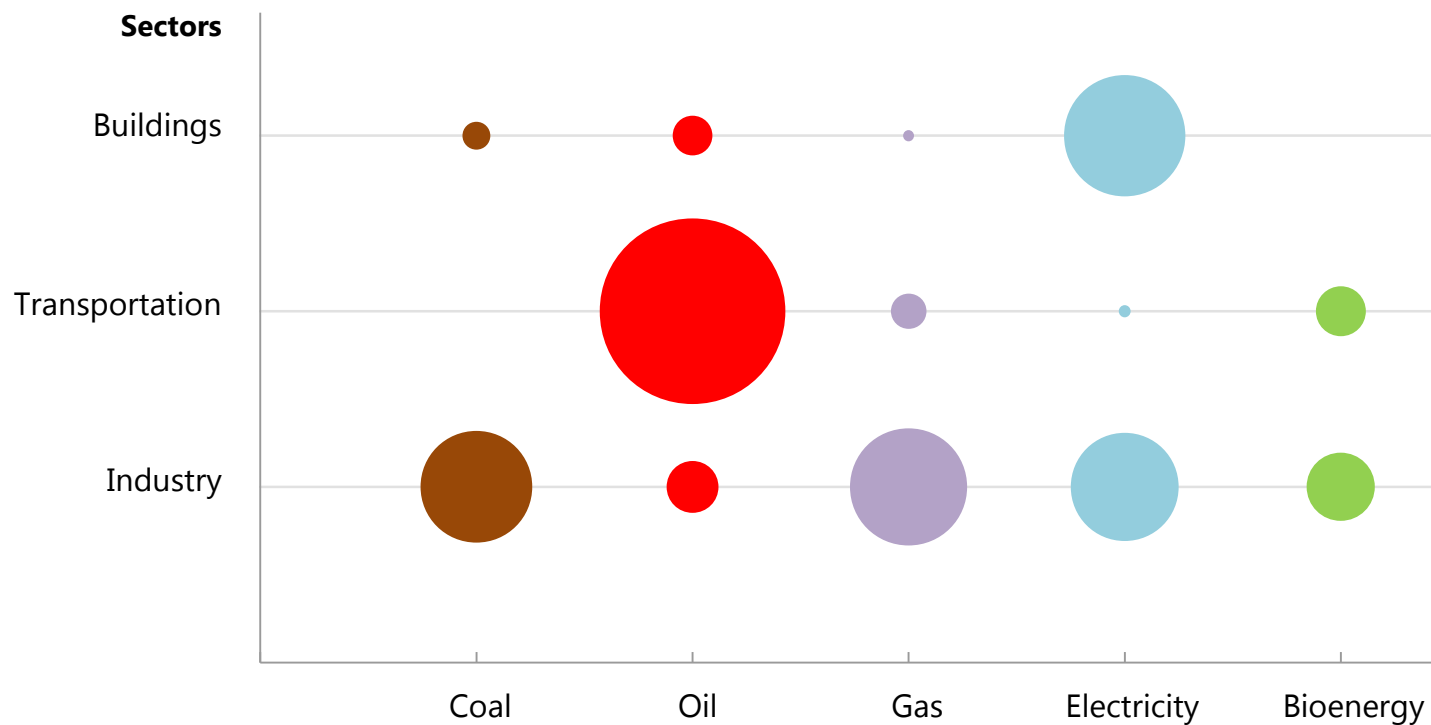
Rapid growth in vehicle ownership and increased demand for mobility and freight services have also pushed up demand for oil by more than half since 2000. Oil accounts for more than one-third of regional primary energy mix, far ahead of coal (20%) and gas (19%).

The use of energy from renewable sources (excluding the traditional use of solid biomass for cooking) has also doubled over the last two decades, but meets less than 20% of total primary demand. Strong resource availability across a portfolio of renewable technologies have supported a quadrupling of hydropower, as well as increased modern use of bioenergy in heating and transport.

Despite falling costs, solar PV and wind's contribution has remained small, though some markets are now putting in place frameworks to better support investment.

Oil in transport and electricity for buildings have led the growth in final energy consumption since 2000

Growth in final energy consumption by sector and type, 2000-18



Notes: This figure shows growth in energy consumption in end-use sectors, but does not include transformation sectors, i.e. electricity generation and oil refining. The area of bubble shows relative size of incremental energy consumption from 2000 to 2018.

The efficiency of vehicles and of appliances is becoming a critical variable for energy consumption trends

Oil for transport and electricity for buildings together have accounted for almost 50% of the increase in final energy consumption in Southeast Asia since 2000. The direct use of coal and gas in the industry sector accounted for a further 26% of growth.

The expansion of oil and electricity consumption relates closely to the broader trend of rising urbanisation and growth in middle-class households, which have boosted demand for mobility and for a range of electrical appliances and applications in the residential and service sectors.

Vehicle ownership has almost tripled since 2000 and associated fuel consumption has doubled. Demand growth would have been even higher without structural changes and efficiency improvements to the vehicle fleet. There has been more than 30% improvement in the fuel economy of the car fleet over this period, and overall efficiency was also helped by the consumer preferences for two/three-wheeled motor vehicles, which expanded from 70% to 80% of the fleet.

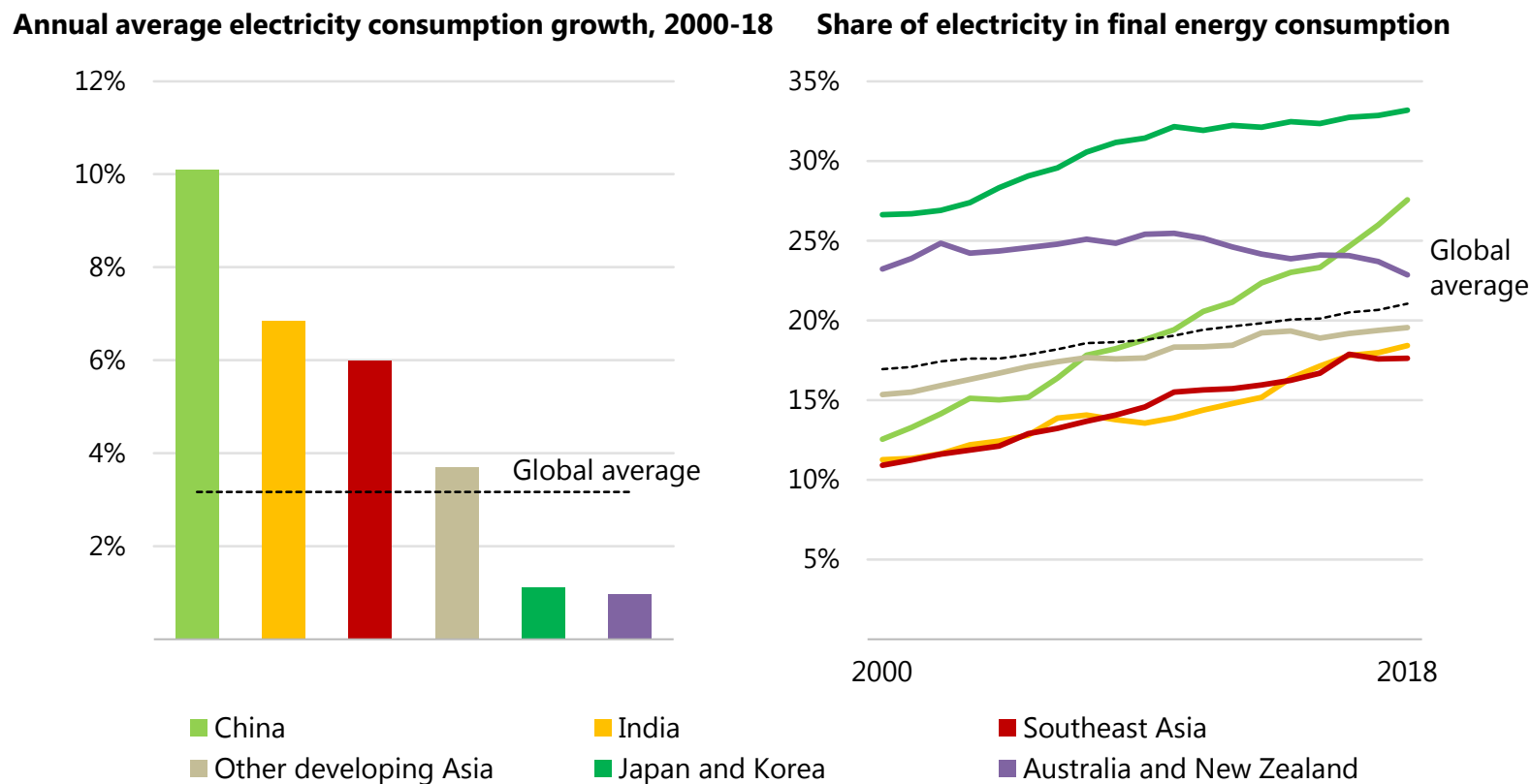
Electricity use for lighting, appliances and equipment in buildings has grown at around 6% per year on average over the last two decades. Residential space cooling demand has been particularly strong, as ownership of air conditioners (AC) almost tripled and affiliated electricity consumption quadrupled.

Cooling has been a strong driver of both overall and peak power demand. Using more efficient AC systems represents a potentially powerful tool for avoiding or deferring large supply investments to meet rising electricity needs (see The Future of Cooling in Southeast Asia section, slides 121-136).

Recognising this potential, ASEAN energy ministers are exploring policy measures, including through the endorsement of a 2015 roadmap, that facilitates harmonised energy performance standards for air conditioners.

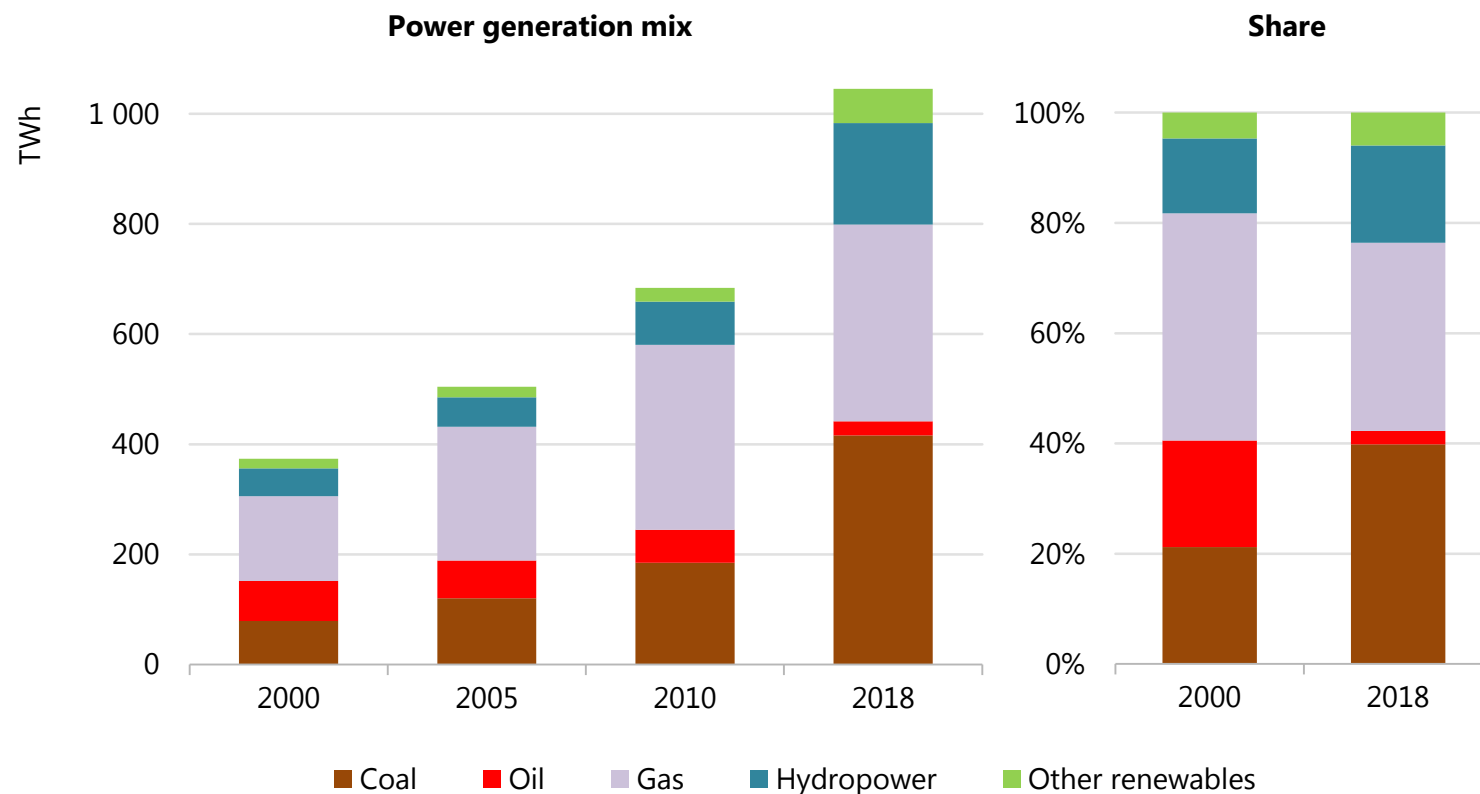
Electricity consumption growth is among the world's fastest, and there is large scope for electricity to expand its role in overall energy consumption

Average rates of electricity consumption growth and share of electricity in final energy consumption in selected Asian economies



Coal and gas have underpinned Southeast Asia's electrification

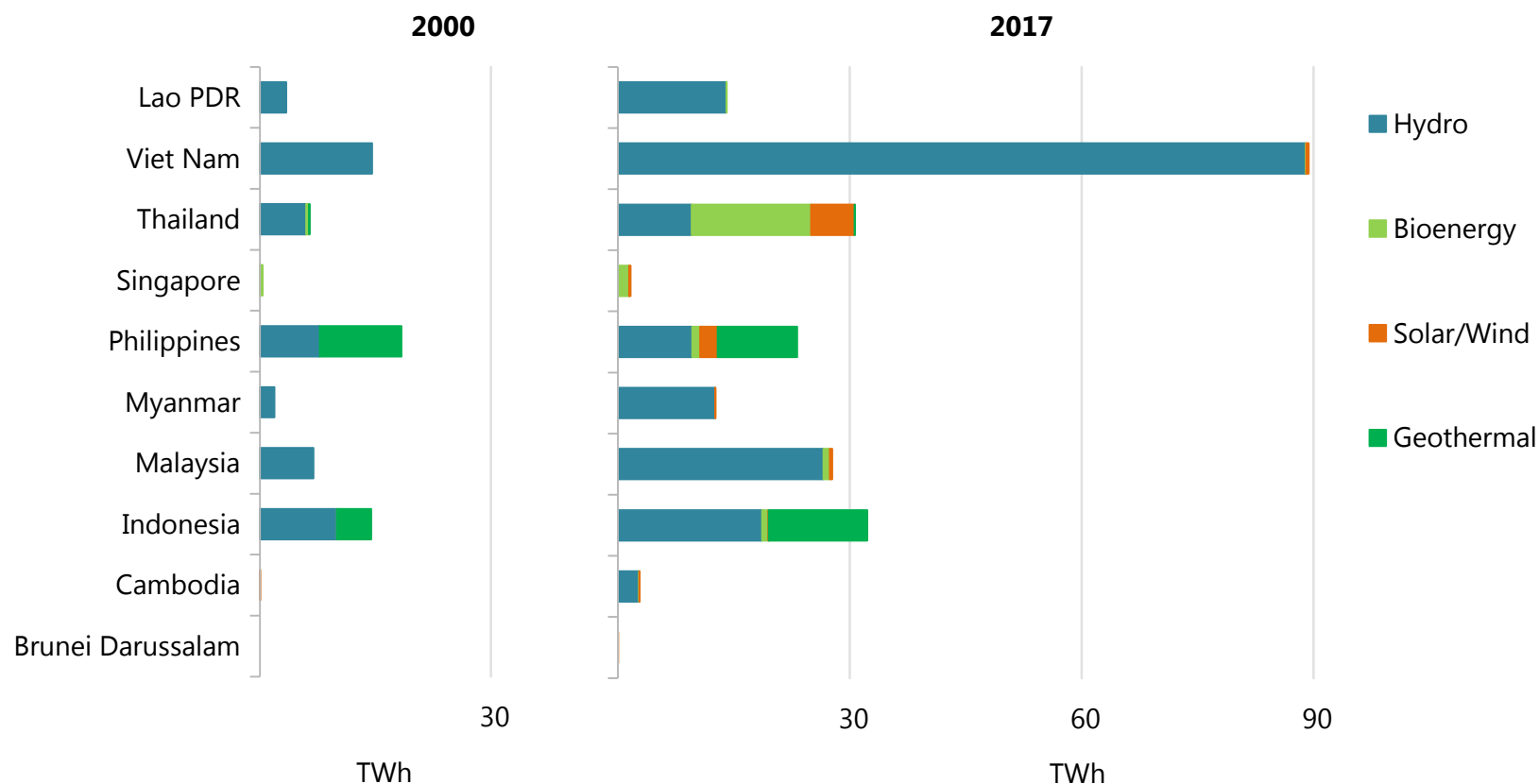
Power generation mix and shares by fuel in Southeast Asia, 2000-18



Notes: TWh = terawatt-hours. Other renewables include solar PV, wind, geothermal and modern use of bioenergy.

Hydropower has dominated the expansion of renewables-based power. There is significant potential across a portfolio of other renewable technologies

Electricity generation from renewable energy sources in Southeast Asia, 2000 and 2017



Notes: TWh = terawatt-hours. Data for Lao PDR are 2015.

Signs of progress with access to electricity and regional electricity co-operation, but also some unfinished business

Electricity consumption growth in Southeast Asia has been among the world's fastest at 6% per year since 2000. The expansion in demand has been largely met by a rise in coal-fired power generation, followed by natural gas and hydropower.

Millions of new consumers in the region have gained access to electricity since 2000, yet some 45 million people in the region are still without electricity today. The share of oil in the region's power mix has fallen sharply, although some communities in remote areas often still use diesel generators to generate electricity.

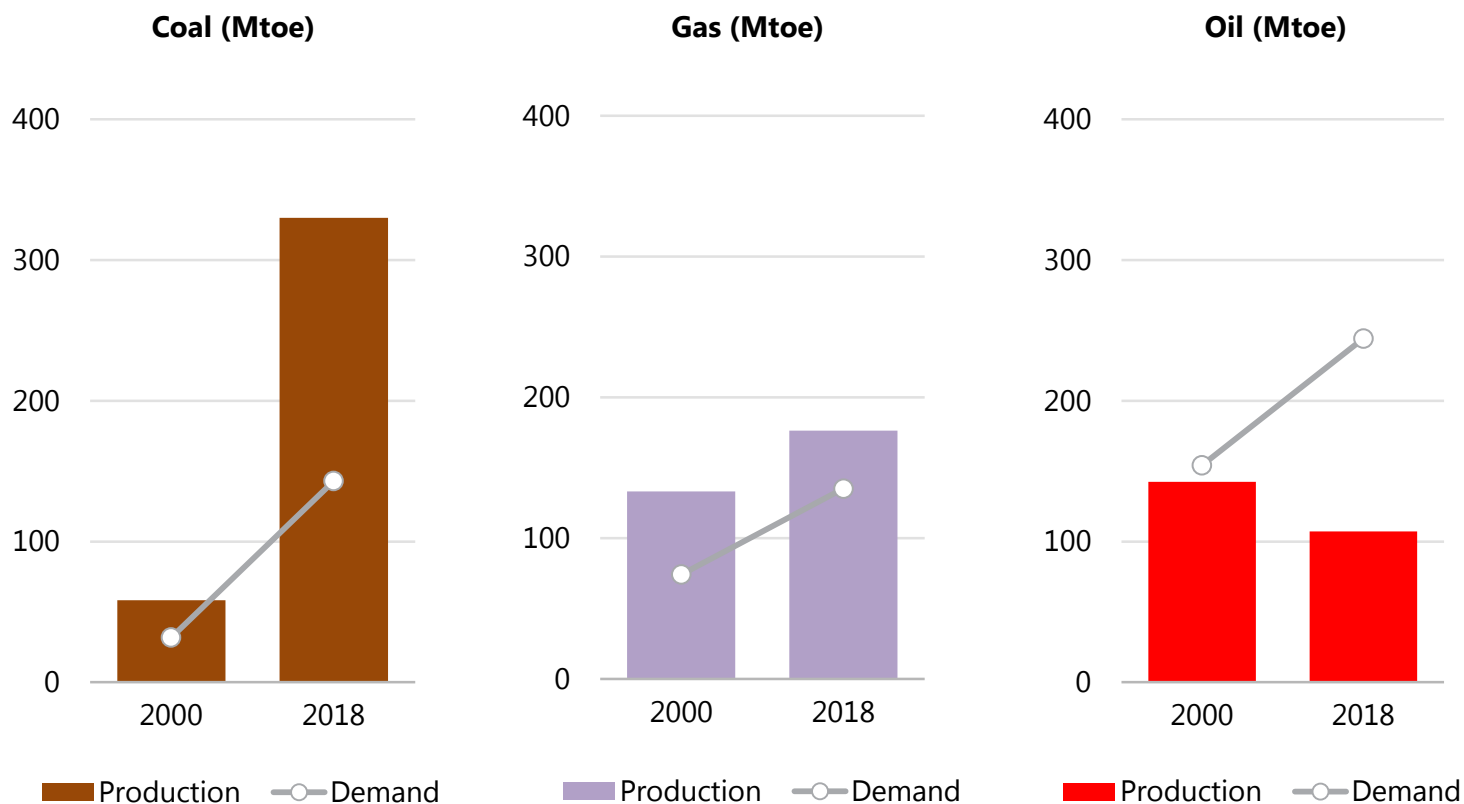
A range of fuels, technologies and approaches are likely to be required to achieve full electricity access. The most appropriate route depends on local resource availability and circumstances, such as population density and distance from the existing grid. But a common theme across the region is the way that falling costs for renewables are opening new doors for cost-effective access, especially where there is high reliance on costly diesel-based options or where grid extension would be very expensive (IEA, 2018).

Most power systems in Southeast Asia are structured as single-buyer markets with generation mostly from large-scale coal- and gas-fired power plants. Electricity from renewables has been led by an expansion of hydropower in the Greater Mekong Subregion, Indonesia and Malaysia, geothermal in Indonesia (one of the world's leading markets for this resource) and bioenergy in many areas. The vast potential of solar PV and wind is only starting to be tapped.

The resilience of electricity networks and level of system integration are major factors in shaping the region's power sector. Regional system integration can be a powerful enabler for the uptake of renewables; it smooths the balance between electricity demand and supply by allowing for aggregation of resources, power system assets, and available flexibility options over a larger geographical area (see Regional power trading in Southeast Asia section, slides 137-159). While network integration has high-level support through the ASEAN Power Grid and other initiatives, significant progress would be needed in power system operations and investment frameworks to foster broader electricity system integration.

Most of the rising fossil fuel needs, with the notable exception of oil, were met by indigenous production...

Change in fossil fuel supply and demand in Southeast Asia, 2000-18



Note: Mtoe = million tonnes of oil equivalent.

... but Southeast Asia is now on the verge of becoming a net-importer of fuels

A growing imbalance between rising demand and stagnant or falling production is gradually pushing Southeast Asia towards becoming a net-importer of fossil fuels.

Over the past two decades, an overall increase in the production of fossil fuels has kept aggregate volumes ahead of demand growth. However, the gap between demand and regional output has widened for oil, while recent market dynamics suggest that the production surplus for natural gas may slip in the next few years.

Oil production in Southeast Asia has gradually edged downwards over recent years, as new investment and field development – especially since the downturn in oil prices in 2014 – have not kept pace with natural production decline from more mature producing areas. Considered alongside rising demand, this pushed net import needs of the region up to more than 4 million barrels per day (mb/d) in 2018.

Turning to natural gas, Malaysia (7% of global exports), Indonesia (8%) and Brunei (3%) were all significant exporters of liquefied natural gas (LNG) in 2018. However, despite a strong overall expansion of gas production by

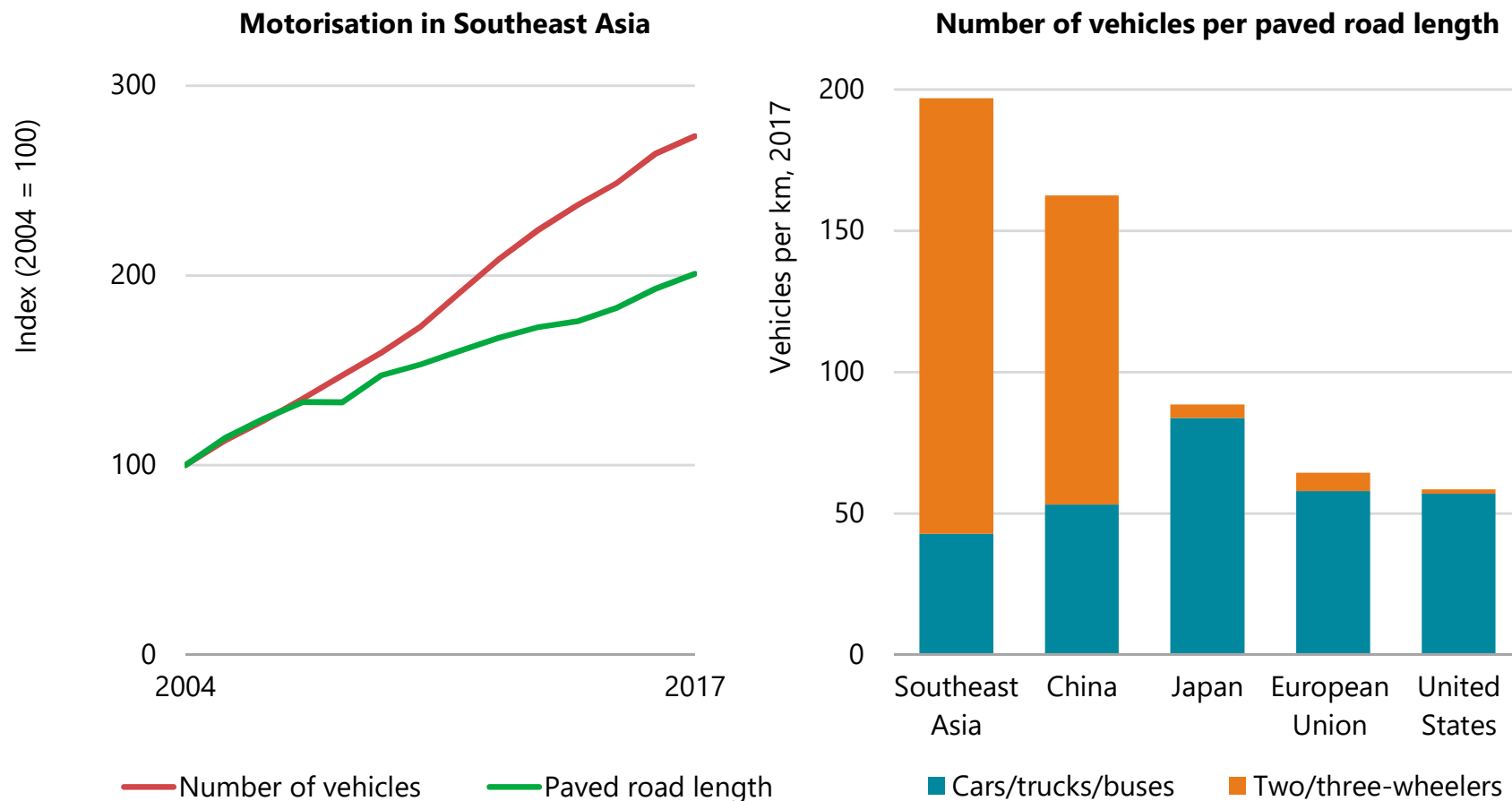
more than 30% since 2000, a correspondingly strong increase in demand has dragged down the regional gas export surplus.

Coal production remains robust, at well above 400 million tonnes of coal equivalent (Mtce), with the majority from Indonesia, where it serves as a primary export good that helps to ease a widening account deficit. However, there are considerable uncertainties over future export opportunities, especially to China and India, and Indonesia's rising domestic demand is gradually creating a wider gap between the pace of growth in production and export surplus.

Overall, these trends point to Southeast Asia becoming a net-importer of fossil fuels in the next few years. An overall regional surplus of supply over demand of 120 million tonnes of oil equivalent (Mtoe) supply in 2011 eroded by three-quarters to just above 30 Mtoe in 2018.

Focus on mobility: Southeast Asia's roads are crowded, mostly with two/three wheelers

Indicators for vehicle ownership and road network growth in Southeast Asia and selected countries

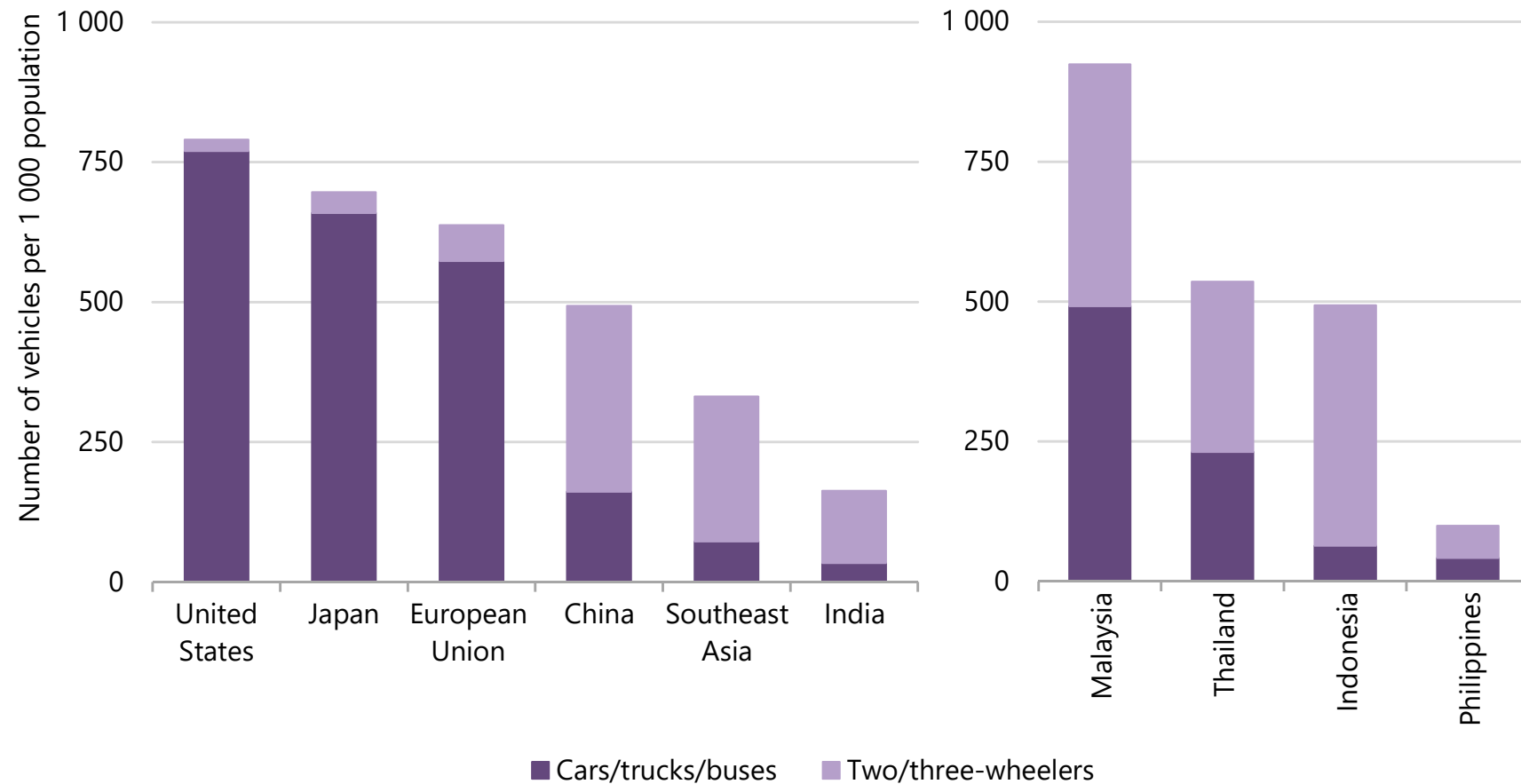


Notes: Number of vehicles per paved road length is not the sole factor for road congestion, which is also related to road width, type of road, time of use, annual average mileage, vehicle ownership rates in urban areas and other factors.

Sources: IEA analysis; European Union Road Federation (2017).

There is ample scope for growth in car ownership

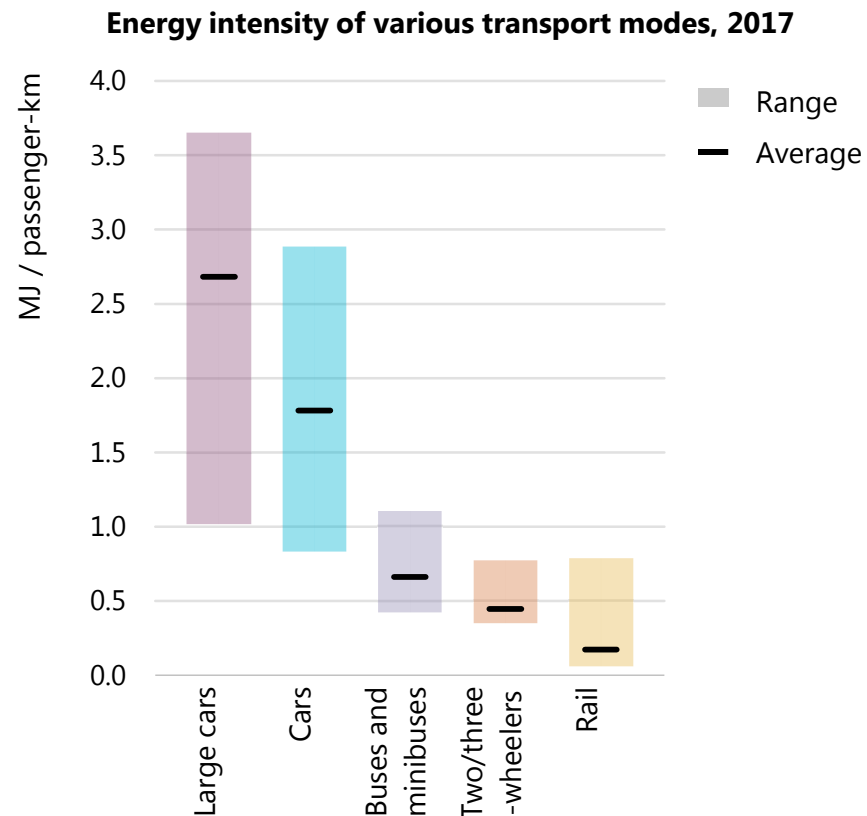
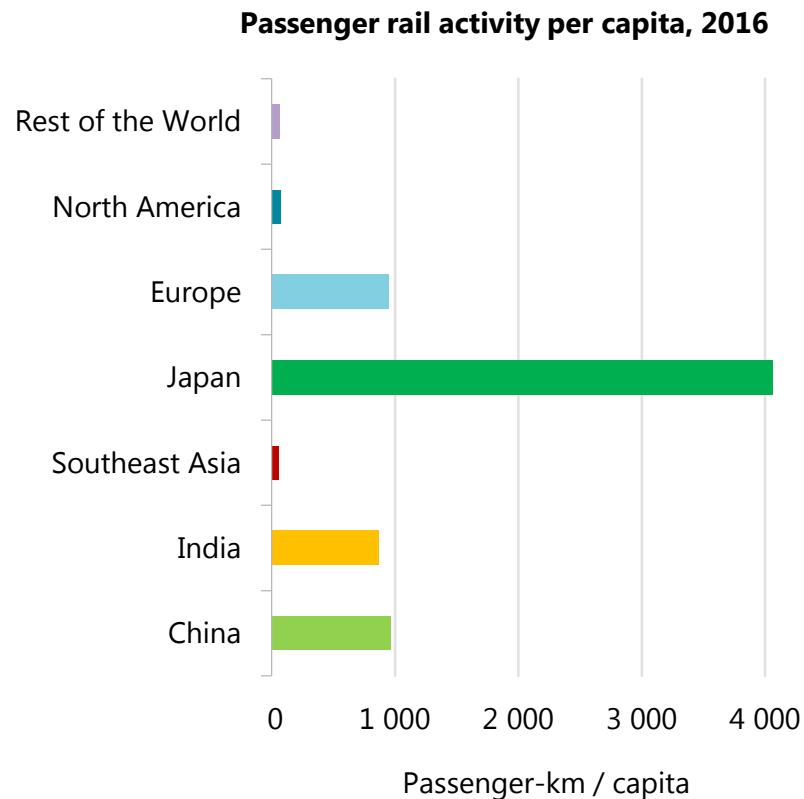
Vehicle ownership in Southeast Asia and selected countries, 2017



Sources: The ASEAN Secretariat (2018); IEA analysis.

More road than rail activity in Southeast Asia

Passenger rail activity per capita for selected countries and energy intensity of various transport modes



Note: Passenger-km = passenger kilometre; MJ = megajoule.

Source: *The Future of Rail*, IEA (2019a).

Fuel efficiency standards, electric mobility and mass transit systems are under-developed

The expansion of vehicle ownership in Southeast Asia reflects an increasingly road-based pattern of mobility in Southeast Asia, as alternatives in the form of mass transit and electrified transport are relatively underdeveloped.

However, in most parts of the region expansion of the road network has not kept pace with the rising number of vehicles. As a result, the region's reliance on driving has created some of the world's heaviest traffic and boosted emissions of pollutants that worsen urban air quality. Rising fuel consumption is also pushing up oil imports, with implications for energy security.

The high level of vehicle penetration in Southeast Asia relative to road capacity is possible because motor vehicles consist mainly of small two-wheelers (motorcycles, scooters) and three-wheelers (auto rickshaws), which together represent almost 80% of total annual vehicle sales. Nearly all (99%) have combustion engines, whereas in China more than 50% of two/three-wheelers are electric.

The level of car ownership in Southeast Asia is low on a per-capita basis, suggesting that with further economic development, and without stronger measures to steer

commuters towards alternative options, the congestion crunch may worsen. Moreover, despite improvements in fleet fuel performance, the lack of specific fuel efficiency standards for vehicles may continue to put upward pressure on oil demand.

In some cities, metro rail systems aim to facilitate more sustainable mobility (e.g. Bangkok, Manila, Singapore and recently Jakarta). Construction of such large-scale infrastructure requires considerable time, as well as political and financial capital, but can bring major dividends for the cities in question.

Ride-sharing services, such as Go-Jek in Indonesia, have sprung up to provide new mobility options, taking advantage of spare capacity by private operators and helping to address "last-mile" gaps, i.e. movement from a transportation hub to a final destination, that can often undermine interest in new rail and transit projects in areas with less mature public transport networks.

Factors shaping the energy outlook

Macroeconomic trends and challenges for sustainable growth (42-47)

Private and public sector roles in Southeast Asia's energy transition (48-51)

Selected energy policies in Southeast Asian countries (52-54)

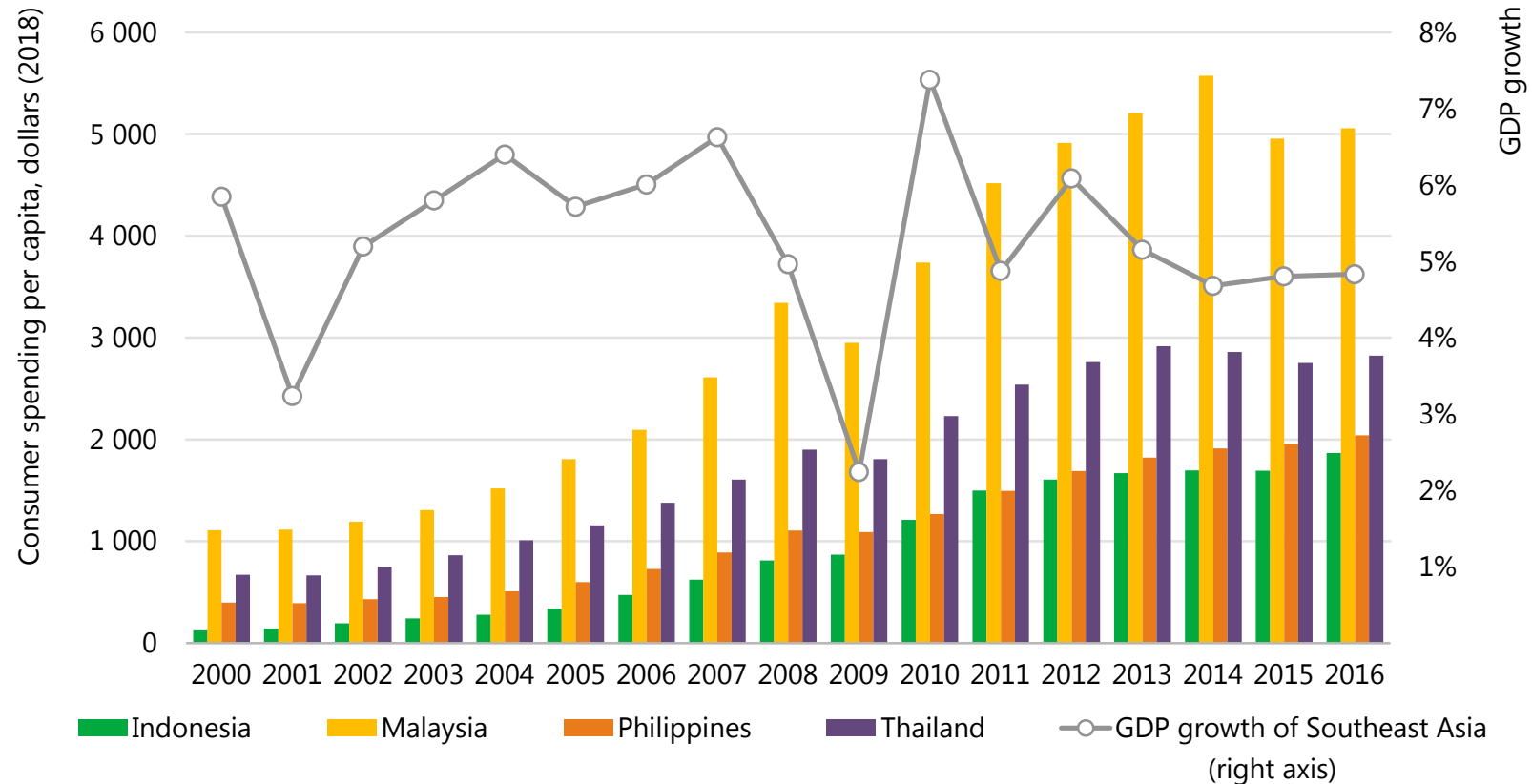
Seven key factors shaping the Southeast Asia energy outlook

The projections for energy to 2040 in this report are shaped by seven key factors. Some of these are held constant between the scenarios, such as the assumptions for economic and demographic growth. Other factors vary by scenario, notably energy policies, pricing and regulation, and their impact on investment, financing, energy security and environmental outcomes.

- **Economic trends and rising incomes:** How will economic growth and the role of foreign direct investment evolve? What type of consumption patterns will characterise the expanding middle class and how will this translate into spending on appliances, vehicles and other energy-consuming goods?
- **Demographics and urbanisation:** How will the influx of people into towns and cities be managed and what will this mean for energy use?
- **Air quality, climate risks and environmental degradation:** How will countries respond to the threat of climate change and risks to human health from poor air quality? How will concerns about waste and water quality be manifested?
- **Access, affordability and energy security:** How will the availability, affordability and performance of various energy sources and technologies evolve? Will universal energy access be achieved? How will countries react to the prospect of increased reliance on imported energy?
- **Investment and financing:** Will energy investments attract sufficient and attractively priced capital? What role will public and private sources play? What risks, such as financial sustainability, may affect the bankability of projects?
- **Energy policies, pricing and regulation:** What energy strategies, such as pathways to meet Nationally Determined Contributions or to reduce distortions in energy pricing, will guide energy decision making? What policies and regulations will be implemented to achieve these strategies?
- **Project economics:** How will technology costs, in particular those of clean energy technologies, evolve and how quickly will these project-level shifts be felt in regional trends for investment and energy use?

With rising incomes, a new consumer class is emerging

GDP growth in Southeast Asia and consumer spending per capita for selected countries, 2000-16

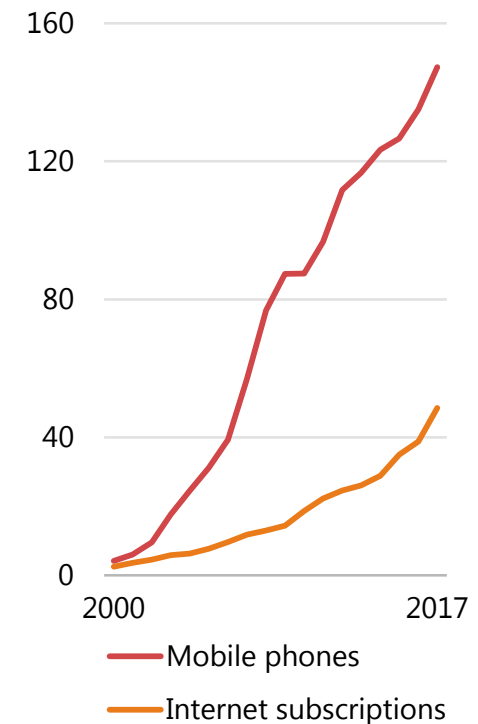
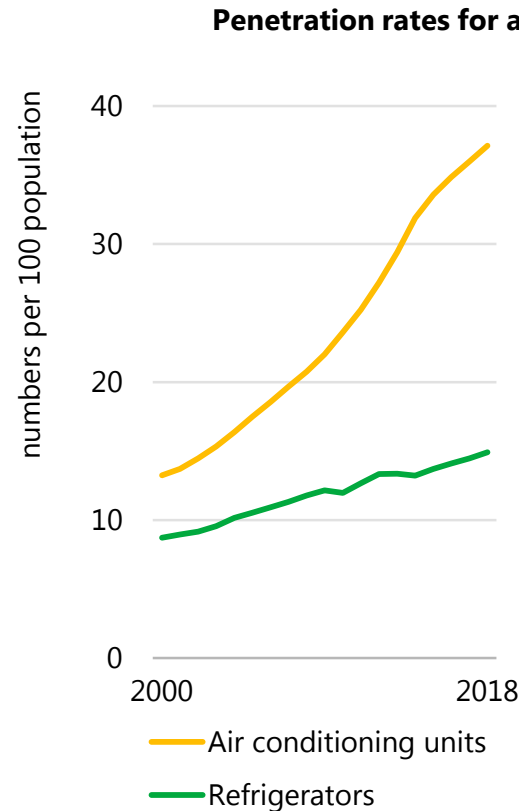
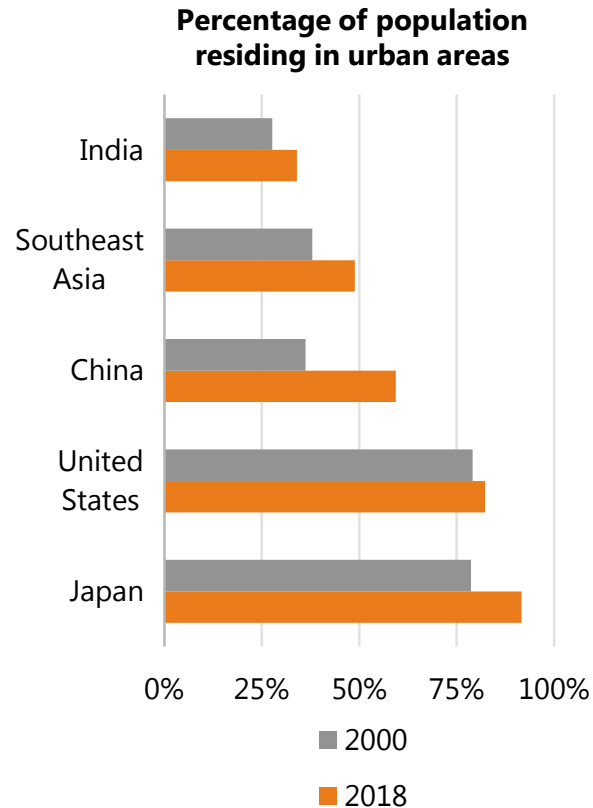


Note: GDP = gross domestic product (\$2018, PPP).

Sources: United Nations Statistics Division (2019); IEA analysis.

Urbanisation and ownership trends are accelerating

Share of population in urban areas and ownership rates of selected devices in Southeast Asia



Sources: The ASEAN Secretariat (2018); IEA analysis.

Economic and demographic trends are pushing energy needs higher

In Southeast Asia, annual economic growth has averaged around 5-6% over the past two decades. The trends have varied by country and over time, but rising incomes have spurred dramatic increases in consumer spending, e.g. expanding almost five-times in Malaysia and more than quadrupling in Thailand since 2000. Conditions have also improved for many consumers at the lower end of the income spectrum.

Southeast Asian countries are also experiencing rapidly increasing urbanisation levels, as people migrate to take advantage of higher paying industrial and service job opportunities. In 2018, nearly 50% of Southeast Asia's population lived in urban areas, compared with below 40% in 2000. While the influx has been swift, there remains large scope for higher levels of urbanisation as Southeast Asia is still below levels in advanced economies.

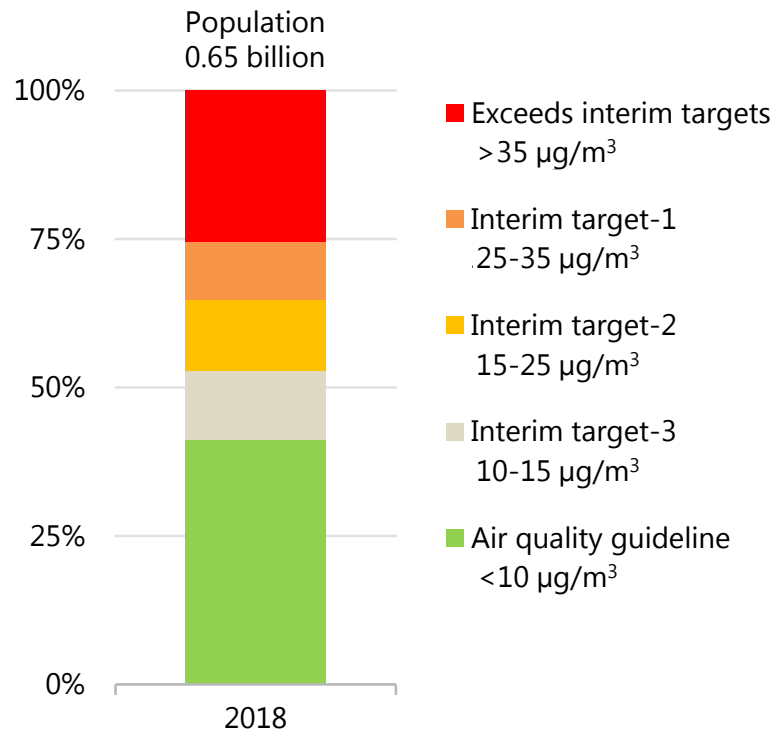
These factors have pushed up demand for conveniences and technologies that are increasingly part of the fabric of modern society. Over the past two decades, air conditioner ownership – a strong driver of both overall and peak electricity demand – has tripled in Southeast Asia, while mobile phone and internet subscriptions have soared.

Faced with these pressures, policy makers across Southeast Asia are intensifying their efforts to ensure that energy is a spur, rather than a hindrance, to the region's advancement. This includes action to remove obstacles to investment in energy supply while also focusing on demand-side measures. If a well-managed, sustainable and affordable expansion of energy supply can be achieved, the potential prize in terms of improved welfare and quality of life for the region's population is huge.

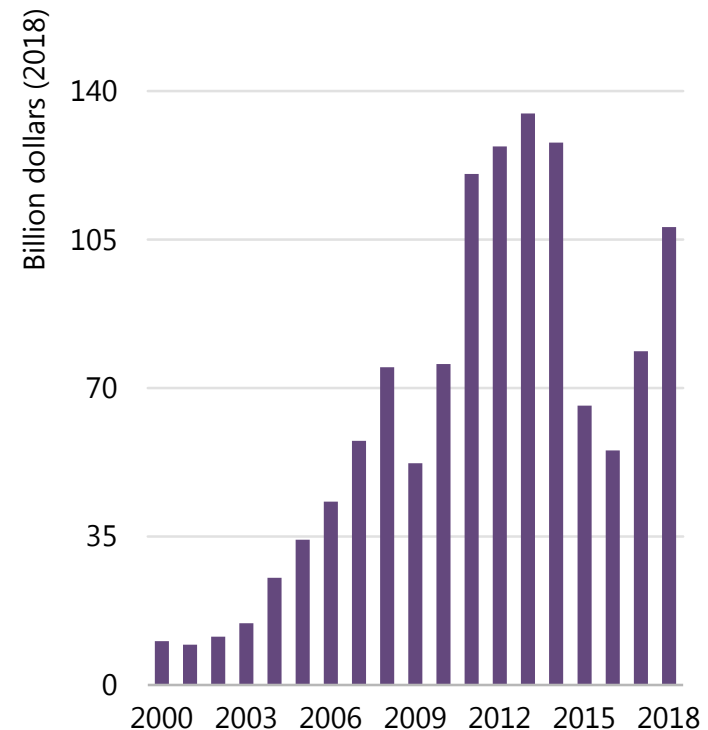
Today's consumption patterns are increasing risks to public health and the balance of payments

Population exposed to different levels of fine particulate matter and value of net oil imports in Southeast Asia

Population exposed to different levels of PM_{2.5}



Value of net oil imports



Notes: PM_{2.5} = particulate matter with a diameter of less than 2.5 micrometres; µg/m³ = micrograms per cubic metre. Interim targets and Air Quality Guideline refer to World Health Organization exposure thresholds.

Sources: International Institute for Applied Systems Analysis; IEA analysis.

The response to energy demand pressures has come with significant costs

Southeast Asia's response to rising energy demand pressures to date has focused mainly on increasing fossil fuel supply and, in some cases, on shielding consumers from abrupt rises in prices. While this response has supported consumption without increasing the burden for consumers, it has also come with significant societal costs.

Coal use for power generation, oil consumption for transport and traditional use of biomass for the residential sector are the main energy-related sources of pollutant emissions that cause poor air quality. In Southeast Asia, around 80% of the population are exposed to levels of fine particulate matter that exceed the lowest World Health Organization interim target.

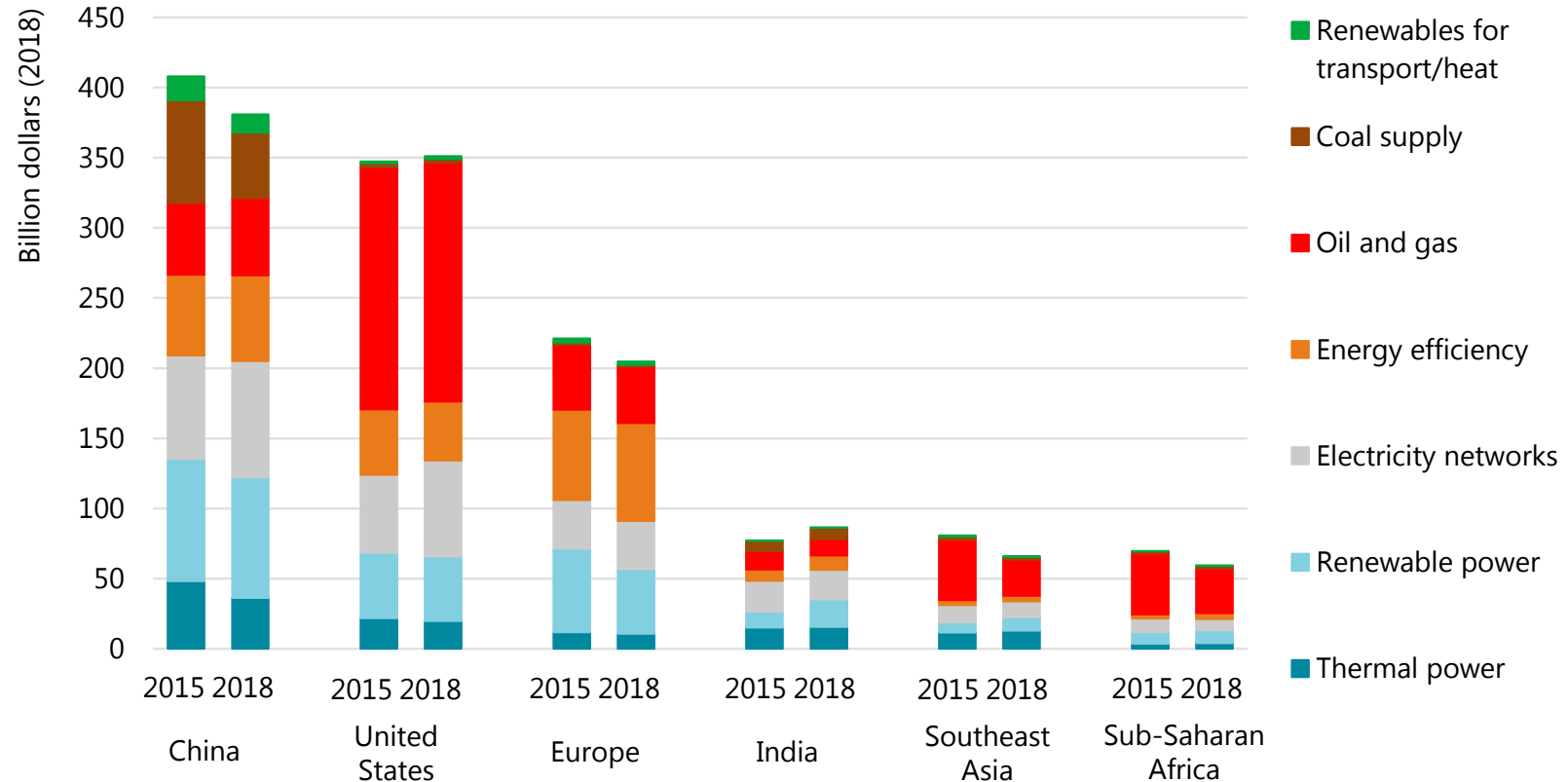
In addition to the local pollution effects of the current energy pathway, strong growth in fossil fuel consumption has led to a doubling of regional energy-related CO₂ emissions in the past two decades, contributing to global risks of climate-related impacts.

Another cost of fossil fuel dependence is visible in rising reliance on imports and higher import bills. The cost of oil imports has risen since 2000 by a factor of ten to over USD 100 billion in 2018. This sum has fluctuated considerably in line with international market prices, and volatility has also put pressure on national budgets in cases where prices are held below international market levels.

To safeguard security of supply, most Southeast Asian countries rely on industry stockholding obligations or operational stocks held by national oil companies to mitigate the impact of potential oil disruptions. Indonesia and Thailand are evaluating the option to establish government-held reserves. Energy security would also be served by diversifying the energy mix to bring in a greater share of indigenous renewable energy resources, in tandem with improved energy efficiency.

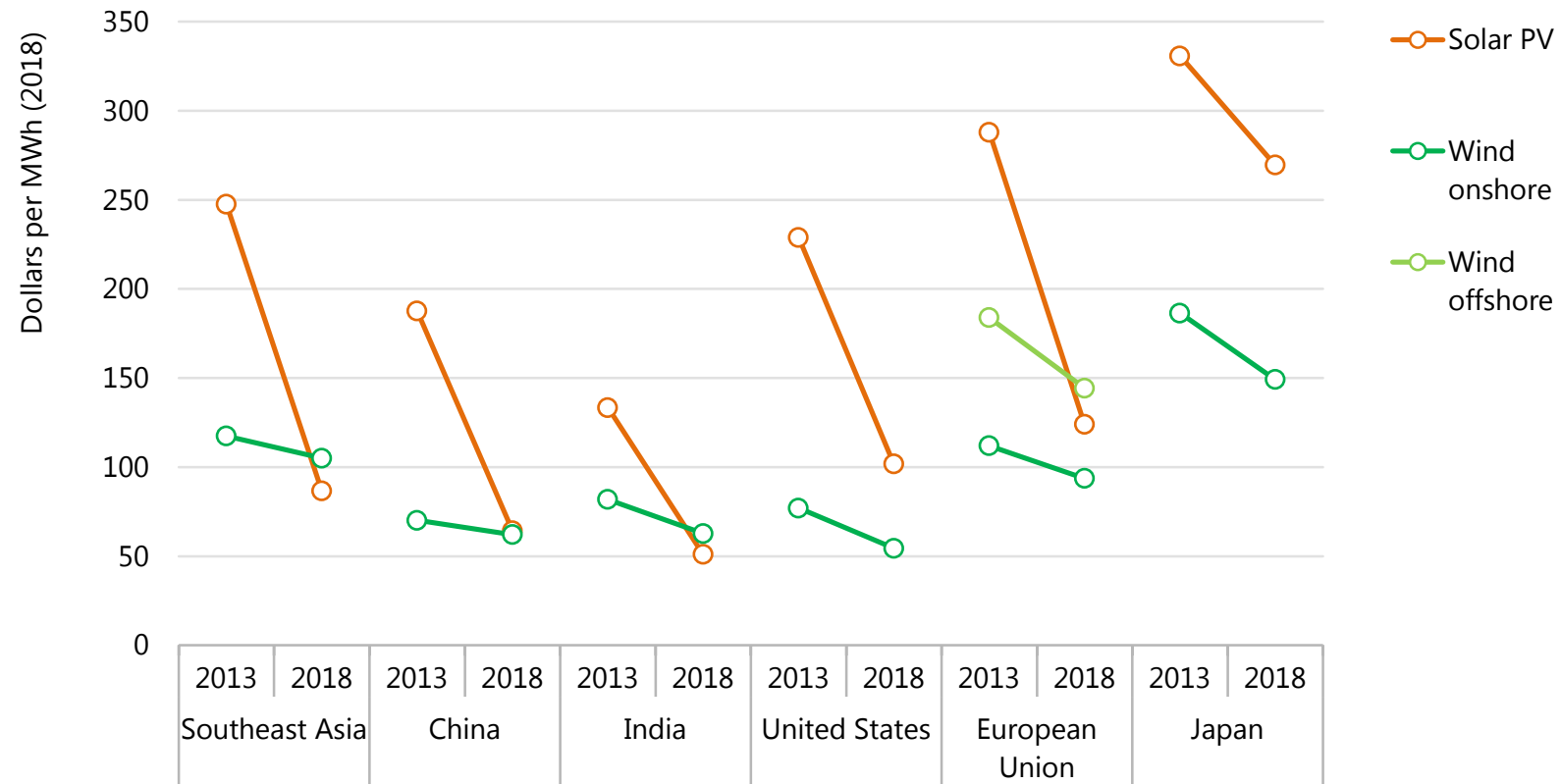
Energy investment has trended downwards in Southeast Asia

Energy investment in selected countries and regions, 2015 and 2018



Falling costs are expanding opportunities for renewable electricity

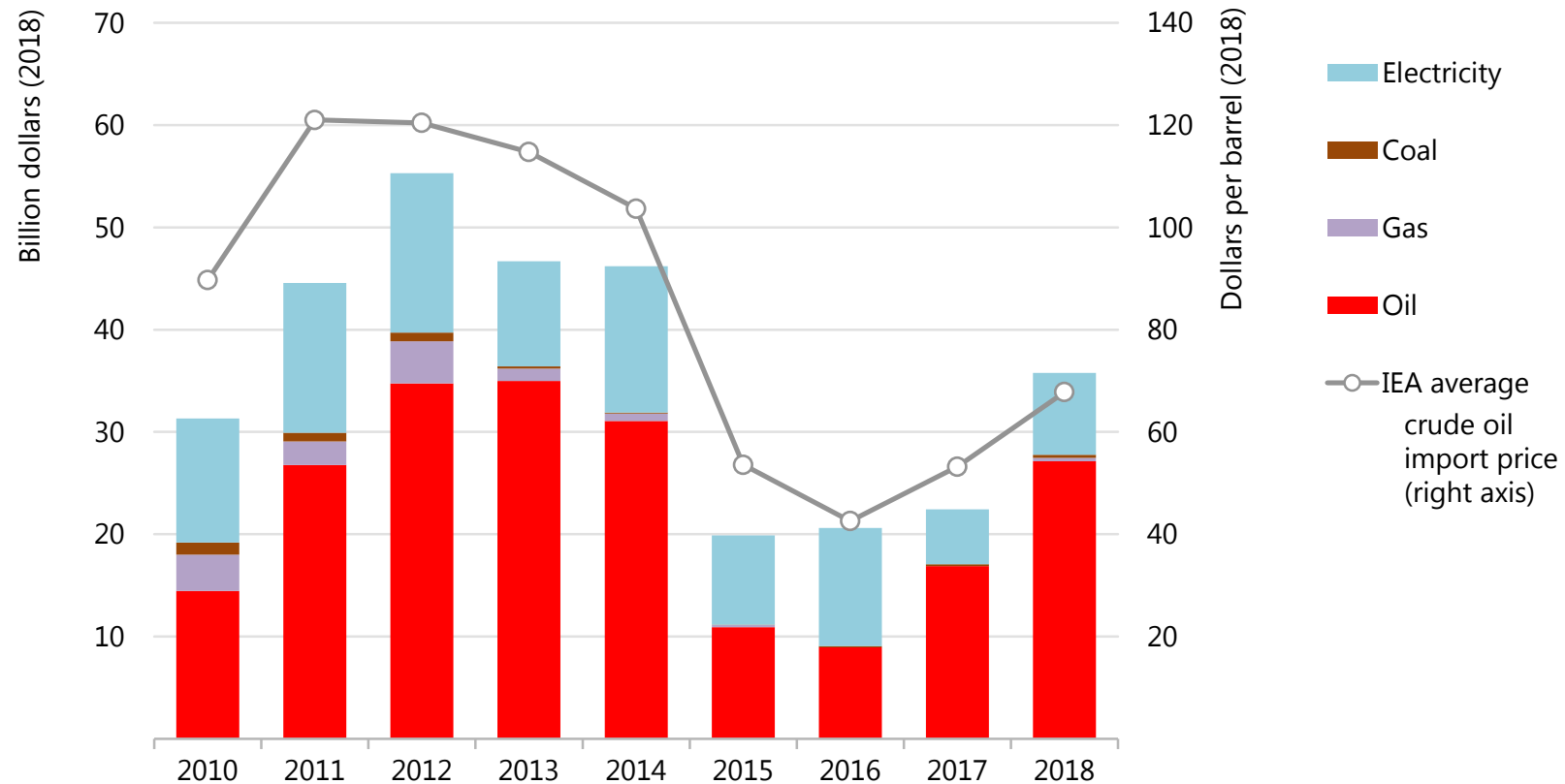
Levelised cost of electricity in selected regions and countries, 2013-18



Notes: MWh = megawatt-hour. Economic life time of solar PV and wind is assumed to be 25 years.

Pricing regulations continue to distort energy choices and burden state budgets, despite some improvements

Fossil fuel consumption subsidies in Southeast Asia, 2010-18



Policies are critical in determining the volume and type of investments

Meeting Southeast Asia's energy needs and policy priorities will depend on mobilising higher levels of investment. Recent trends suggest only slow progress in achieving these aims. Since 2015, energy investment in the region is down almost one-fifth. In India, also a fast-growing market in Asia, investment is up by 12% over the same period.

Most of the decline in investment in Southeast Asia since 2015 stemmed from lower spending on oil and natural gas supply; this was partially offset by an increase in investment in the power sector. However, overall energy investment as a share of both population and economic output are low on an international basis (see Investment in Reliable, Sustainable and Affordable power section, slides 160-190). In addition, there has been insufficient attention to demand-side investment, with efficiency accounting for only around 6% of total energy investment.

Mobilising investment requires broad participation from the private sector, as well as the targeted use of public funds. Attracting adequate capital at an affordable cost of finance will be contingent on addressing the risks that affect the bankability of projects. To this end, the level of policy commitment and implementation towards meeting long-term goals and strategies is critical.

In the power sector, there are signs that falling costs are mobilising investment in new renewable capacity. For example, the levelised cost of electricity (LCOE) in Southeast Asia has declined by 65% for solar PV over the past five years, which has stimulated deployment in some countries.

One framework issue that continues to distort decision making and the relative competitiveness of various energy sources is the presence of subsidies that shield purchasers from underlying changes in international energy prices. Despite some recent improvements from reforms and lower fuel import costs, Southeast Asian governments provided around \$35 billion in fossil fuel consumption subsidies in 2018, equivalent to nearly 0.5% of GDP.

Achieving long-term energy security and sustainability goals depends on getting the prices right and having predictability and stability in sectoral frameworks. For capital-intensive technologies and enabling infrastructure (e.g. electricity grids, transport systems), governments play a critical role in setting clear long-term targets, backed by measures that help to reduce risks and the cost of capital.

Selected energy policies in Southeast Asian countries

Country	Sector	Policies and targets
Brunei Darussalam	Efficiency	Reduce total energy consumption by 63% from BAU levels by 2035.
	Renewables	Achieve 10% of electricity generation from renewables by 2035.
	Climate change	Reduce CO ₂ emissions from morning peak-hour vehicle use by 40% from BAU level by 2035.
Cambodia	Electrification	Electrification for all villages by 2020 and 70% electrification for households by 2030.
	Renewables	Increase hydropower capacity to 2 241 megawatts by 2020.
	Climate change	Reduce GHG emissions 27% from baseline emissions by 2030 with international support.
Indonesia	Electrification	Achieve electrification ratio of 99.7% by 2025.
	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% by 2020 and 29% by 2030 from BAU levels, and 41% by 2030 with international support.
Lao PDR	Electrification	Achieve electrification rate of 98% by 2025.
	Efficiency	Reduce final energy consumption by 10% from BAU level.
	Renewables	Achieve 30% share of renewables in primary energy supply by 2025.

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

Notes: BAU = business-as-usual. GHG = greenhouse gases.

Selected energy policies in Southeast Asian countries (continued)

Country	Sector	Policies and targets
Malaysia	Efficiency	Promote energy efficiency in the industry, buildings and residential sectors with methods of standard setting, labelling, energy audits and building design.
	Renewables	Increase capacity of renewables to 2 080 MW by 2020 and 4 000 MW by 2030.
	Transport	Introduce 100 000 electric vehicles by 2020 with 125 000 charging stations.
	Climate change	Reduce GHG intensity of GDP by 35% by 2030 from 2005 level, increase to 45% reduction with enhanced international support.
Myanmar	Electrification	Achieve electrification rate of 80% by 2030.
	Efficiency	Reduce primary energy demand by 8% by 2030 from 2005 level.
Philippines	Electrification	Achieve 100% electrification by 2022.
	Efficiency	Reduce energy intensity 40% by 2030 from 2010 level.
		Decrease energy consumption by 1.6% per year by 2030 from baseline forecasts.
	Renewables	Triple the installed capacity of renewables-based power generation from 2010 level to 15 GW by 2030.
Climate change	Reduce GHG emissions by 70% from BAU level by 2030 with the condition of international support.	

* Notes: MW = megawatts. BAU = business-as-usual. GHG = greenhouse gases.

Selected energy policies in Southeast Asian countries (continued)

Country	Sector	Policies and targets
Singapore	Efficiency	Improve energy intensity by 35% by 2030 from 2005 levels.
	Renewables	Increase solar PV capacity to 350 MW by 2020 and 1 GW beyond 2020.
	Climate change	Reduce GHG emissions by 16% below BAU level by 2020, stabilise emissions with the aim to peak around 2030.
Thailand	Efficiency	Reduce energy intensity by 30% by 2036 from 2010 level.
	Renewables	Increase share of renewables to 30% in total final energy consumption by 2036; increase share of renewables-based power to 36% in generation capacity and to 20% in generation by 2037. Increase share of renewables in transport fuel consumption to 25% by 2036.
	Transport	Increase to 1.2 million electric vehicles and 690 charging stations by 2036.
	Climate change	Reduce CO ₂ emissions from power sector to 0.283 kg CO ₂ in 2037 from 0.413 kg CO ₂ in 2018. Reduce GHG emissions by 20% from BAU level by 2030, increase to 25% with enhanced international support.
Viet Nam	Electrification	Ensure most rural households have access to electricity by 2020.
	Efficiency	Increase commercial electricity savings to more than 10% of total power consumption by 2020 relative to BAU.
	Renewables	Increase the share of non-hydro renewables-based generation capacity to 12.5% by 2025 and 21% by 2030.
	Climate change	Reduce GHG emissions by 8% by 2030 and by 25% from BAU levels with international support.

* Notes: MW = megawatts. GW = gigawatts. BAU = business-as-usual. GHG = greenhouse gases. kg CO₂ = kilogrammes of carbon dioxide.

Southeast Asia's energy prospects to 2040

Introduction: Southeast Asia's energy prospects to 2040

Our projections for Southeast Asia to 2040 start with the Stated Policies Scenario (STEPS), which outlines a pathway for the region that reflects today's policy frameworks and ambitions. We then explore the implications of this scenario for energy security, import bills and a range of environmental indicators.

Next is a discussion of the Sustainable Development Scenario, in which accelerated clean energy transitions put the region on track to meet goals related to climate change, universal energy access and air quality.

The energy projections in this *Outlook* are highly sensitive to underlying assumptions about economic growth and demographic trends — the principal drivers of demand for energy services in most countries. Based on projections from the International Monetary Fund and others, we assume that the region's GDP grows at 4.4% per year between today and 2040, compared with the 5.2% per year achieved since 2000. The region's population is assumed to grow from 650 million in 2018 to almost 770 million in 2040. The share of this population living in urban areas expands from just under half today to more than 60% in 2040.

The first in the series of *Southeast Asia Energy Outlook*, *World Energy Outlook Special Reports* was in 2013. What did the 2013 edition project for 2018? How does it differ from the most recent data for what actually happened?

In the New Policies Scenario (predecessor of the Stated Policies Scenario) from the 2013 edition, we projected that Southeast Asia would use around 685 million tonnes of oil equivalent (Mtoe) of energy in 2018. In practice the latest estimate for the region is slightly higher, at around 700 Mtoe. The region used more bioenergy and hydropower than projected and less natural gas, but most projections (including coal, oil and other renewables) were very close to the actual outcomes.

This represents a warning sign. The outcomes represented by the Stated Policies Scenario to 2040 are by no means set in stone, but they do represent a distinctly possible future for the region. This outcome can be redirected towards a more secure and sustainable future, but this requires concerted exercise of policy leadership to avoid some of the pitfalls that lie ahead.

Stated Policies Scenario

Overview (58-62)

Electricity (63-67)

End-use sectors (68-76)

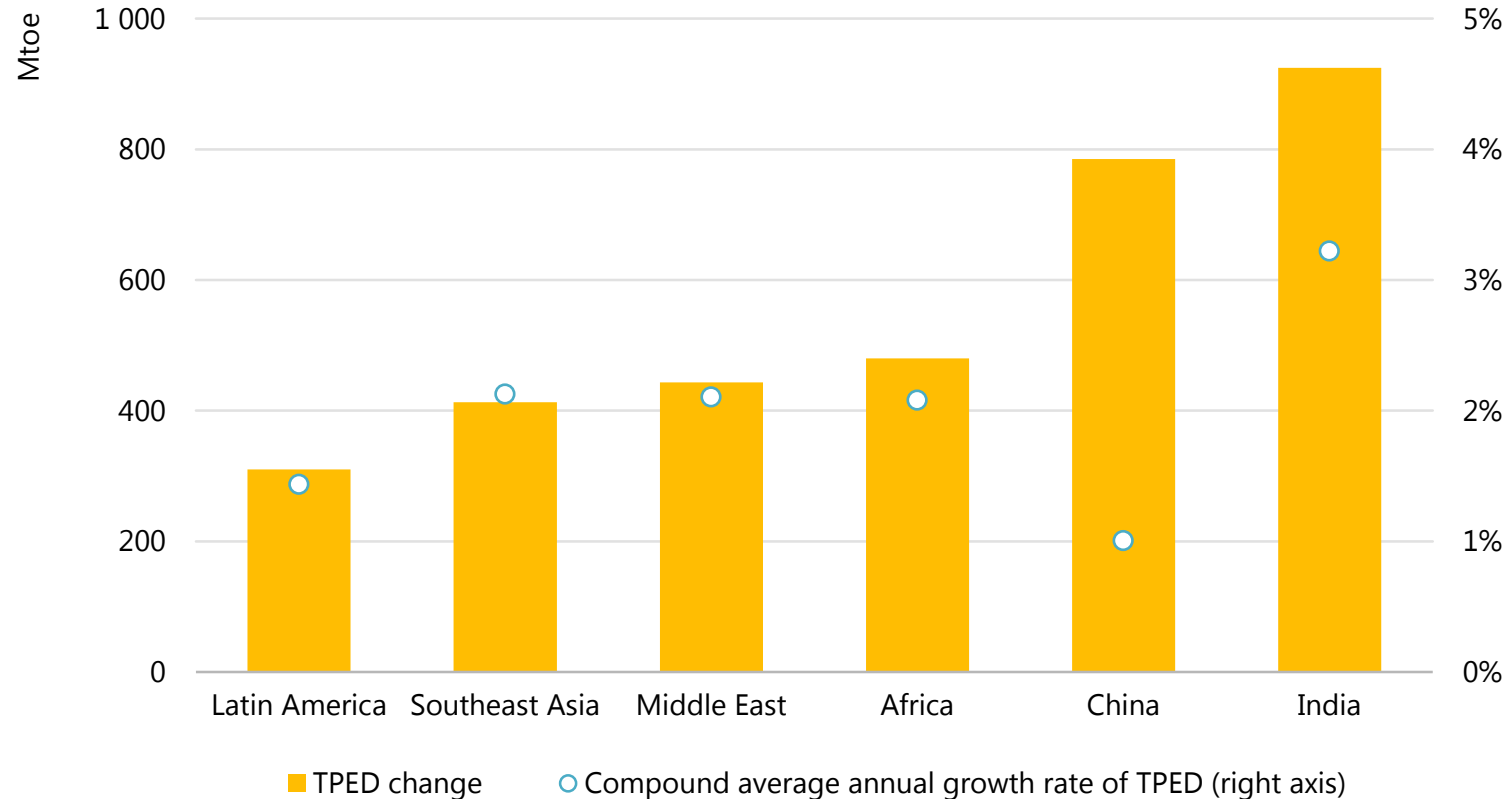
Oil and natural gas (77-87)

Coal (88-91)

Renewables (92-96)

With rising incomes and population, Southeast Asia contributes strongly to growth in global energy demand

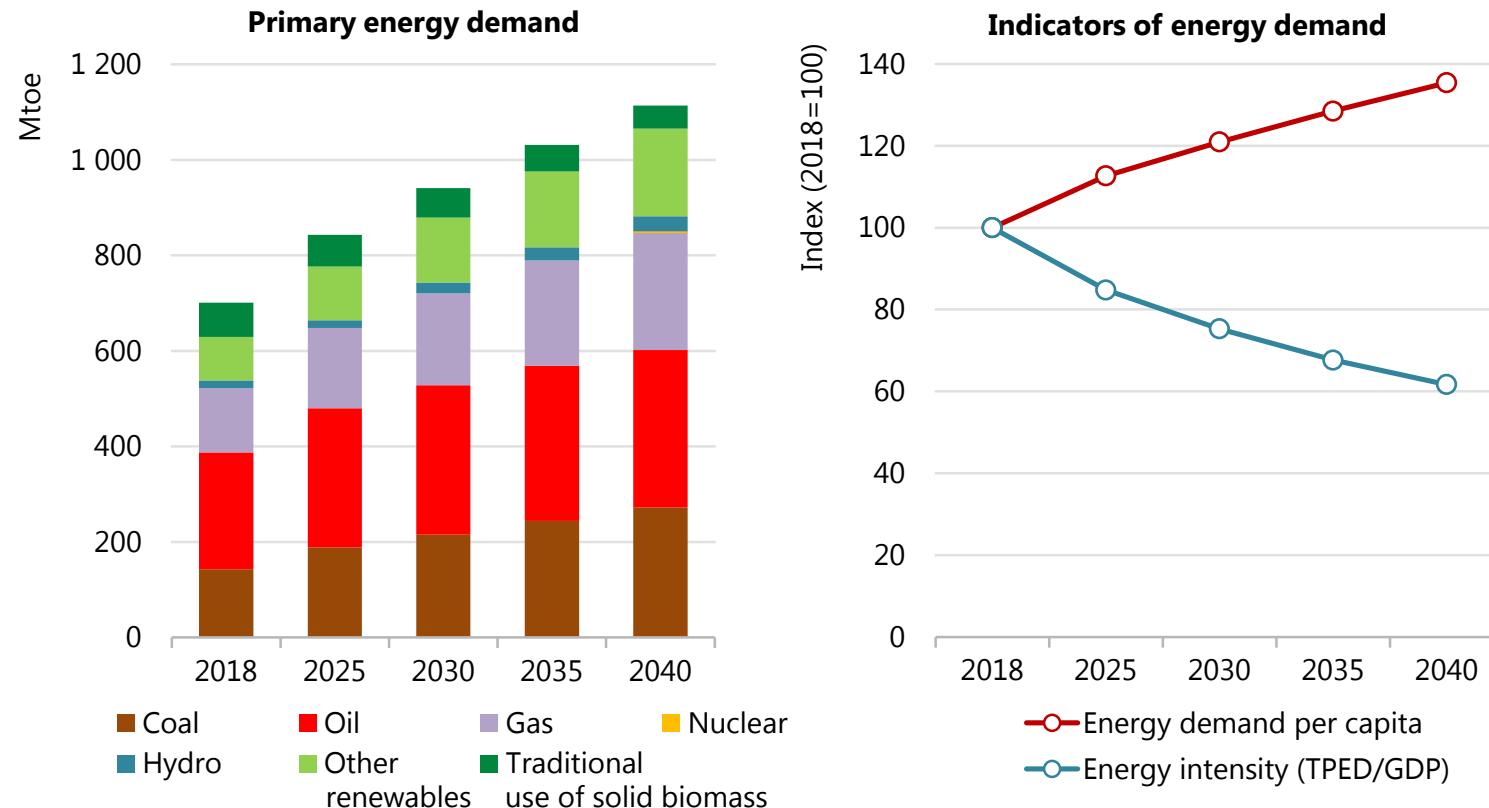
Change in total primary energy demand in selected regions in the Stated Policies Scenario, 2018-40



Note: Mtoe = million tonnes of oil equivalent; TPED= total primary energy demand.

Southeast Asia mobilises all fuels and technologies to meet its energy needs

Primary energy demand in Southeast Asia in the Stated Policies Scenario



Notes: Mtoe = million tonnes of oil equivalent; TPED= total primary energy demand; GDP = gross domestic product (\$2018, power purchasing parity [PPP]).

Other renewables include solar photovoltaics, wind, geothermal and modern use of bioenergy.

With today's policy plans and ambitions, Southeast Asia's expanding energy system remains strongly dependent on fossil fuels

The Stated Policies Scenario reflects the direction that Southeast Asia's energy system is heading, based on our assessment of the policies that have been implemented or announced by governments, including the Nationally Determined Contributions under the Paris Agreement. In this scenario, the region's primary energy demand grows by 1.6- times to 1 110 Mtoe by 2040.

This expansion contributes 12% of total global demand growth through to 2040. While Southeast Asia's growth is about a half of India and China in absolute terms, its average annual growth rate, at over 2%, is the second-highest after India and on par with Africa and the Middle East.

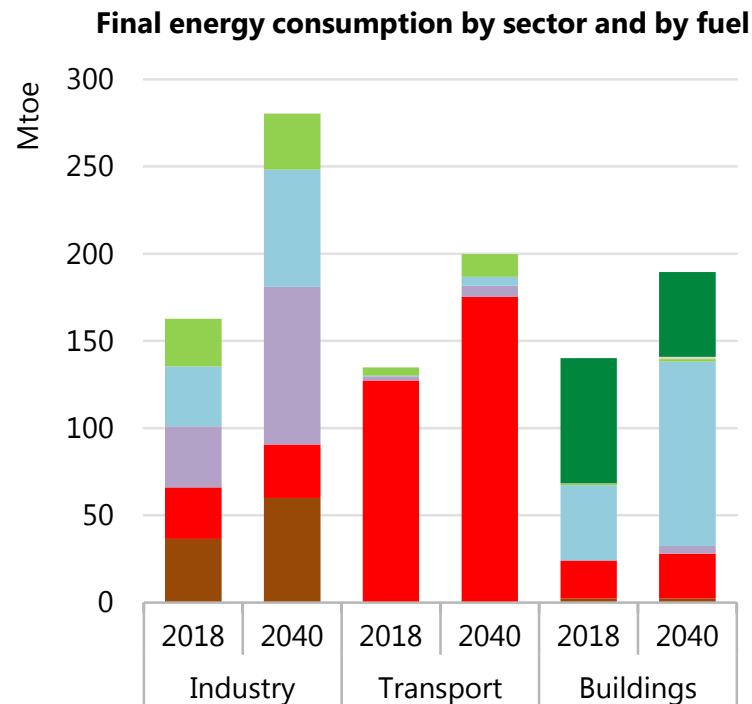
Primary energy demand per capita increases by 35%, boosted by economic growth and rising living standards, coupled with an increase in urban population. However, per capita demand in 2040 remains almost 60% lower than that of advanced economies.

The growth rate of demand slows compared with that from the past two decades as the energy intensity of demand improves by nearly 40% to 2040. This stems from a structural economic shift towards less-energy intensive manufacturing and services sectors, as well as policies promoting more efficient use of energy. The region's energy intensity declines by over 30% from 2005 to 2025, exceeding the target set out in the ASEAN Plan of Action for Energy Cooperation (APAEC) for the period.

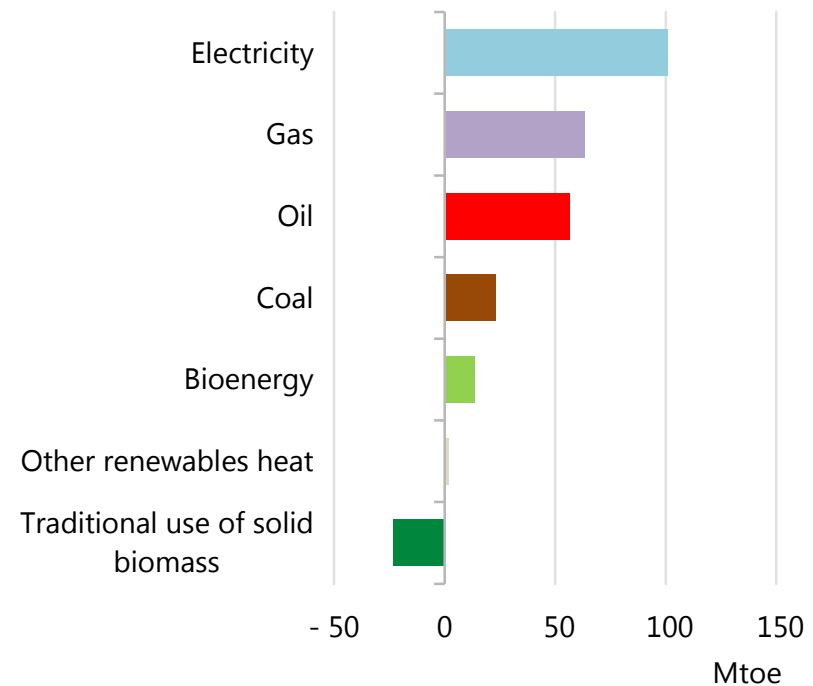
Overall, the energy demand increase is largely supported by fossil fuels, with coal, oil and gas meeting 80% of the growth. Fossil fuels still represent three-quarters of total energy demand in 2040. Despite rising in absolute terms, the share of renewables (excluding traditional biomass) in primary energy demand remains flat at around 15% to 2025, which falls well short of the APAEC target of 23%, before picking up toward 2040.

In the absence of stronger efforts to promote efficiency, consumption levels expand robustly across all end-use sectors...

Final energy consumption in Southeast Asia in the Stated Policies Scenario



Change in final energy consumption by fuel, 2018-40



■ Coal
 ■ Oil
 ■ Gas
 ■ Electricity
 ■ Bioenergy
 ■ Other renewables heat
 ■ Traditional use of solid biomass

Notes: Mtoe = million tonnes of oil equivalent. Other sector includes agriculture and non-energy use. Other renewables heat includes solar and geothermal consumed as heat in end-use sectors.

... with industry the main source of growth in final energy consumption

Total final energy consumption in the region increases by over 50% to around 680 Mtoe by 2040 in the Stated Policies Scenario, with all end-use sectors seeing notable increases. While there are strong increases in the direct use of oil and natural gas, the contribution of electricity rises particularly rapidly.

Energy consumption for industry sees the largest increase among end-use sectors, rising by over 70% to reach 280 Mtoe in 2040. Energy demand for manufacturing activities rises both in non energy-intensive industries such as automotive and electronics as well as in energy-intensive sub-sectors such as iron and steel and chemicals. Natural gas and electricity serve most of the projected energy demand growth in industry, though bioenergy makes an increased contribution.

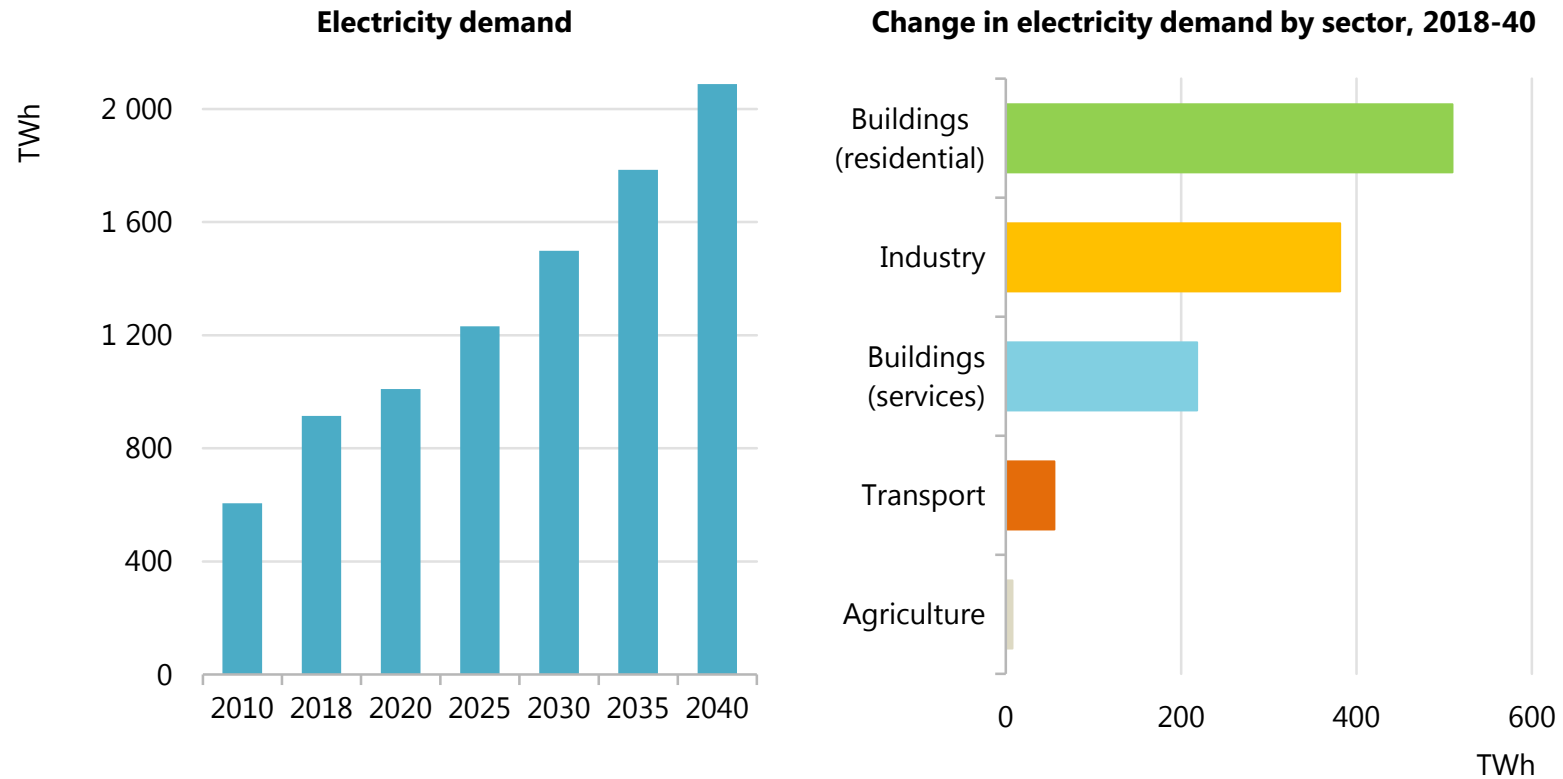
In the buildings sector, total final energy consumption increases by 35% to 190 Mtoe in 2040. Here the contribution of electricity rises the most, particularly in the residential sector, where urban households expand their use of appliances and cooling services, the efficiency of which has a big impact on the outlook. Improved access to electricity is another driver.

In the Stated Policies Scenario, three-quarters of the rise in electricity demand is met – in roughly equal shares – by coal-fired power generation, particularly in Indonesia, and by renewables.

Increased demand for mobility leads to a 50% boost to energy consumption for transport to 200 Mtoe in 2040. Most of this rise comes from road transport as vehicle ownership expands. Oil continues to be the dominant energy source, but biofuels play an increasing role, supported by blending standards in Indonesia and Thailand.

Electricity demand more than doubles to 2040...

Electricity demand in Southeast Asia in the Stated Policies Scenario



Note: TWh = terawatt-hours.

... as residential and industrial electricity use expands rapidly

Electricity demand in Southeast Asia grew at an annual average rate of over 5% from 2010 to 2018, twice the world average. Electricity demand doubles in the region in the next 20 years to 2 000 terawatt-hours (TWh), an annual growth rate of nearly 4%, also twice as fast as the rest of the world. The share of electricity in final energy consumption is 18% today, below the level in most other regions, but this share rises rapidly to 26% in 2040 and reaches the global average.

The buildings sector (residential and services) sees the largest growth in electricity use, increasing 2.5-times to over 1 200 TWh by 2040. 70% of the increase is from residential electricity demand which rapidly grows to overtake industry as the largest electricity end-user sector towards 2040.

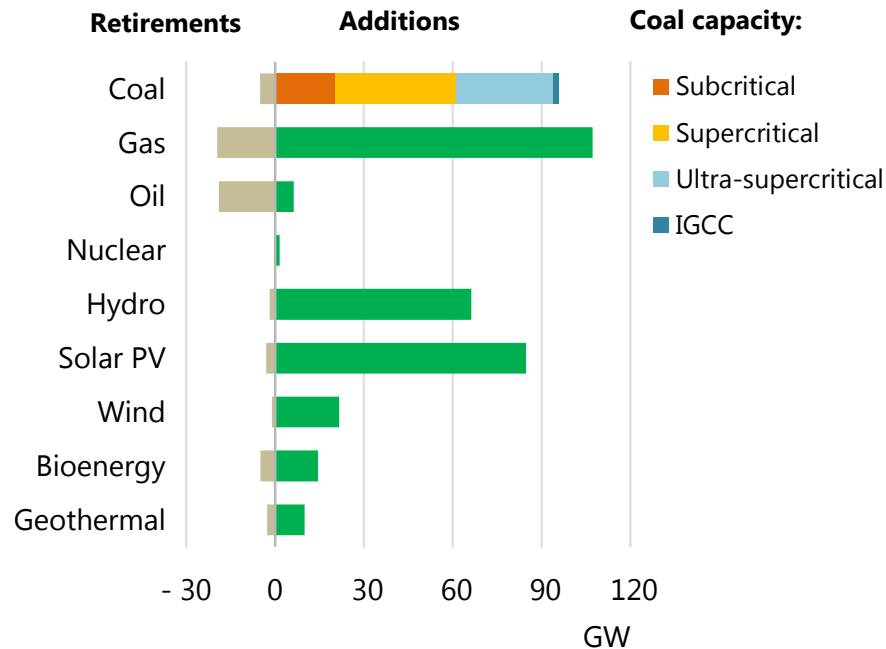
Industrial electricity demand doubles to 780 TWh by 2040. Two-thirds of this increase is attributed to non energy-intensive industries. Among energy-intensive industries, electricity demand in iron and steel grows most significantly, more than tripling, as production in electric arc furnaces (as well as blast furnaces) increases to meet expanding steel demand and to substitute for imported steel.

Electricity demand in transport grows by a factor of 16, albeit from a very low base. The share of electricity in the transport sector remains small at below 3%, only half the global average of 5% in 2040. Compared with other regions, policy support and deployment of electric mobility options, including railways and electric vehicles, remains quite limited.

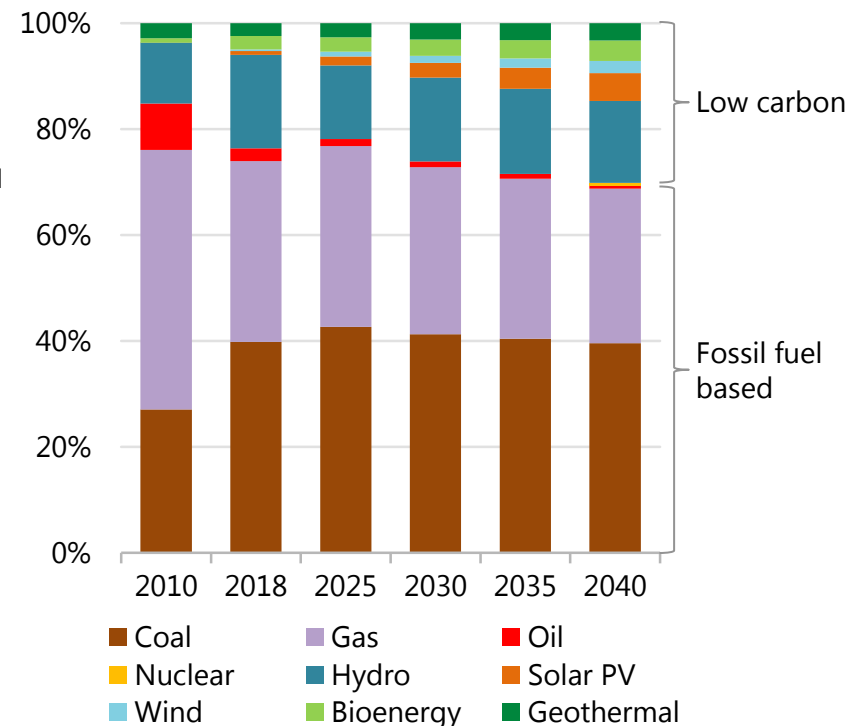
Based on today's policies and plans, coal is set to retain a strong position in the region's electricity generation mix...

Change in installed power capacity and share of power generation by technology in Southeast Asia in the Stated Policies Scenario, 2019-40

Change in installed power capacity by technology, 2019-40



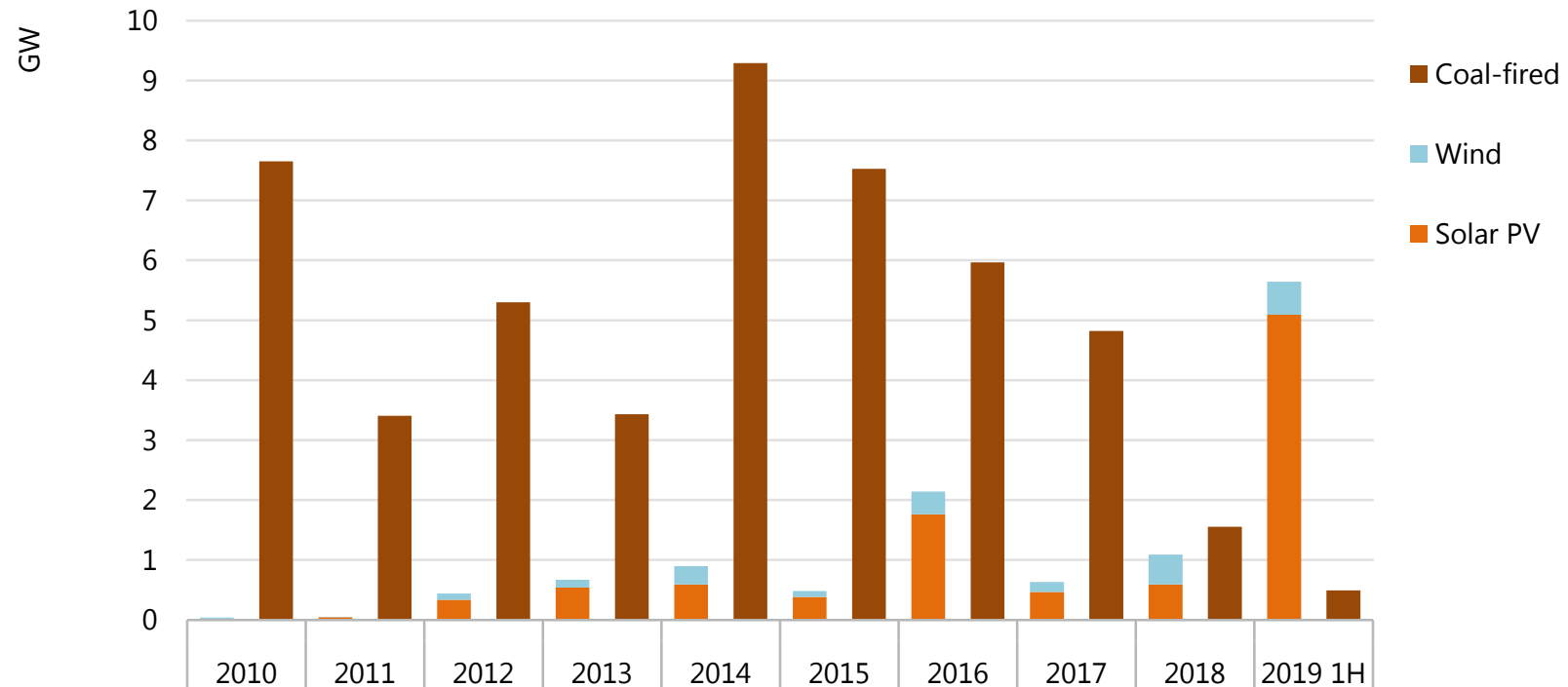
Share of power generation by technology



Note: IGCC = integrated gasification combined-cycle; GW = gigawatts; solar PV = solar photovoltaics.

... although lower final investment decisions for new coal-fired generation in 2019, along with a rise in solar additions, hint at an inflection point

Approved coal, solar PV and wind capacity additions in Southeast Asia



Note: GW = gigawatts; solar PV = solar photovoltaics; 2019 1H = first-half of 2019.

Sources: McCoy Power Reports (2019); BNEF (2019); IEA analysis.

Renewables are set to play a larger role in power systems, but without stronger policy frameworks they meet only around a third of the increase in power generation

Relatively low generation costs and indigenous supply priorities have traditionally supported a focus on coal in power sector planning. However, the declining costs of renewables and concerns over emissions and pollution are starting to alter this picture. There is a trend in some policy documents to boost the future share of renewables-based capacity and generation, and also to revise down the future share of coal.

- Thailand's 2018 Power Development Plan (PDP) anticipates a 7% share for coal-fired generation capacity in 2037, down from a 14% share in 2036 in the previous plan, while raising the share of renewables-based generation from 44% to 49% (with an additional 10 gigawatts (GW) of non-hydro renewables by then).
- Indonesia's Electricity Supply Business Plan 2019-2028 (RUPTL) raised renewables capacity additions to 16.7 GW from 14.9 GW in the previous ten-year plan. Hydro and geothermal power account for the majority of planned new renewables capacity.
- Viet Nam's revised 7th Power Development Plan (2016) lowered coal's share in planned installed capacity from near 52% to under 43% for 2030, with renewables at 38%, up from 25%. Solar capacity is planned at 12 GW for 2030.

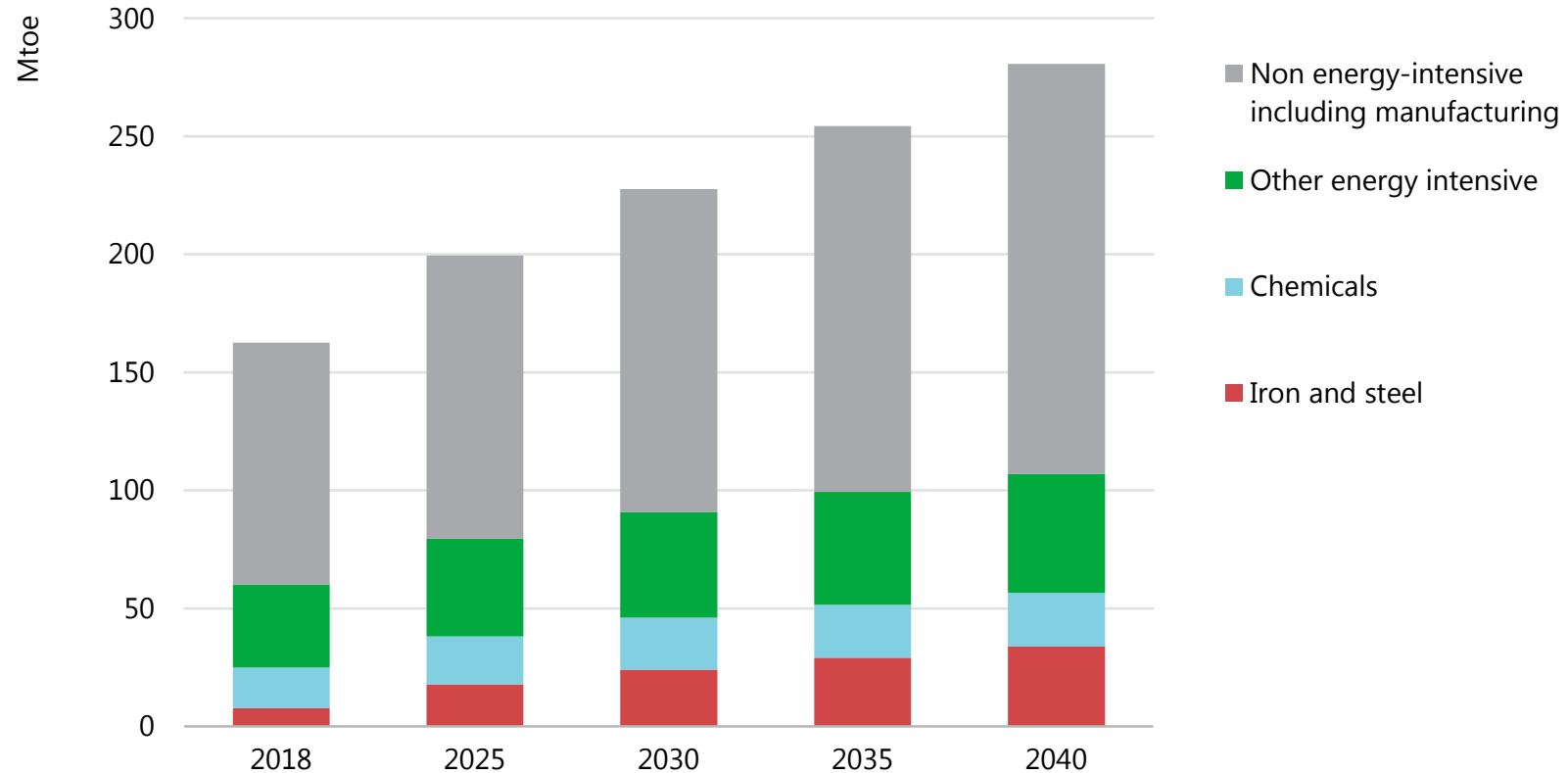
This shift in long-term planning is already visible in near-term project developments, with a significant slowdown in decisions to move ahead with new coal-fired capacity and a rise in additions of solar and wind. This means that approved coal-fired capacity is being supplanted by capacity additions of solar PV and wind for the first time.

Considering projects under construction and a measured assessment of currently planned additions means that coal continues to expand across much of Southeast Asia in the Stated Policies Scenario: net capacity additions of 90 GW mean that total coal-fired capacity reaches 165 GW by 2040. As a result, the share of coal-fired generation in the region remains broadly flat at near 40% over the next two decades – a contrast with most other parts of the world. The composition of these additions shifts towards more efficient technologies, but the capacity of the least efficient (and most polluting) subcritical fleet also expands, despite some anticipated retirements.

Policy support and increasingly attractive economics mean that renewables-based capacity in Southeast Asia increases by more than 180 GW to reach 250 GW by 2040, of which solar PV and hydropower make large contributions. However, without a stronger policy push, new generation from renewable sources covers only a third of the projected rise in total power output.

A flourishing manufacturing sector pushes up industrial energy demand

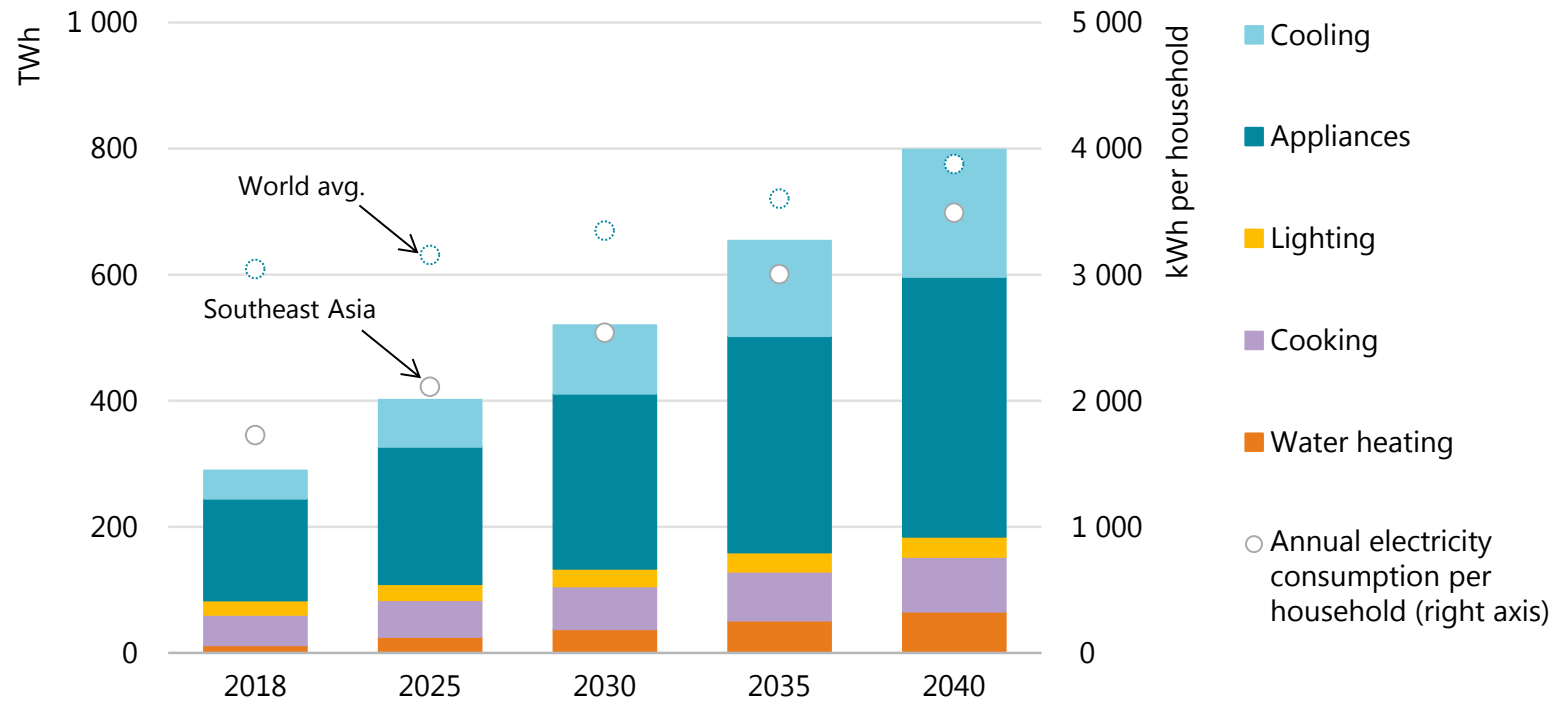
Energy consumption by industry sector in Southeast Asia in the Stated Policies Scenario



Notes: Mtoe = million tonnes of oil equivalent. Other energy intensive includes cement, paper and aluminum industries.

Rising household incomes translate into higher appliance ownership and demand for cooling

Residential electricity demand by end-use and annual electricity consumption per household in Southeast Asia in the Stated Policies Scenario



Note: TWh = terawatt-hours; kWh = kilowatt-hour.

There are strong underlying drivers for energy use in industry and buildings across Southeast Asia

In industry, energy consumption almost doubles by 2040 as the role of manufacturing increases in the region's economy. Energy-intensive industries (e.g. iron and steel, chemicals, cement, pulp and paper and aluminium) account for about 40% of the energy demand increase and non energy-intensive industries for about 60%. The level of demand growth is partly offset by energy efficiency improvements, which are encouraged in part by policies.

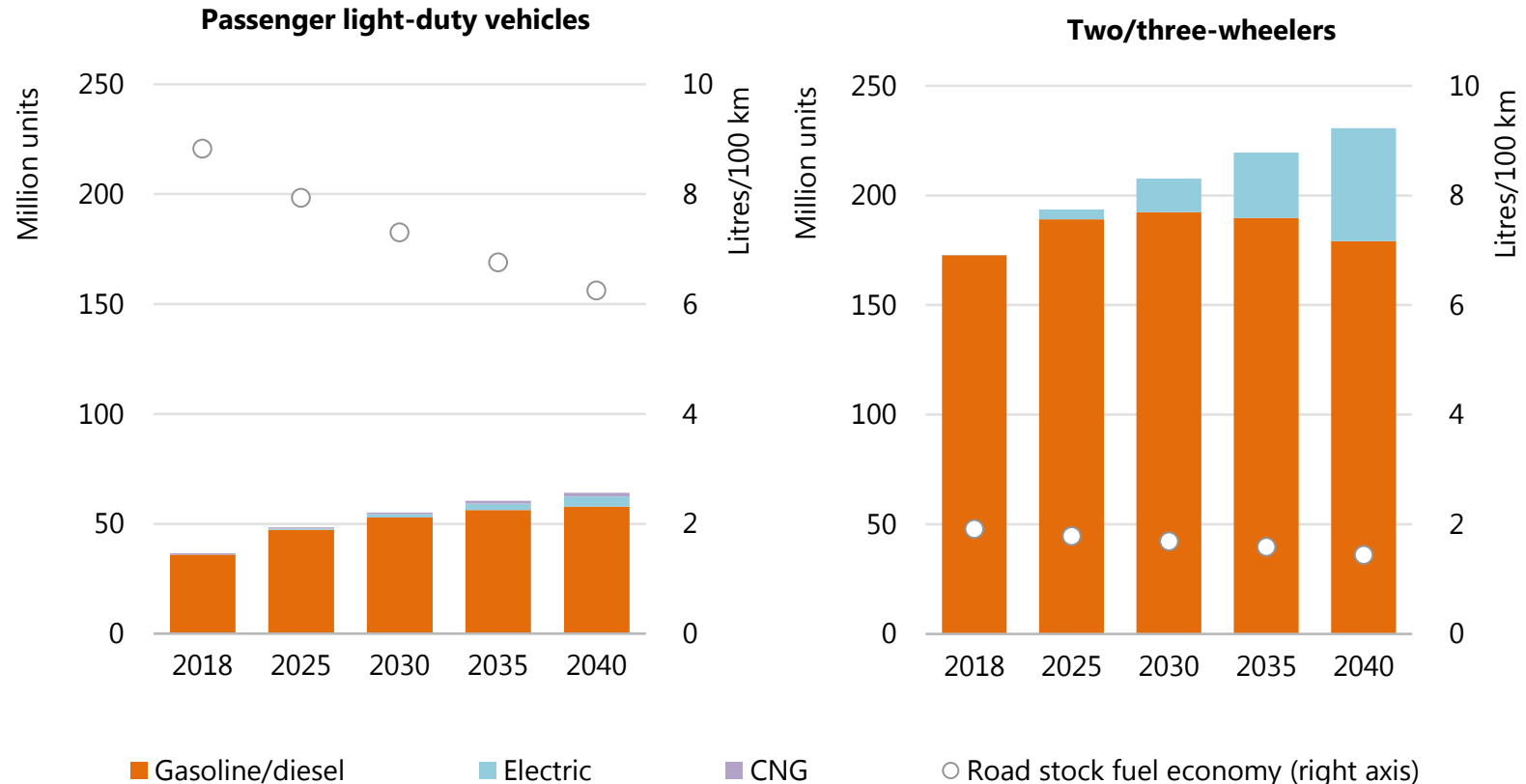
In the iron and steel sector, increasing demand for crude steel spurs construction of blast furnace plants and raises the sector's energy intensity (the energy used to produce 1 tonne of steel) by 35% from 2018 to 2040. Alongside the use of electric arc furnaces, the robust demand for steel in construction and manufacturing (e.g. automobiles) means that countries such as Viet Nam and Indonesia plan to expand blast furnace steel plants which use coking coal in the production process. In Viet Nam, which overtook Thailand as the region's largest steel consumer in 2015, a steel maker plans to almost quadruple its annual crude steel production in blast furnaces to over 25 million tonnes, equivalent to around one-third of the current production in the entire region.

In the buildings sector, increased electricity use drives up overall energy demand, meeting almost all the increase in the sector by 2040. The residential sub-sector accounts for three-quarters of the building sector energy demand as household electricity use triples, thanks to wider ownership of home appliances such as refrigerators, washing machines and air conditioners (see The Future of Cooling section, slides 121-136).

Coupled with the declining role of traditional use of bioenergy in cooking, the rapid growth of electricity boosts its share in the buildings sector energy mix to over half in 2040 from just above 30% today. The electricity consumption per household more than doubles to around 3 500 kilowatt-hours (kWh) per year, rapidly narrowing the gap with the world average by the end of the projection period.

Fuel efficiency improves and electricity starts to gain ground for two/three-wheelers...

Stock and fuel economy of road vehicles in Southeast Asia in the Stated Policies Scenario



Note: CNG = compressed natural gas; km = kilometres.

... but oil remains in the driving seat for transport

Road transport accounts for 90% of the sector's energy demand and over 80% of its increase to 2040. Two/three-wheelers continue to account for the majority of newly registered vehicles in the region (19 million in total by 2040) thanks to their affordability and convenience in manoeuvring through congested traffic in urban areas.

Rising incomes and urbanisation mean increased ownership of cars. Passenger light-duty vehicles (PLDVs) on the road increase by 75% to 64 million and 1-in-12 people owns a PLDV, compared with 1-in-18 today. This rate of ownership is still far below the projected world average (1-in- 4.5 in 2040).

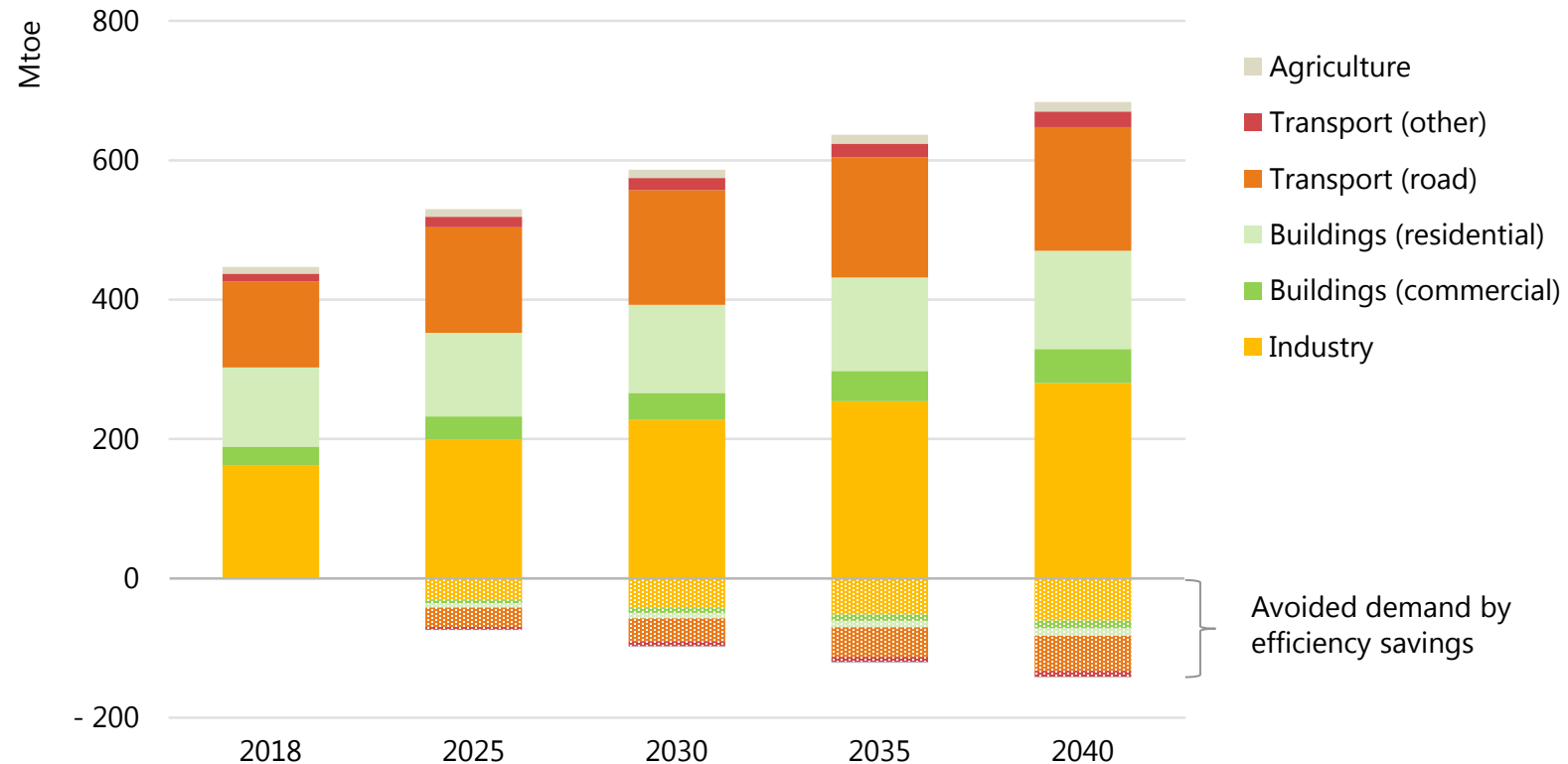
Petroleum products continue to serve as the dominant fuel for road transport, although biofuels, supported by blending mandates and targets in countries such as Indonesia, Thailand and Malaysia, increase to account for 7% of transport fuel needs by the end of the projection period.

Electrification of mobility is projected to make relatively limited inroads in Southeast Asia in this scenario, reflecting the limited policy and infrastructure support that has been announced thus far. The main impact is in a rising share of electric two/three-wheelers, particularly over the 2030-2040 timeframe. Some countries including Thailand, Malaysia and Philippines have established mid- to long-term electric vehicle targets that include these small vehicle classes.

Outside of road transport, aviation contributes to growth in transport energy demand (all fuelled by oil) during the projection period, with consumption more than doubling to meet a strong rise in passenger air transport.

Efficiency improvements constrain only a part of the rise in final energy consumption

Final energy consumption and energy savings by sector in Southeast Asia in the Stated Policies Scenario



Note: Mtoe = million tonnes of oil equivalent.

There is huge untapped potential for efficiency across Southeast Asia

The energy efficiency policies and measures in place, plus our assessment of the impact of announced intentions, keep energy demand around 20% lower in the Stated Policies Scenario in 2040, compared with a trajectory without these factors. Most of the avoided energy demand is in the industry and road transport sectors. The impacts of energy savings increase over time, as new efficiency measures gradually penetrate the market.

While the degree of implementation and enforcement of energy savings policies varies across the region, there is huge untapped potential to reduce energy demand even further by adopting cost-effective energy efficiency measures.

In Indonesia, energy efficiency improvements since 2000 limited energy use by 9% in 2017 compared with a trajectory without efficiency efforts (IEA, 2018). Looking ahead, the industry and services sectors and passenger transport make the biggest contributions to overall efficiency gains with high mandatory policy coverage in industry (representing nearly 50% of consumption) and in non-residential buildings (over 30%). In the residential buildings sector, a gradual tightening

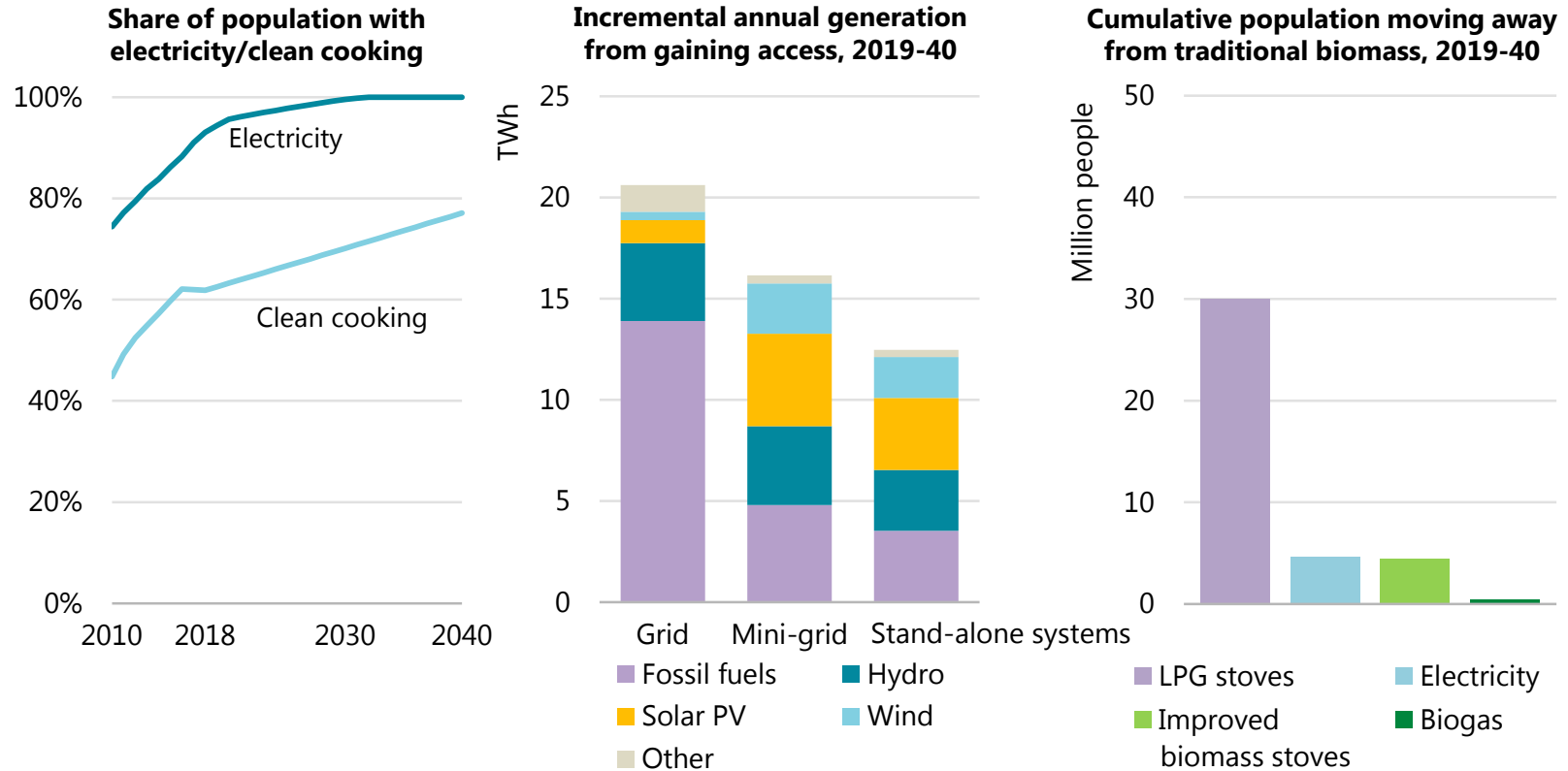
of the minimum energy performance standards (MEPS), provision of mandatory energy efficiency labels for air conditioners and the phase-out of electricity subsidies are being implemented.

Despite such measures, Indonesia's primary energy demand grows by more than 60% in the Stated Policies Scenario. With stronger policies and the adoption of a range of cost-effective measures, as described in the IEA Efficient World Scenario, demand growth could be substantially lower (IEA, 2018).

Many countries in the region are taking steps to promote energy efficiency. For example, such as Singapore, Thailand, Malaysia, Philippines and Viet Nam have introduced MEPS and energy-efficient labelling schemes. Less-developed economies including Myanmar, Lao PDR and Cambodia are preparing energy efficiency legislation and standards as well as labelling programmes. These developments are part of an ASEAN-wide effort to reduce energy intensity planned in the APAEC, which includes harmonising minimum energy performance standards for appliances.

Universal access to electricity is within reach, a major achievement ...

Energy access in Southeast Asia in the Stated Policies Scenario



Note: TWh = terawatt-hours; solar PV = solar photovoltaics; LPG = liquefied petroleum gas.

...while access to clean cooking remains a major challenge

Many countries in Southeast Asia are projected to achieve universal access to electricity by 2030, meeting one of the Sustainable Development Goals, followed by the few remaining markets in the early 2030s. Of the 38 million people gaining electricity access in the coming decade, connections to a main electricity grid account for about 40%. Mini-grid and stand-alone systems provide access in remote areas, accounting for 33% and 25% respectively. The role of renewable sources is significant, providing electricity to 45% of those who gain access.

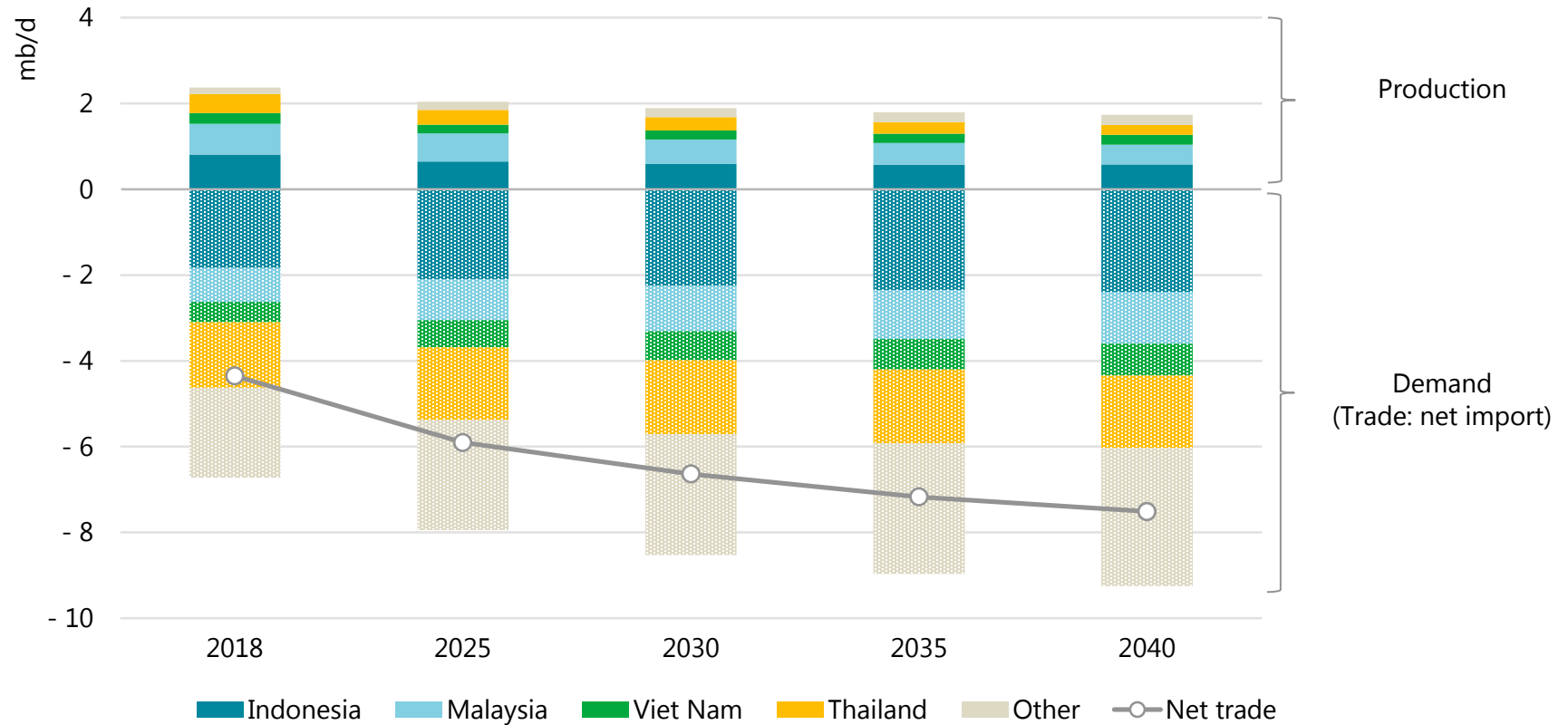
Access to clean cooking has improved in the past decade, with the share of the population using clean fuels and technologies rising from 45% in 2010 to 62% in 2018. Even as population levels rose, the number of people relying on traditional uses of biomass declined by over 60 million during the period. The decline was driven by economic growth, urbanisation, policies and market dynamics that supported the increased availability of alternative fuels such as liquefied petroleum gas (LPG).

In Indonesia, the number of people without clean cooking access declined by half since 2010, in part due to the Kerosene-to-LPG Conversion Program launched in 2007. Under the initiative, the government shifted subsidies from kerosene to LPG and provided households with a free stove, one fill and an additional LPG cylinder (IEA, 2017). In 2012, another initiative was launched to achieve universal access by 2030. Viet Nam has also made substantial improvements, driven by the efforts of non-governmental organisations with government support in the form of LPG price stabilisation (UN, 2018).

The impact of “stated policies”, however, leaves the clean cooking rate just below 80%, meaning that some 175 million people in the region remain without access in 2040. Challenges to higher levels of penetration of clean cooking include limited availability of alternative fuels in remote areas and preferences for traditional cookstoves for cultural or affordability reasons.

Oil supply: structural decline in production means rising reliance on imports

Oil supply demand balance in Southeast Asia in the Stated Policies Scenario



Notes: mb/d = million barrels per day. Production includes processing gains. Demand includes international bunkers.

Southeast Asia accounts for a rising share of global oil imports by 2040

Southeast Asia's oil demand (including international bunkers) surpasses 9 million barrels per day (mb/d) by 2040, up from just above 6.5 mb/d today. Fuel for the transport sector and feedstock for petrochemicals represent 90% of growth in the Stated Policies Scenario. Oil consumption for all types of road transportation rises from 2.5 mb/d today to 3.3 mb/d in 2040, while rising demand for air travel more than doubles jet fuel consumption. With increased petrochemical activity, demand for naphtha products increases by more than 50% to almost 1 mb/d by 2040. On the other side of the ledger, oil demand for power generation and heat plants decreases somewhat.

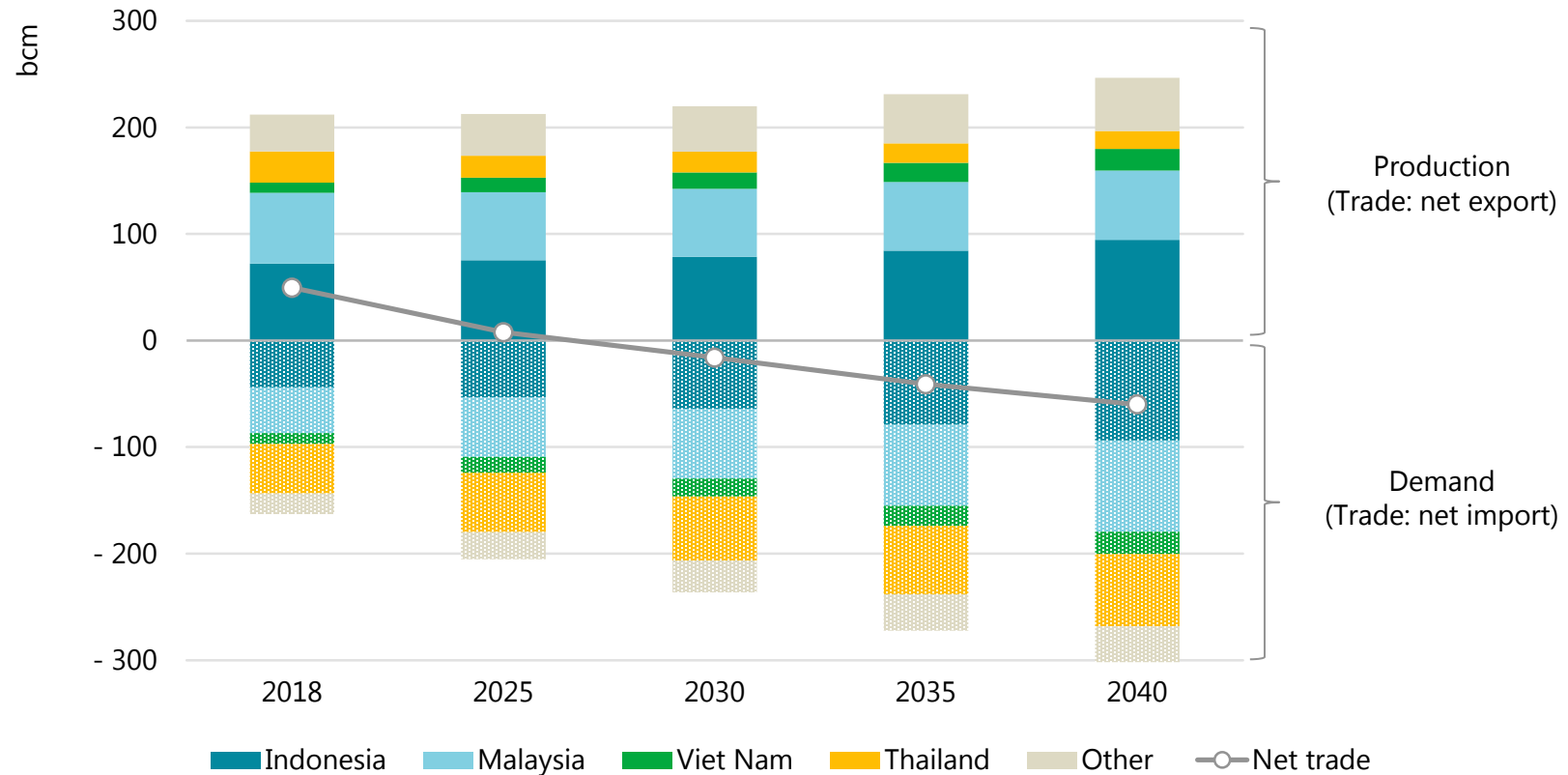
In terms of supply, around 60% of current regional production comes from offshore fields located in shallow waters (less than 450 metres (m) water depth). There are substantial remaining technical recoverable resources across the region - estimated at close to 80 billion barrels – as well as nearly 13 billion barrels of proven reserves, however there are promising prospects in more challenging deep water plays. Combined with the ongoing maturation of shallow water basins and very limited unconventional resources, oil production falls from 2.3 mb/d today to 1.5 mb/d in 2040.

The main oil producers today, Indonesia and Malaysia, both see production tailing off by 2040 in the projection, despite new discoveries in 2019, as new projects (increasingly in deepwater) do not offset declines elsewhere; production in both cases is around 500 000 barrels per day (kb/d) by 2040. Thailand also sees a very strong drop in oil output, but Viet Nam, which has the region's largest proven oil reserves, keeps production around today's levels thanks to projects such as the upcoming Lac Da Vang and Block B. Production levels remain steady through 2040.

As a result of the projected supply-demand dynamics, Southeast Asia becomes steadily more reliant on oil imports, which rise to well over 7 mb/d from near 4 mb/d currently. Growing import demand in Southeast Asia is part of a wider shift in global oil trade, away from the Atlantic basin – where the United States becomes a significant net exporter – and towards Asia.

Gas supply: Southeast Asia starts looking to the rest of the world for LNG...

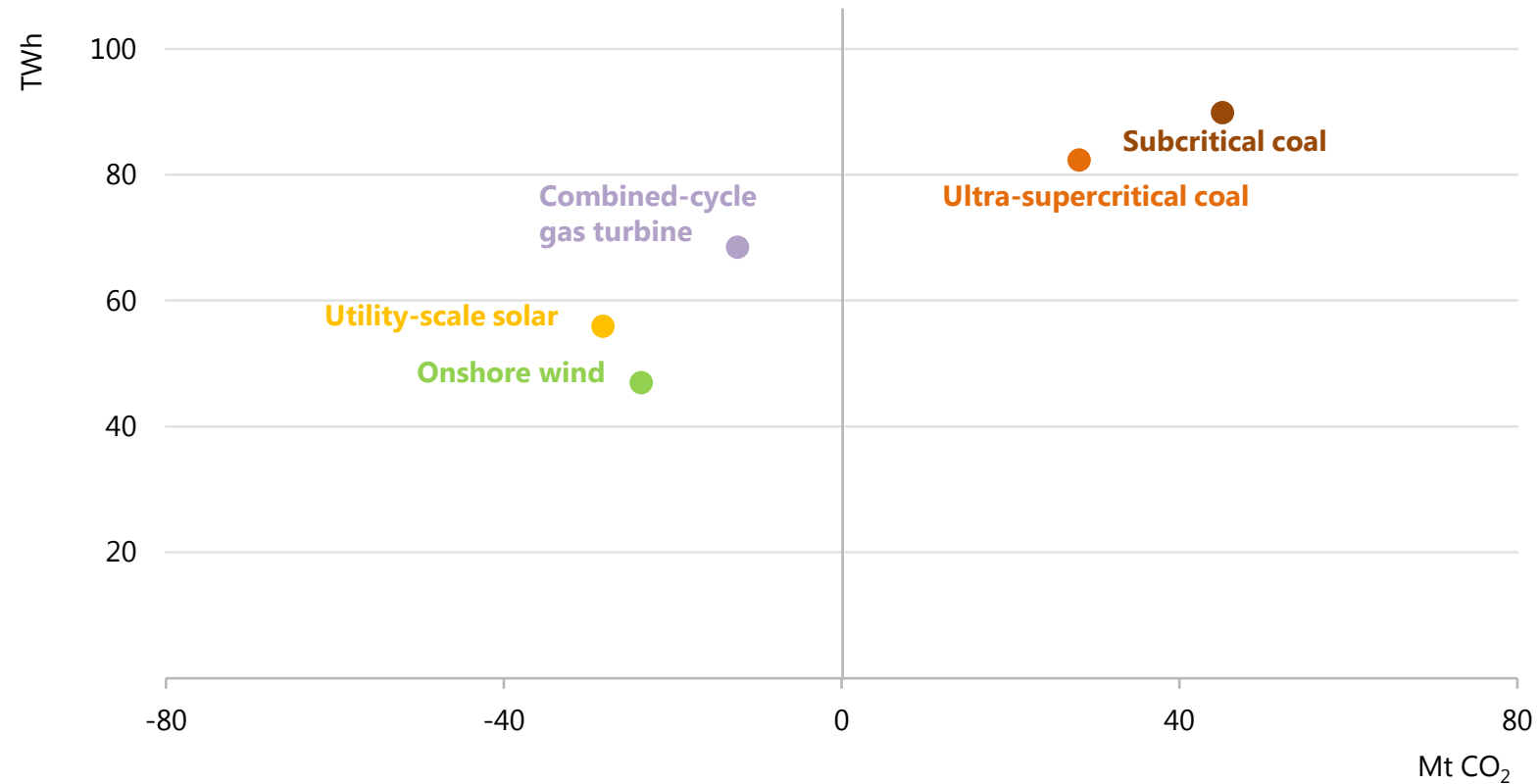
Gas supply demand balance in Southeast Asia in the Stated Policies Scenario



Note: bcm = billion cubic metres.

... which affects the case for gas-to-power

Affects of various \$5 billion investments in power generation in Southeast Asia on electricity generation and CO₂ emissions, assessed over a 30-year period



Notes: TWh = terawatt-hours; Mt CO₂ = million tonnes of carbon dioxide. Baseline for emissions calculation is today's average carbon intensity of power generation in Southeast Asia, i.e. around 600 grammes of CO₂/kWh.

A new set of pressures on Southeast Asia's gas balance

The power sector has traditionally been the mainstay of natural gas demand in Southeast Asia, but this changes in the Stated Policies Scenario. Gas-for-power has accounted for 55% of growth in gas consumption since 2000, but this share drops to just over 40% over the period to 2040. Industrial demand becomes the main driver for the rise in the overall gas demand to almost 300 billion cubic metres (bcm) in 2040, from 160 bcm today.

The dilemma for gas is that, as domestic production growth slows and in some cases declines, the marginal cubic metre of gas is increasingly imported as liquefied natural gas (LNG). Under these circumstances, the outlook for gas depends on policy priorities. If the priority for a new investment in power generation capacity is to maximise electricity output, then coal comes out on top (as it does in this region in the Stated Policies Scenario). If the priority is to reduce emissions relative to today's average emissions intensity for the region (the baseline in the figure on slide 80), then wind, utility-scale solar – or carbon capture, utilisation and storage (CCUS) retrofit of an existing coal plant – all offer larger long-term emissions savings than gas-fired combined-cycle gas turbine (CCGT) plants.

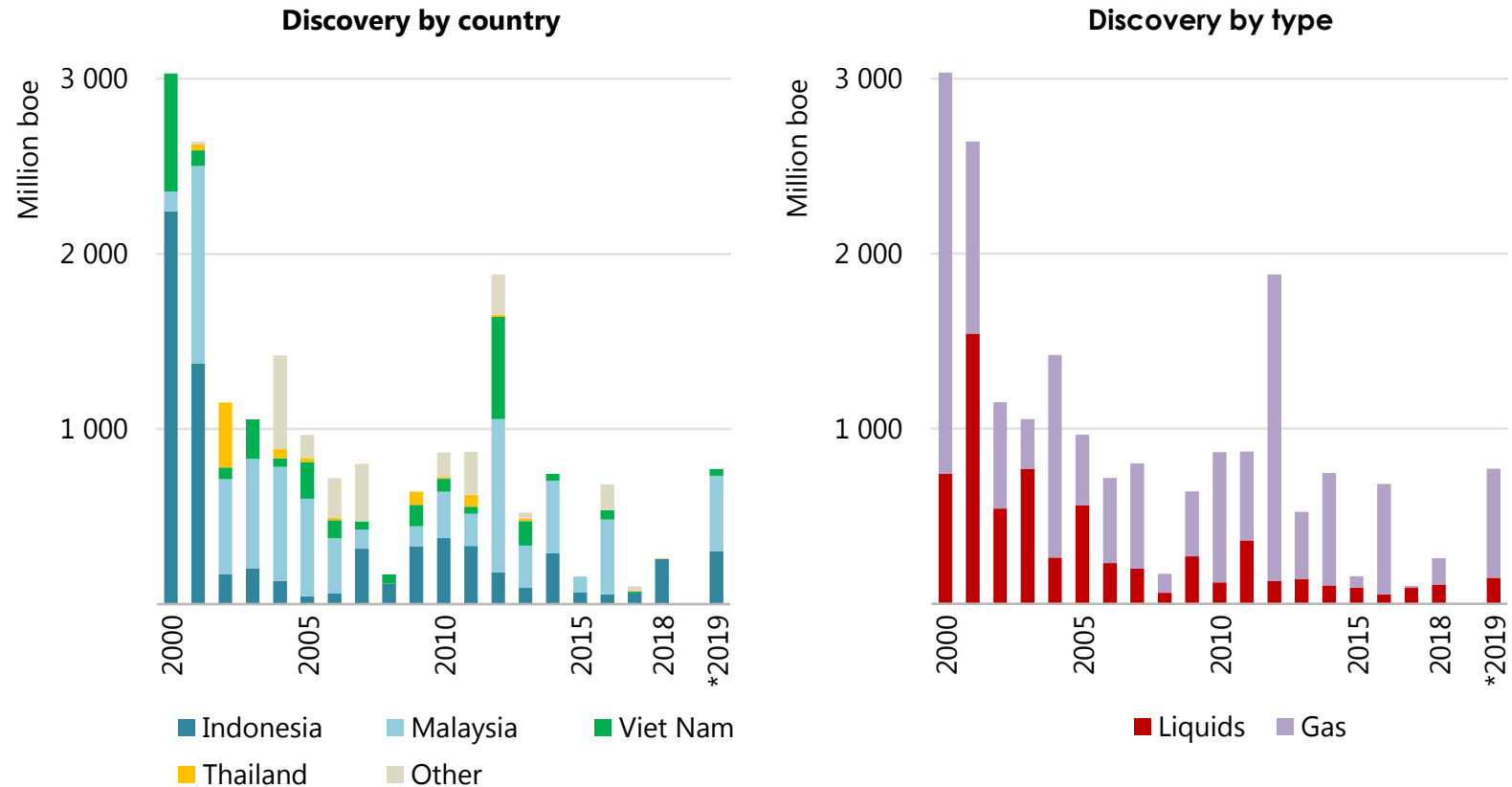
For gas to be preferred, policy makers need to value a portfolio of qualities that it brings to the table (without being top-ranked in any of them). This is a less compelling case than it has offered in the past, which is why – even as absolute output rises – the share of gas in the region's power mix continues to fall back from 30% today to less than 25% by 2040.

On the production side, overall gas production edges higher and reaches 250 bcm in 2040, from around 210 bcm today. Indonesia accounts for most of this growth as new resource developments broadly keep pace with demand. Viet Nam and Myanmar also add to the regional balance, but production in Malaysia flatlines while Thailand's gas output almost halves to 17 bcm in 2040 (Viet Nam takes its place as the third-largest producer in the region). Philippines is also on the brink of becoming a net gas importer.

Southeast Asia as a whole is projected to become a net gas importer in the late 2020s, a major turnaround for a region that is home to some of the major traditional names in LNG export – Malaysia, Indonesia and Brunei Darussalam.

Southeast Asia has been finding fewer hydrocarbons (although 2019 picked up)

Oil and gas discoveries by country and type



* 2019 includes discoveries for Q1/Q2.

Note: boe = barrel of oil equivalent.

Source: IEA analysis based on Rystad Energy.

Southeast Asia has options to boost future hydrocarbon output

In Southeast Asia, a confluence of factors raises oil and gas supply concerns in the years ahead - the volume of oil and gas discoveries is decreasing, production from national oil companies (NOCs) and oil majors is falling, and there have been fewer approvals of new developments after the oil price drop in 2014. These factors drive a structural decline of oil production in the Stated Policies Scenario, although aggregate gas production rises slightly.

A key question for producer countries is their ability to slow declines and increase recovery levels in existing fields.

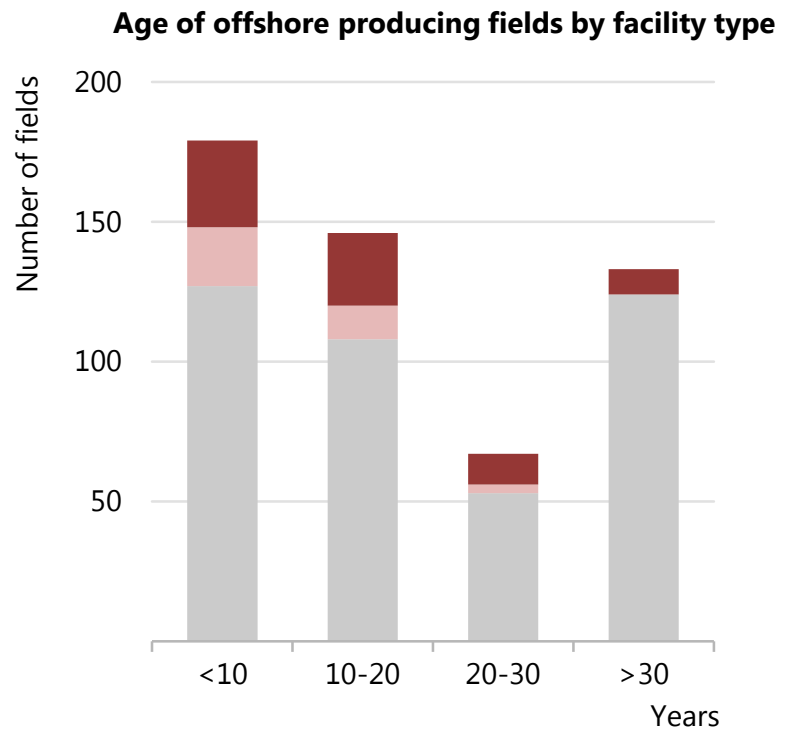
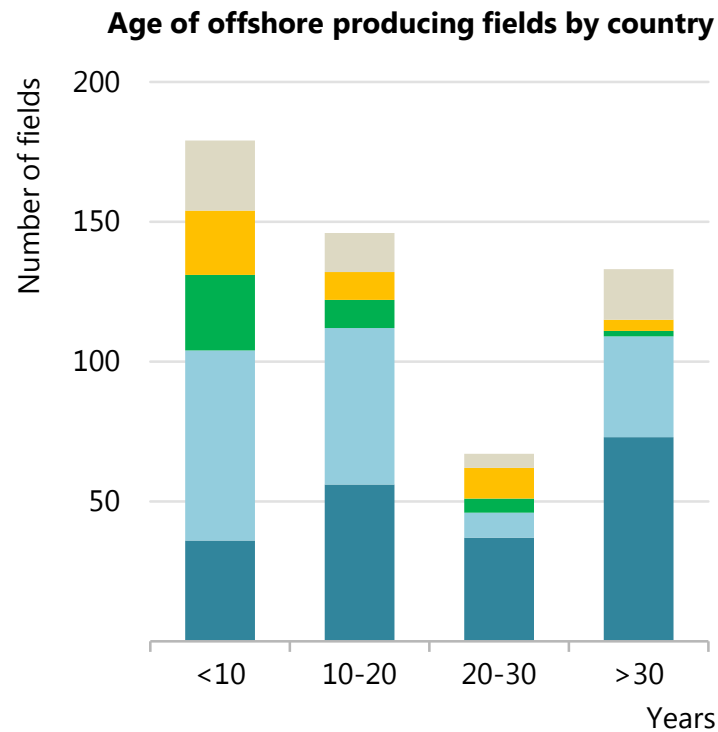
A combination of policy improvements, technological developments and business strategies could ease the situation. Improved fiscal terms and capital cost incentives could help to attract investment for more complex developments such as enhanced oil recovery (EOR) and resources found in deep waters, potentially increasing recovery rates and opening up new upstream plays.

While EOR is not new to the region - Indonesia and Malaysia are applying the practice for onshore (Duri, Minas, Handil) and offshore fields (Baram Delta, Tapis, Dulang, North Sabah) - its high cost can dissuade activity during periods of lower oil prices. Indonesia now provides up to a 10% higher share for contractors in the gross split contract system; Malaysia introduced new fiscal terms for deepwater developments in 2018.

Increased application of digital technologies (e.g. artificial intelligence, cloud computing and machine learning) could also decrease development costs and improve the time-to-market for new resources. Moreover, the portfolios of the region's major upstream players could be enhanced through investment overseas, as their regional market share has dropped to under 75% in 2018, from near 90% in 2000. For example, activities by Petronas in Canada's LNG sector, PTTEP in the United Arab Emirates and Pertamina in Iraq have helped maintain earnings, which can then be recycled for use in domestic investment.

An emerging issue for the region is the anticipated uptick in fields that will need to be decommissioned...

Age of offshore producing fields by country and facility type



■ Indonesia ■ Malaysia ■ Viet Nam ■ Thailand ■ Other

■ Steel platform ■ Subsea tieback ■ Other

Source: IEA analysis based on Rystad Energy.

... as today's offshore oil and gas platforms reach the end of their operational lifetimes

The decommissioning of offshore platforms is set to play a larger role in shaping the oil and gas sector in Southeast Asia over the period to 2040. Experience from US offshore waters and the North Sea shows that regulation plays an important role in addressing the financial, operational and environmental risks.

By 2030, more than 200 offshore fields will have ceased production in the Southeast Asia region. Almost 40% of all offshore producing fields have been in operation for more than 20 years (in Indonesia, the level is 55%).

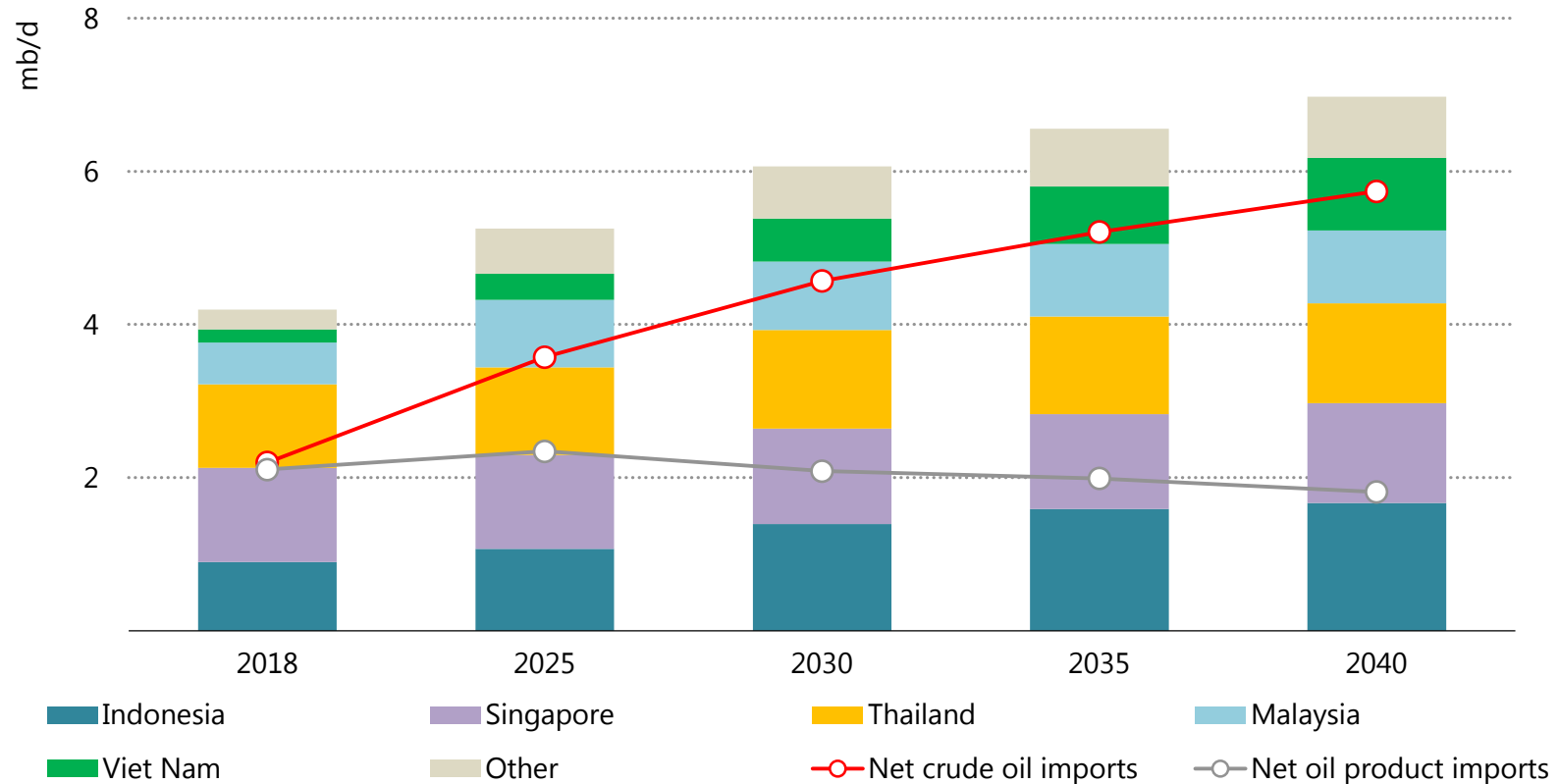
The overall decommissioning costs for such assets is difficult to state with precision, but could range from \$30-100 billion in Southeast Asia. Most governments provide tax relief to contractors and in Southeast Asia these tax reductions are on the order of 30-50%. The potential for cost overruns associated with complex operations remains a persistent risk.

While decommissioning activities have commenced on a small scale, e.g. in Thailand, further experience will be needed. Moreover, the complexity level may rise as the types of projects being decommissioned are set to evolve - most activities to date have involved steel platforms in shallow water, but the future also points towards the dismantling of more complex structures in deeper water.

Regulations typically allow for the possibility of re-using or re-purposing some offshore infrastructure. One option that has been tried in the United States and Southeast Asia is the "rigs-to-reefs" approach, which leaves some of the rig behind to become an artificial habitat for marine life. While not all platforms may be suitable, such options, where applicable, can provide a more cost-effective approach than full removal.

Oil refining: the chase to keep up with rising oil product demand...

Refinery runs by country and net trade balance for crude oil and oil products



Note: mb/d = million barrels per day.

... underpins a growing divergence between crude oil and oil product imports

In response to rising consumption for oil products, there are activities to expand refining capacity in Southeast Asia. Malaysia's RAPID refinery (300 kb/d) is expected to start operation from late 2019. A number of expansion projects at existing refineries are underway, notably in Indonesia, Philippines, Viet Nam and Thailand.

Refinery runs in Southeast Asia increase by two-thirds to almost 7 mb/d between 2018 and 2040. While Singapore is the largest refining centre today, the growth is higher in Indonesia, Malaysia and Viet Nam. These three countries account for 70% of the region's refining activity growth in the period to 2040. Higher refinery runs keep net oil product imports to the region stable through to 2040.

Vibrant bunkering activities in the region raises the import requirements for kerosene and diesel (more in the short-term) while those for fuel oil (today's largest imported product) reduce from 2020 due to the new International Maritime Organization regulation on sulfur. The availability of IMO-compliant fuels such as marine gasoil (MGO) or very low-sulfur fuel oil (VLSFO) is set to have a major influence

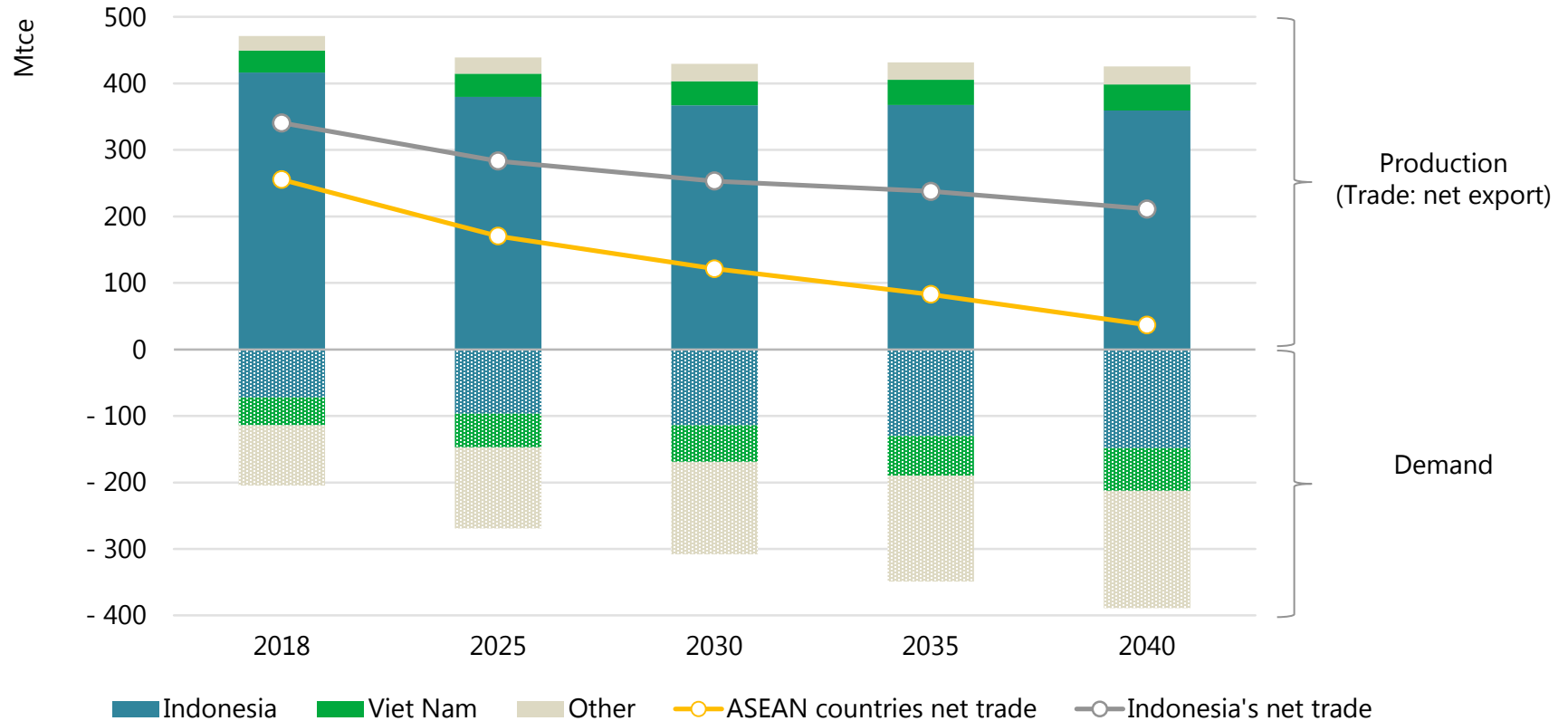
on the competitiveness of bunkering hubs post-2020, there are many activities underway to ensure greater availability of VLSFO in the port.

Today Southeast Asia imports similar volumes of crude oil and oil products, around 2 mb/d each. In the future, there is a growing divergence between the two. While net oil product imports remain steady, net crude import requirements grow substantially by two-and-a-half times to around 5.7 mb/d by 2040.

The bulk of the crude oil is imported via the Strait of Malacca, a major chokepoint in global oil and gas trade. As a result, the volume of oil passing through the Strait surpasses that through the Strait of Hormuz, today's largest chokepoint, by 2040. This presents potential risks of physical congestion, collision or attacks, highlighting the need for vigilance on oil security.

Coal supply: uncertainties on all sides

Coal supply demand balance in Southeast Asia in the Stated Policies Scenario



Note: Mtce= megatons of coal equivalent.

Strong coal demand growth outpaces stagnating production

Annual coal production in the region declines by 10% to around 420 million tonnes of coal equivalent (Mtce) in 2040. Accounting for almost 90% of the region's coal production, Indonesia sees its output decrease through 2030, due to stagnate investment in coal mines in the 2020s. A subsequent recovery of investment is driven by higher prices, albeit to a limited extent due to depletion of the best resource sites.

In the Stated Policies Scenario, the region's demand for coal is robust, doubling to nearly 400 Mtce by 2040 at an annual average growth rate of 3%, while the global trend for coal demand stays flat over the same period. Steam coal accounts for over 90% of the increase, mainly to fuel new coal-fired power generation.

Nearly 100 GW of new coal-fired capacity is set to come online in Southeast Asia, predominantly in Indonesia, Viet Nam and Malaysia. Around 30 GW of this is already under

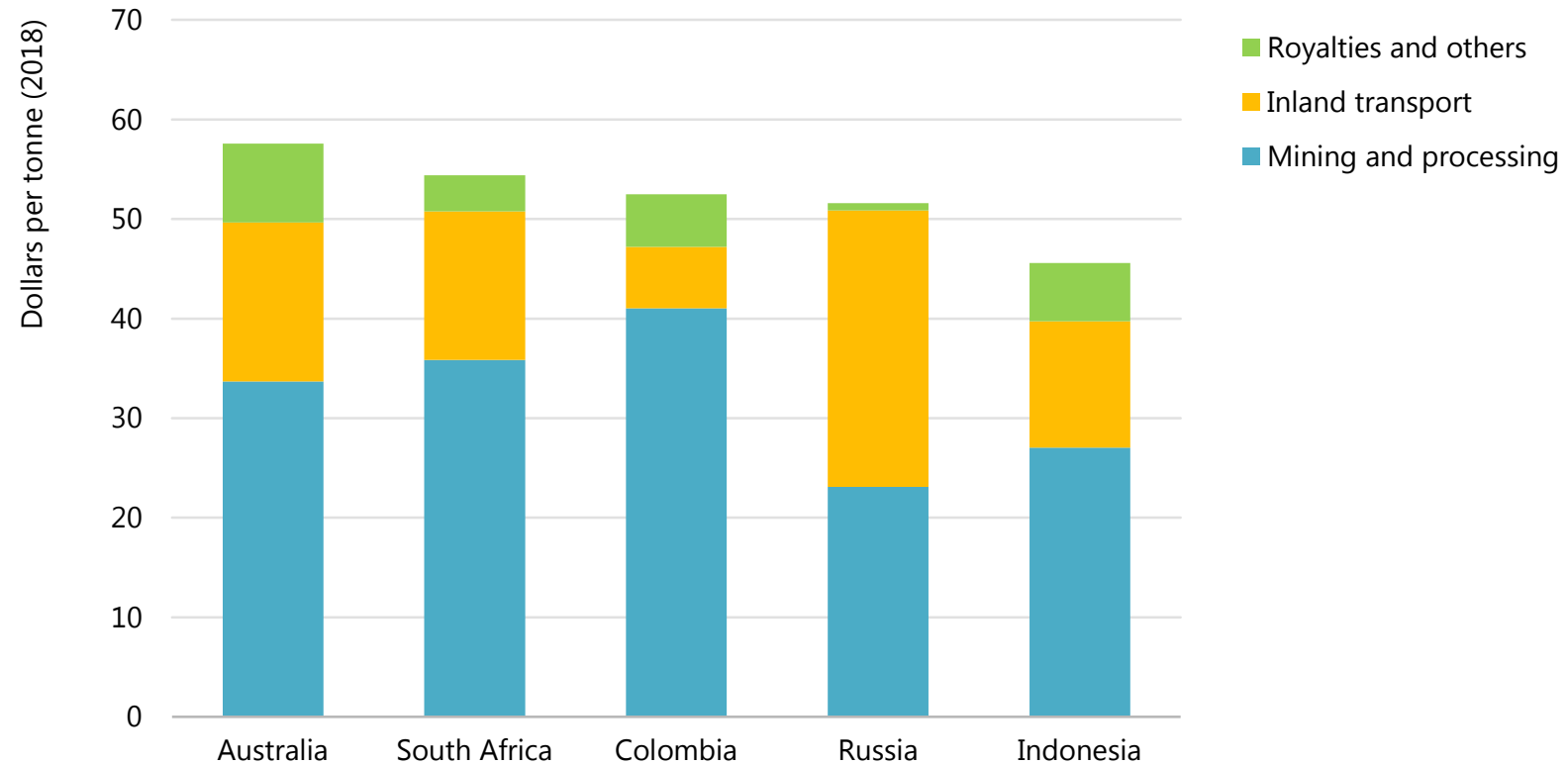
construction, but there is nonetheless downside risk to the outlook, as development of coal-fired power plants is facing increasing public opposition, for instance in Thailand and Philippines, and more challenging financing.

The remaining 6% of the increase comes from coking coal, which more than triples in demand from 4 Mtce today to 16 Mtce, as crude steel production triples by 2040. Some countries, including Viet Nam and Indonesia, plan to expand production capacity of crude steel using blast furnaces.

With increasing demand and slowing production growth, Southeast Asia's current trade surplus erodes to near zero by 2040. While Indonesia reduces coal exports by 40% to service domestic demand, imports in other parts of Southeast Asia double.

Indonesia has an edge on coal supply costs...

FOB cash cost components of major steam coal exporters, 2018



Note: FOB = free on board.

...but faces increasing demand, which limits export opportunities

Indonesia is a competitive coal exporter with a mining cash cost of production at \$46 per tonne, thanks to well-developed transport infrastructure and low labour costs. This competitiveness has helped the country to further increase exports until 2018 driven by strong production growth.

However, Indonesia's exports are projected to decline, from 350 Mtce today to 210 Mtce in 2040 in the Stated Policies Scenario. A growing share of production is destined to serve increasing domestic demand while output declines by 14%.

With the world trade volumes of coal projected to stay broadly flat to 2040, Australia and Russia are well-positioned to increase exports to offset the reduced role of Indonesia, which predominantly serves Asian markets. By the 2040, Indonesia is overtaken by Russia in terms of export volumes.

There is an upside to exports from Indonesia if suppliers, who generally respond rapidly to price signals from international markets, ramp up production and exports when seaborne prices become more attractive, as occurred in 2017.

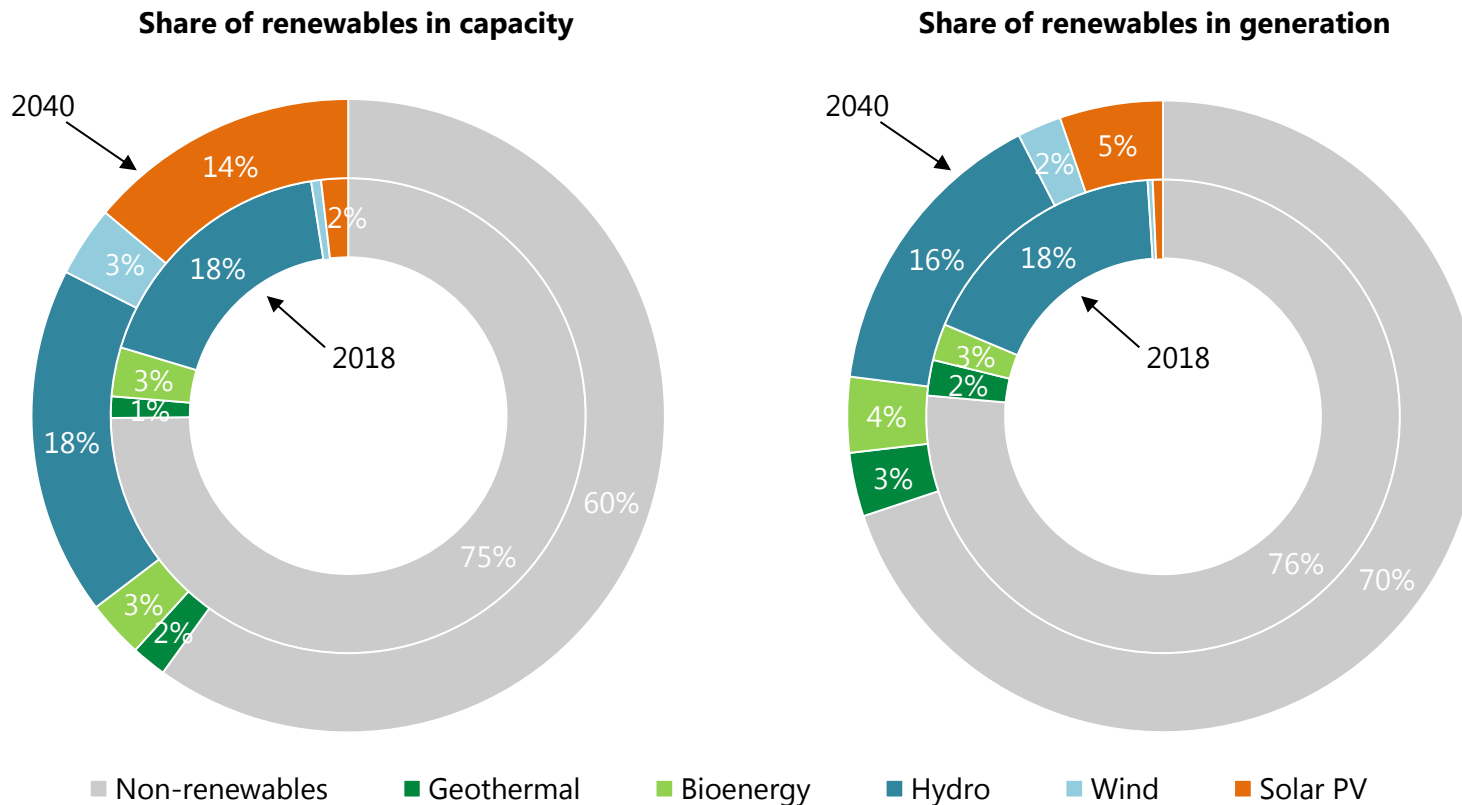
Nonetheless, Indonesian producers face substantial uncertainty in their two largest exports markets, China and India. Chinese imports have fluctuated substantially in the past as Chinese policy makers grapple with the challenge of restructuring the coal supply sector while also reforming the main domestic users of coal, power and industry.

Diversification away from the Chinese market may not be straightforward, however, due to the relatively low calorific value of Indonesian coal. Indonesian coal exporters are eager to benefit from a growing steam coal market in India, but the ultimate scale of import growth in India is uncertain, due to demand-side factors as well as efforts to boost domestic output.

Lignite production in Thailand currently serves domestic demand while half of the steadily increasing thermal coal production in Philippines reaches consumers overseas. Over the projection period, strong demand increases in Southeast Asia (excluding Indonesia) outpaces production growth and imports increase to some 170 Mtce by 2040.

Renewables in power generation are rising, but could be much higher...

Share of renewables in installed capacity and generation in Southeast Asia in the Stated Policies Scenario, 2018 and 2040



... if policy and regulatory frameworks are supportive

In the Stated Policies Scenarios, Southeast Asia boosts renewables-based generation from 24% of the power mix today to 30% by 2040. However, this share lags far behind other major economies in Asia, such as China and India, where renewables reach above 40% share of generation by 2040. What is holding back the growth of renewable generation in Southeast Asia?

Robust growth in hydropower – whose generation costs are comparable to coal – accounts for nearly one-fifth of power generation and doubles over the *Outlook* period, even as its share remains steady. Much development to date has been carried out by state-owned utilities and under long-term contracts with independent power producers.

Viet Nam has led hydropower growth, but deployment is broad based, including Cambodia, Indonesia, Malaysia, Myanmar, Philippines and Thailand. Lao PDR, with good hydro resources but low domestic demand, has spurred development based on bilateral trade with neighbouring Thailand (see Regional Power Trading section, slides 137-159). Future growth depends on exploiting additional sites outside the Mekong River Basin, and efforts to manage local environmental impacts and risks associated with long project lead times.

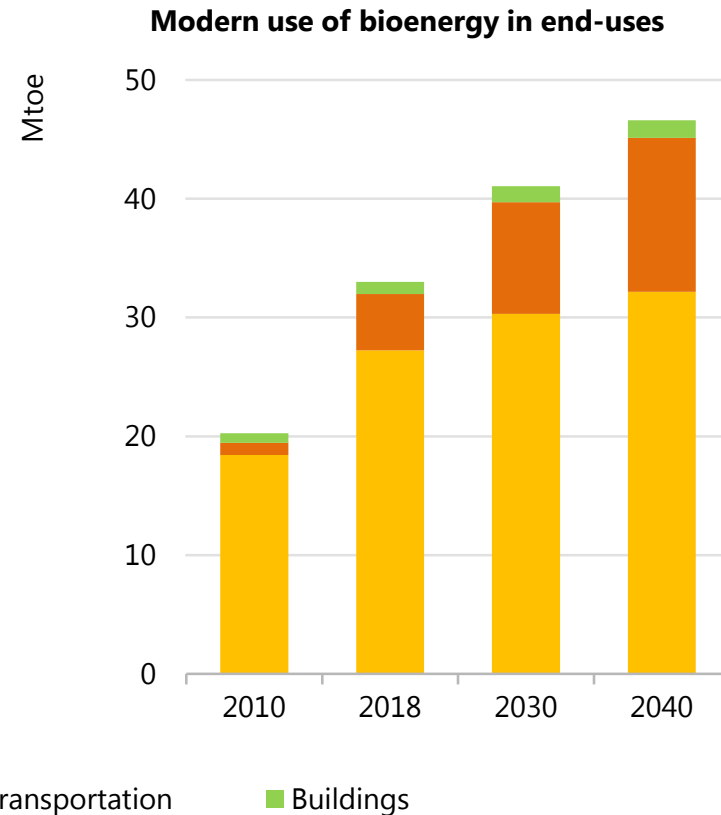
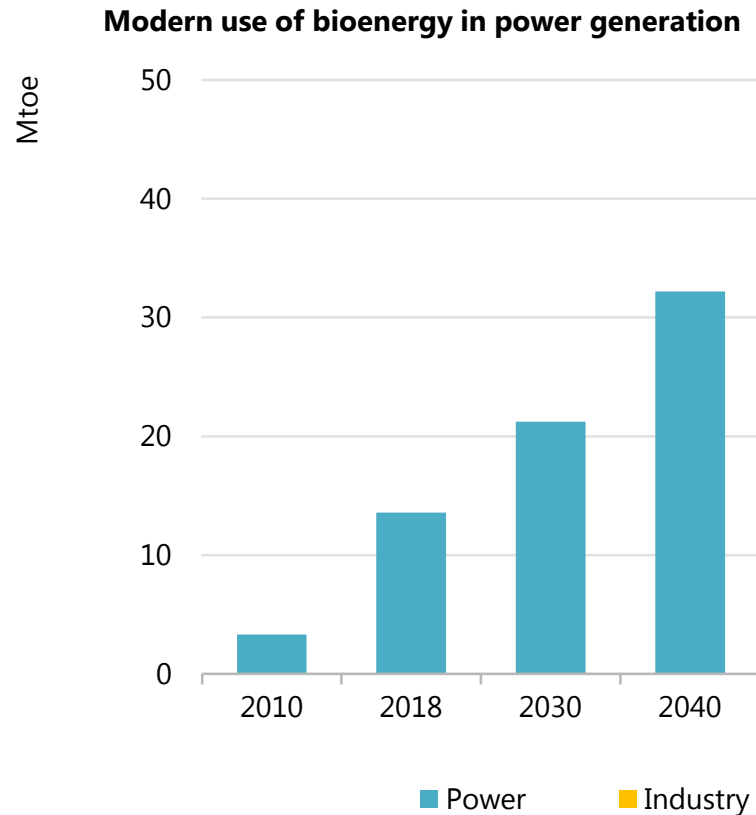
The bulk of regional growth in bioenergy, geothermal, solar PV and wind has been driven by a combination of targets and incentive schemes based on feed-in tariffs, principally in Malaysia, Philippines and Thailand. But such schemes have often been accompanied by stop-and-go implementation and barriers related to licensing and contracts by state-utility off-takers, who have been reluctant to pay for higher cost power (compared to coal).

This incremental progress has inhibited the development of more robust local supply chains that would help to bring costs down in line with international benchmarks (particularly for solar PV and wind).

More consistent policy frameworks to attract investment coupled with system integration improvements will be critical to unlock higher levels of renewables in power developments. For example, in Viet Nam, the recent implementation of attractive feed-in tariffs has spurred the development of nearly 5 GW of solar PV projects – more than five-times its target for 2020. But this is also raising concerns over the adequacy of the grid to accommodate such a rapid increase, which is creating potential for an uneven stop-start cycle of deployment.

Large potential for increasing modern use of bioenergy across various sectors...

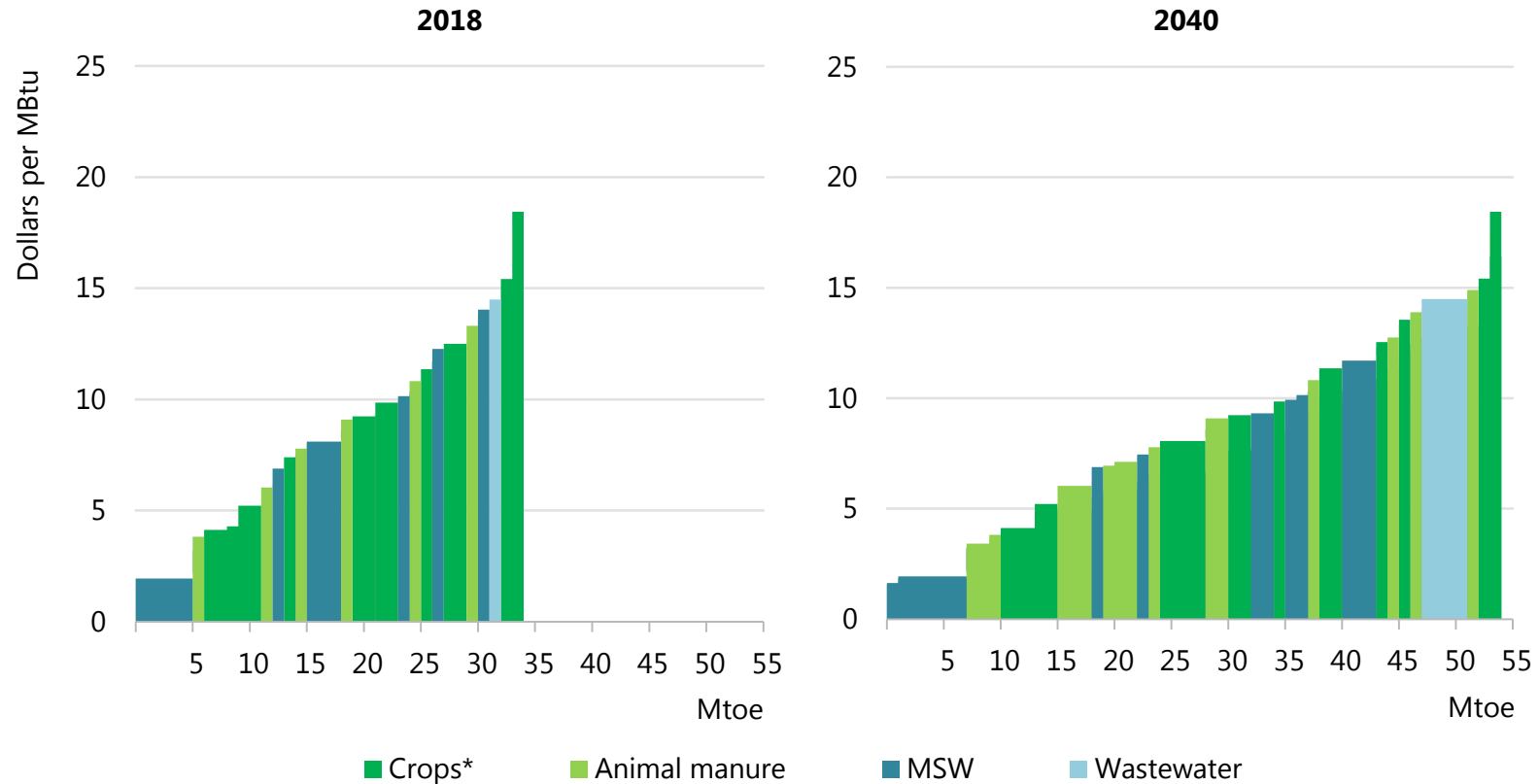
Modern use of bioenergy in power generation and total final consumption in Southeast Asia, 2010-40



Note: Mtoe = million tonnes of oil equivalent.

... with biogas a promising option as supply potentials grow and costs come down

Cost curves of potential biogas supply by feedstock in Southeast Asia, 2018 and 2040



* Crops includes crop residues only, energy crops are excluded given concerns about sustainability.

Note: MBtu = million British thermal units; Mtoe = million tonnes of oil equivalent; MSW = municipal solid waste.

Realising bioenergy's potential will require efforts by governments and industry to expand applications and develop sustainable feedstock supply chains

Modern bioenergy – including biogas, biomass and bioenergy derived from other waste products – is an increasingly important pillar of Southeast Asia's renewable energy mix. Among countries in the region, Thailand has deployed the largest amount of modern bioenergy in the power sector. The main bioenergy feedstocks are from agriculture, reflecting the large weight of the agricultural sector in the economy, and municipal waste. A key example is the utilisation of bagasse, the residue pulp of sugar cane after its juice is extracted, by sugar mills in Thailand to produce thermal energy for the distillation process. In some mills, the steam from bagasse combustion is used to drive steam turbines for power generation.

Indonesia and Malaysia are the world's top-two producers and exporters of palm oil, which is used across a variety of industries from food to cosmetics and pharmaceuticals, as well as in energy, typically as a feedstock for biodiesel. In both countries, the blending of bio-content into diesel for on-road use commenced in 2010, swiftly gaining a foothold in the market and reaching 10% in Indonesia by 2016 and 7% in Malaysia by 2015. As with other bioenergy resources, palm oil can bring energy security and environmental benefits, although this requires that output is managed sustainably, - an important policy issue for the main producers.

Both Indonesia and Malaysia are looking to further boost their domestic biodiesel consumption in an effort to reduce diesel fuel imports. Combined with Thailand putting more emphasis on the roll-out of gasohol, a blended fuel of gasoline and bioethanol derived from crops suitable for ethanol processing, i.e. molasses, cassava and sugarcane juice, the use of bioenergy in transport fuels increases strongly through to 2040.

Southeast Asia also continues to seek increased use of bioenergy in power generation, where it can reduce reliance on imported fuels. In addition, the dispatchability of bio-power plants can contribute to system flexibility.

Biogas can provide a local source of power and heat for rural communities and businesses. We estimate that around 35 Mtoe of biogas could be produced sustainably today in Southeast Asia, equivalent to over 25% of natural gas demand of the region. By 2040, this potential increases to 55 Mtoe; around 40% of this could be produced from crop residues, around 30% from municipal solid waste and 25% from animal manure. In the Stated Policies Scenario biogas demand in Southeast Asia reaches 11 Mtoe in 2040. Biogas is expected to gain more opportunities as costs and available applications improve.

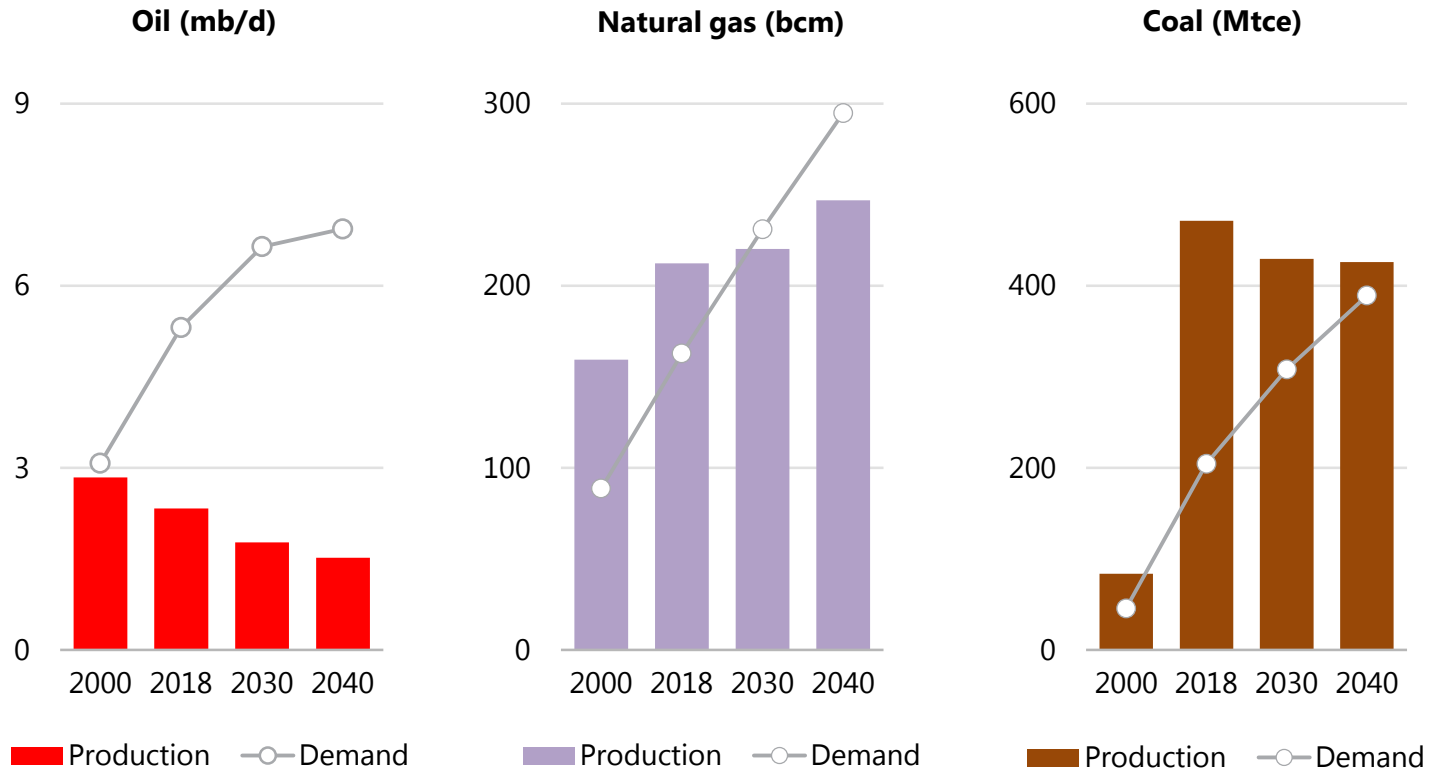
Implications of the Stated Policies Scenario

Growing imports of fuels (98-101)

CO₂ emissions and air pollutions (102-104)

By 2040 Southeast Asia is a large net importer of fossil fuels and the annual import bill exceeds \$300 billion

Fossil fuel production and demand in Southeast Asia in the Stated Policies Scenario



Note: mb/d = million barrels per day; bcm = billion cubic metres; Mtce= million tonnes of coal equivalent.

Energy security and affordability is a serious concern in Southeast Asia, as it becomes increasingly dependent on imported fossil fuels

Southeast Asia's considerable oil, natural gas and coal resources have traditionally allowed the region to enjoy a net energy export position, which was valued at more than \$10 billion per year at the start of the century. However in recent years, falling exports (due to increasing domestic consumption and declining oil production) and rising prices have taken a toll. The fossil fuel trade balance shifted to a deficit of \$57 billion in 2018.

These trends are expected to intensify in the Stated Policies Scenario, as demand for oil rises by around 30% and for natural gas by 80% in the period to 2040. In this scenario, oil production falls by one-third and gas output increases by 16%, but both fall far short of demand growth. This brings a dramatic transformation in the region's trade position and its balance of payments for energy. In 2040, Southeast Asia is projected to register a net deficit in energy trade of over \$300 billion per year.

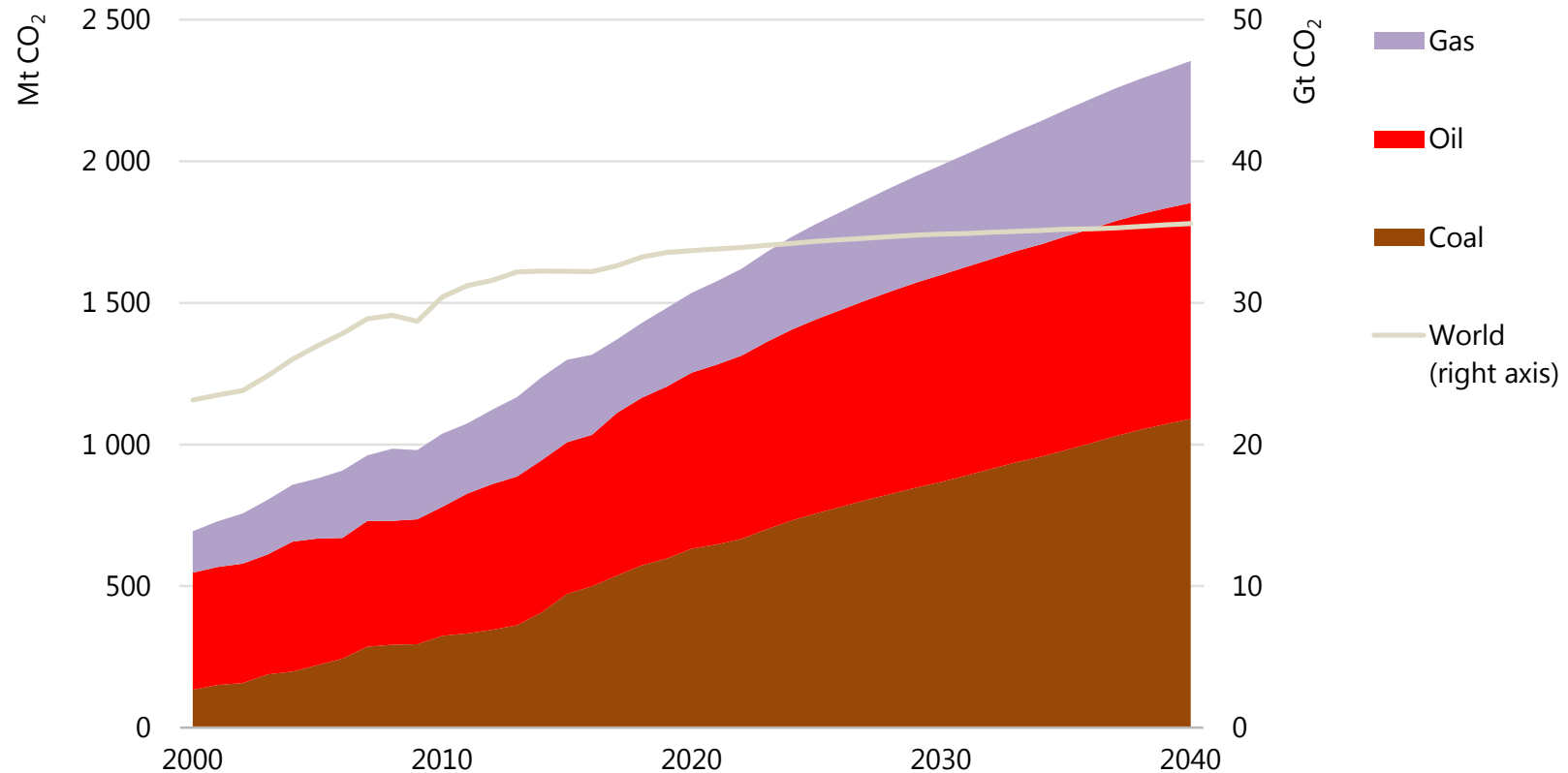
In addition to impacts on the energy trade balance, the large increase in imports raises energy security concerns. Oil import dependency (the amount of oil imported as a proportion of total demand) reaches more than 80% in 2040, up from 65% in 2018, although there are notable differences among countries in the region.

Thailand and Indonesia, with rising oil demand and limited production, are set to see their import dependence rise significantly. With only marginal oil imports today, Malaysia becomes substantially more dependent on imports over the outlook period, as demand growth outpaces its production. Brunei Darussalam is expected to remain self-sufficient due to stable oil production and limited demand growth, reflecting its relatively small population.

Alongside measures to accelerate energy transitions in the region (which would ease projected import needs, as outlined in the Sustainable Development Scenario), options for regional co-operation, such as cross-border stockholding arrangements and joint stockpiling models, could help to ease these energy security concerns. They could provide flexible and pragmatic pathways to improve national and regional oil supply security.

Energy-related CO₂ emissions are more than 60% higher in 2040 than in 2018

Energy-related CO₂ emissions by fuel in Southeast Asia in the Stated Policies Scenario



Note: Mt CO₂ = million tonnes of carbon dioxide; Gt CO₂ = gigatonnes of carbon dioxide.

Unlike in other regions, there are few signs of the decoupling of energy use from CO₂ emissions in Southeast Asia, as coal use remains strong

In the Stated Policies Scenario, the projected rise in energy demand and the continued predominance of fossil fuels in Southeast Asia's energy mix drive a significant increase in energy-related emissions. Carbon dioxide (CO₂) emissions increase by two-thirds over the period from around 1.4 gigatonnes (Gt) in 2018 to almost 2.4 Gt in 2040.

Oil and coal were responsible for a roughly similar amount of CO₂ emissions in 2018, but in the Stated Policies Scenario, coal becomes the largest source of CO₂ emissions by 2020. By 2040, coal accounts for almost half of the region's CO₂ emissions, with oil accounting for 30% and natural gas for 20%.

Bucking the global trend, where the share of the power sector falls in total emissions, by 2040 the power sector in Southeast Asia is responsible for just under half of CO₂ emissions, up from 42% today. As a result, CO₂ emissions in the transport sector decline from a 27% share in 2018 to 23% in 2040, with the trend also helped by vehicle efficiency standards, biofuels and other alternative transport fuels.

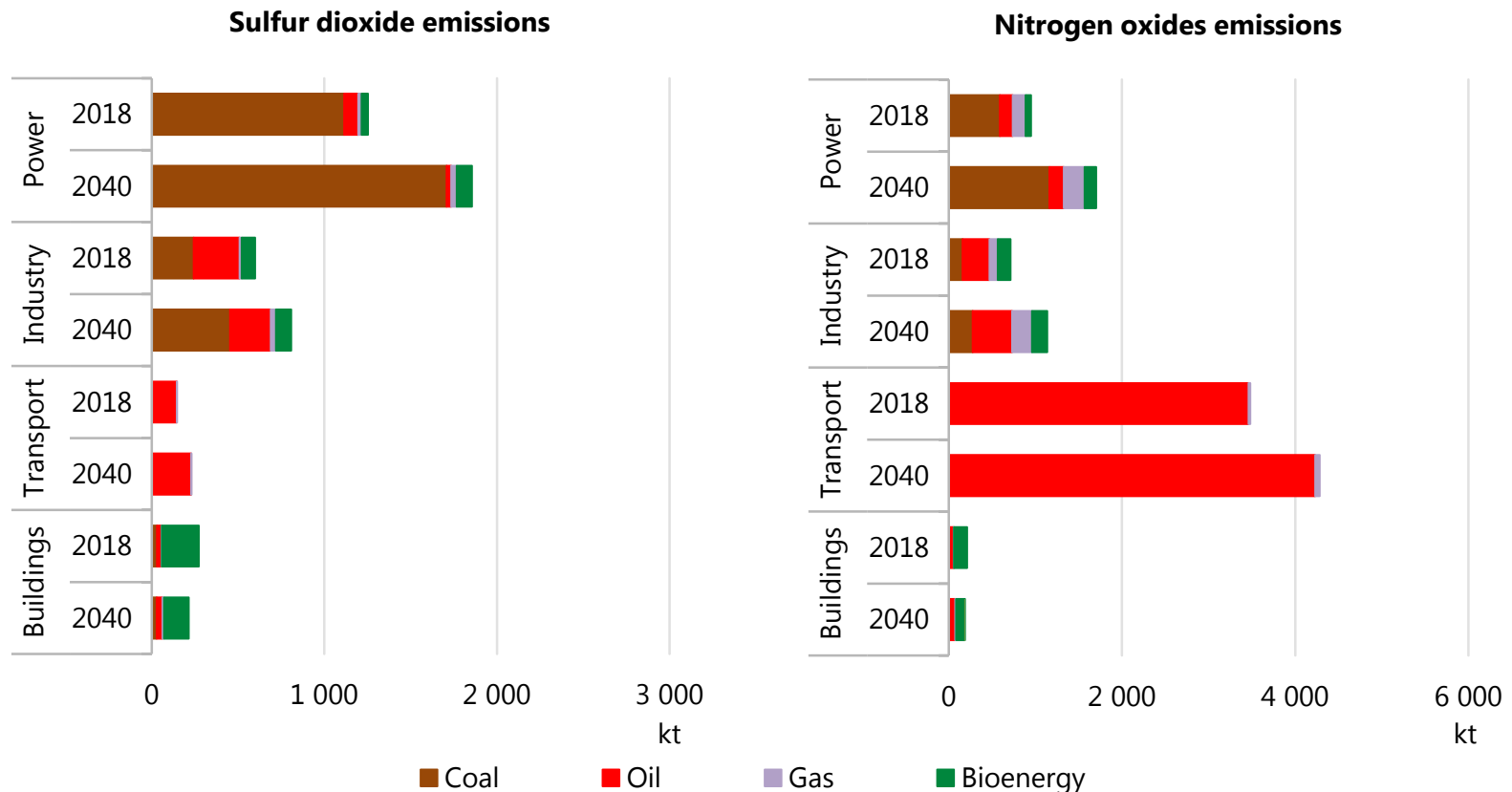
These projections for emissions in the Stated Policies Scenario reflect the continuing reliance on coal-fired power plants to meet a sizeable portion of electricity demand, as well as the continued dominance of oil in the transport sector, as the region rapidly expands petroleum-based mobility.

With an average annual growth rate of 2.3% between 2018 and 2040, CO₂ emissions in Southeast Asia grow seven-times as fast as the global annual average over the same period. While the region's current share of global emissions is relatively small (4.3% in 2018), it increases by more than half to 6.5% over the period to 2040.

The rate of economic growth across Southeast Asia surpasses the rate of growth in CO₂ emissions, delivering an almost 40% decrease in the carbon intensity of GDP. Nevertheless, emissions are set to increase at a faster pace than energy demand, indicating that the relationship between economic development and emissions remains strong in this scenario.

Combustion of coal for power generation and oil for transport are major sources of air pollution in Southeast Asia

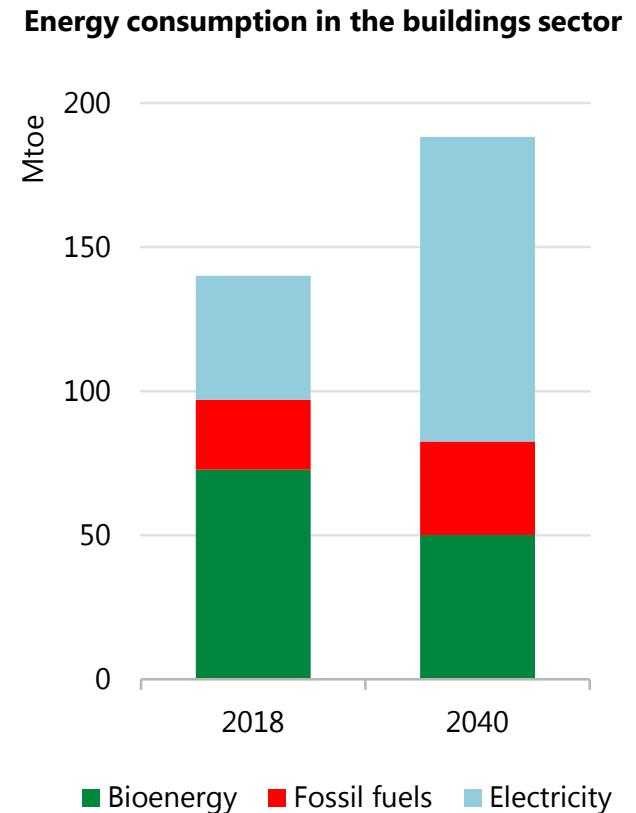
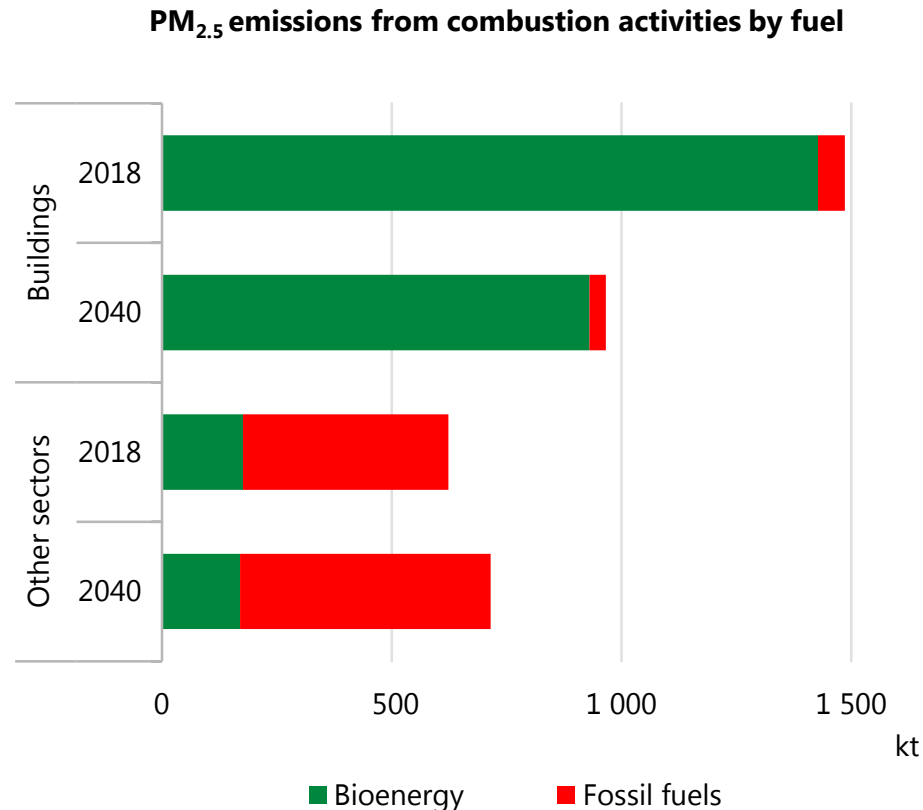
Air pollutant emissions from combustion activities by sector and fuel in Southeast Asia in the Stated Policies Scenario



Note: kt = thousand tonnes.

PM_{2.5} levels decrease with a shift from traditional use of biomass for cooking, but remain sizeable in 2040 due to emissions in other sectors

Fine particulate matter emissions in Southeast Asia in the Stated Policies Scenario



Note: PM_{2.5} = particulate matter with a diameter of less than 2.5 micrometres; Mtoe = million tonnes of oil equivalent; kt = thousand tonnes.

Emissions from fossil fuel combustion and continued use of biomass for cooking present serious threats in terms of air pollution

Several countries in Southeast Asia have established air quality standards that comply with World Health Organization guidelines. Yet enforcement is limited and recommended concentration limits are often exceeded in practice. In 2018, Southeast Asia experienced around 450 000 premature deaths associated with the adverse effects of air pollution.

In the Stated Policies Scenario, the strong position of fossil fuels in the energy mix and relatively weak pollution controls leads to a strong rise in emissions of all major air pollutants in urban areas. By 2040, sulfur dioxide (SO₂) emissions increase by almost 40% due to expanding coal use in power generation and relatively high emission factors (four-times above emission factors in Japan and China) because of sparse deployment of sulfur removal technologies. Emissions of nitrogen oxides (NO_x) also increase by almost 40% over the period. The largest source of NO_x emissions remains oil use in the transport sector.

Fine particulate matter (PM_{2.5}) emissions fall by 20% by 2040, reflecting reduced use of solid biomass in the buildings sector as a cooking fuel. Policy efforts to encourage alternative sources reduce the number of people without access to clean cooking to 175 million in 2040. But the damaging effects of reliance on solid biomass remain acute in some countries, especially in Lao PDR, Myanmar and Cambodia, where half or more of the population still relies on this fuel for cooking in 2040. Affordability is a significant issue: solid biomass is often free, except for the time spent gathering it, while even the cheapest improved cookstoves can cost a poor household several weeks of income.

In the Stated Policies Scenario, the consequences of air pollution on human health remain severe. The number of annual premature deaths associated with outdoor and household air pollution in Southeast Asia rises to more than 650 000 by 2040.

Sustainable Development Scenario

Overview (106-109)

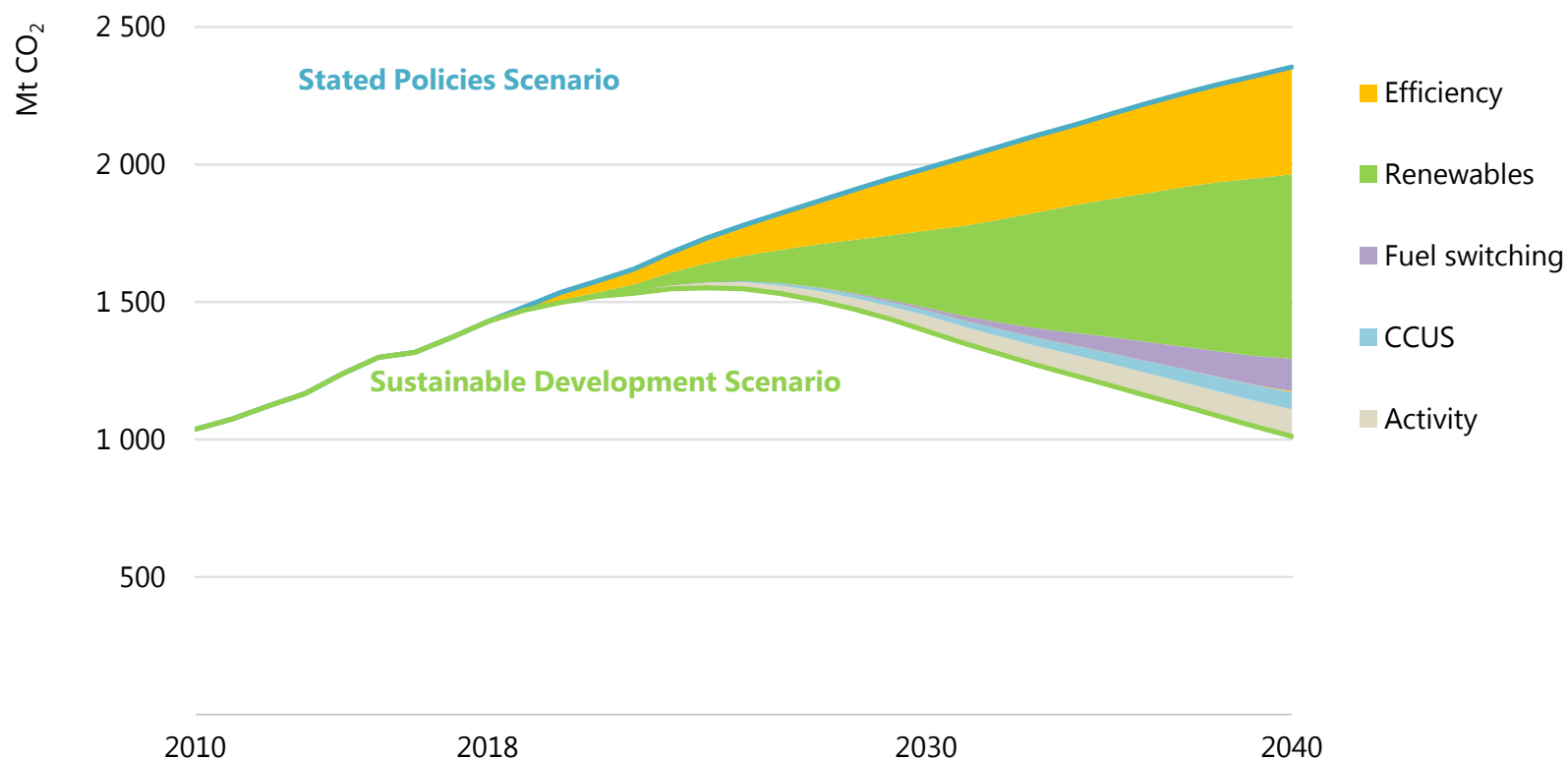
Power mix (110-112)

Energy efficiency (113-115)

Benefits of the Sustainable Development Scenario (116-118)

There is no silver bullet for Southeast Asia's energy transition: multiple technologies and approaches are required

CO₂ emission reductions in the Sustainable Development Scenario relative to the Stated Policies Scenario



Notes: Mt CO₂ = million tonnes of carbon dioxide; CCUS = carbon capture, utilisation and storage. Activity indicates CO₂ emissions reductions due to reduced economic activities that are linked with fuel combustion.

Unlocking the benefits of a low-carbon future under the Sustainable Development Scenario will require much stronger policy efforts

The Stated Policies Scenario shows that Southeast Asia is on track to meet some key energy policy goals, such as achieving universal electricity access. However, it also highlights that the region's current and planned policies fall far short of achieving other critical aims, such as improving environmental sustainability and reducing climate-related risks, while at the same time it leads to additional vulnerabilities and costs in terms of energy security.

The transition of Southeast Asia's energy system towards a low-carbon pathway based on the Sustainable Development Scenario (SDS) would yield manifold benefits to Southeast Asia: attaining universal access to clean cooking; reducing harmful local air pollution; reversing the rising trend in CO₂ emissions; improving energy security and bringing down import bills. But this would require significantly stronger policy efforts than those in the Stated Policies Scenario.

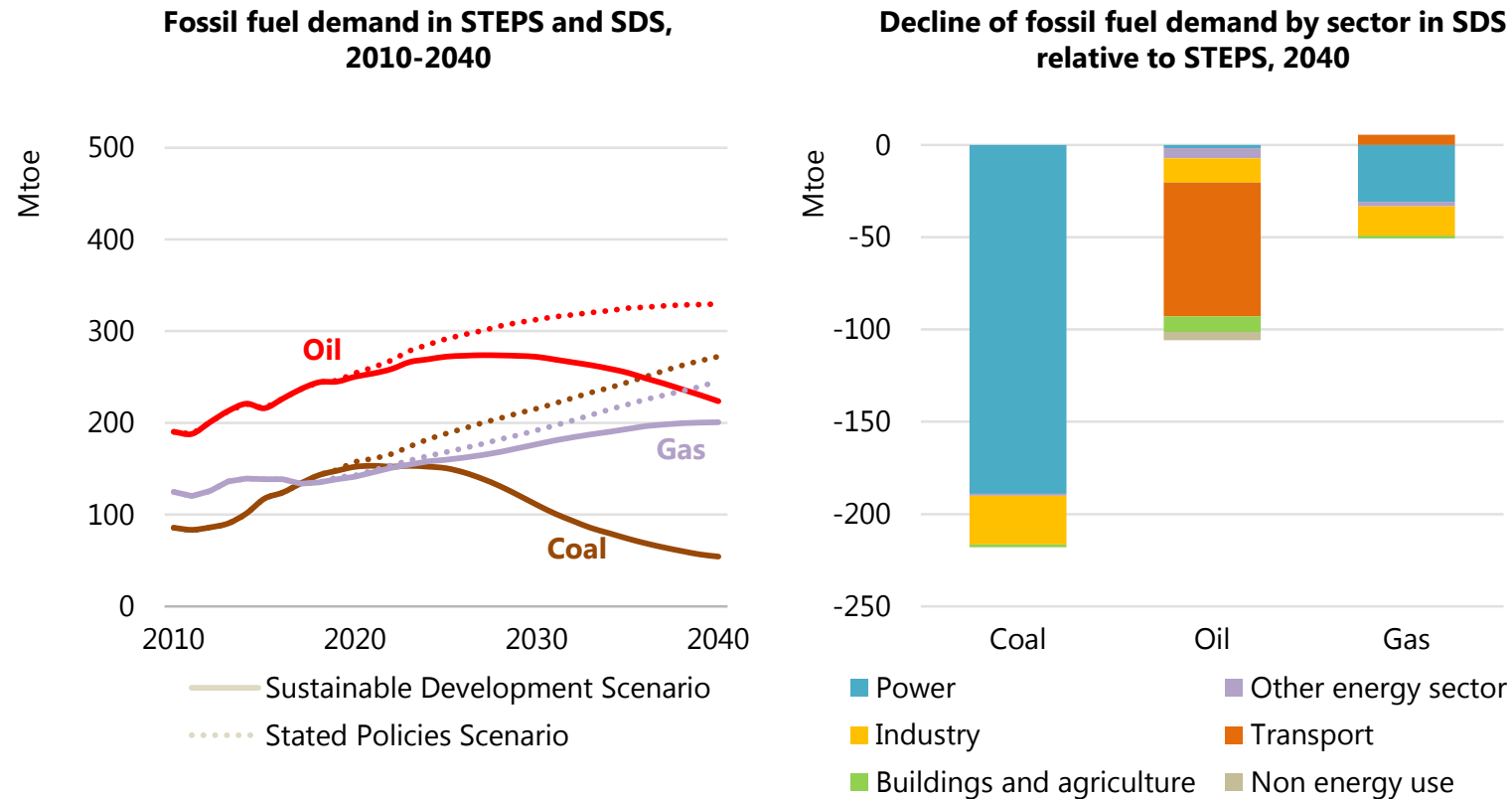
All parts of the energy sector have an important role to play in achieving Southeast Asia's energy transition. Increasing the role of renewables – particularly in the power sector – and improving the efficiency of energy end-use – particularly in rapid growing sectors such as cooling – are key elements in the transition, but a host of other measures are required.

For example, despite some progress in recent years, Southeast Asia has not phased out fossil fuel consumption subsidies, a measure essential to getting energy price signals right and spurring more sustainable energy consumption and investment decisions. Among renewable resources, the region's transition can also be boosted by its large potential for the sustainable use of modern bioenergy, including today's technologies and the development of advanced biofuels to improve the sustainability of transport, as well as increasing the use of biogas as a local source of power, heat and clean cooking for rural communities.

Other priorities to bridge the gap between the Stated Policies and Sustainable Development scenarios include some fuel switching from coal to gas; the retirement or repurposing of today's inefficient coal power plants and the deployment of CCUS technology in both power and industry. Related efforts to expand regional power trade would facilitate better integration and more affordable power supply, but would need to be coupled with strong sectoral measures to promote low-carbon power sources in order to support a reduction in emissions.

Demand for oil and coal in 2040 is 50% lower in the Sustainable Development Scenario relative to the Stated Policies Scenario

Fossil fuel demand by scenario 2010-2040 and decline by fuel and sector, 2040



Note: Mtoe = million tonnes of oil equivalent; STEPS = Stated Policies Scenario; SDS = Sustainable Development Scenario.

Policies adopted to support the objectives of the Sustainable Development Scenario deliver a transformation in the region's energy mix

In the Sustainable Development Scenario, Southeast Asia's total primary energy demand increases only slightly over today's level, as increasing energy efficiency supports a steep decline in energy intensity. But the shifts in energy consumption and power generation deliver a significantly different outlook than in the Stated Policies Scenario.

Coal demand peaks after 2020 and is cut by 80% relative to the Stated Policies Scenario; an average annual decline in coal use of 4.3% over the projection period brings demand down towards 50 Mtoe in 2040. Some 90% of the decline in coal use in 2040 occurs in the power sector, where the share of coal in electricity generation falls to 4% in 2040 (from 40% today).

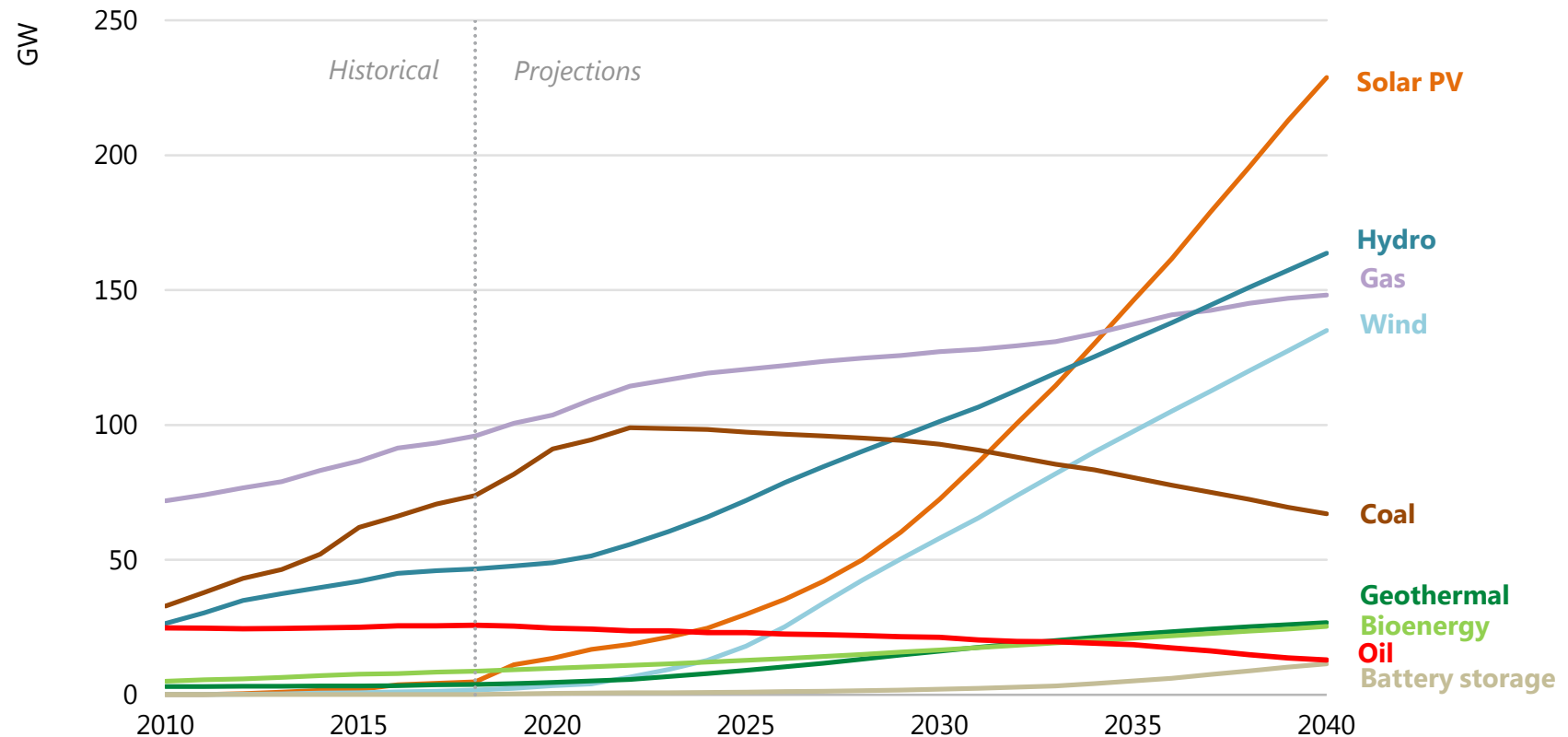
Oil demand peaks soon after coal in the Sustainable Development Scenario and declines to 220 Mtoe in 2040, more than 30% below the level of the Stated Policies Scenario. The majority of the decline in oil demand comes from transport, the largest oil consumer today. This is thanks to the average fuel economy of cars on the road becoming twice as efficient as today, as well as the use of biofuels as an alternative to oil (biofuels consumption increases by almost fourfold by 2040 compared to today's level).

Natural gas is the only fossil fuel that does not experience a pronounced peak and decline in the Sustainable Development Scenario. Its use increases by around 50% by 2040 compared to today's levels.

The traditional use of biomass for cooking across Southeast Asia fades completely in the Sustainable Development Scenario, as a result of policies that promote alternative fuels for cooking and the use of advanced cookstoves. By 2040, the traditional use of solid biomass is around 90% lower than today (compared with a decline of around 30% in the Stated Policies Scenario).

Solar PV and hydro lead in installed power capacity after 2035 and renewables comprise almost three-quarters of capacity by 2040

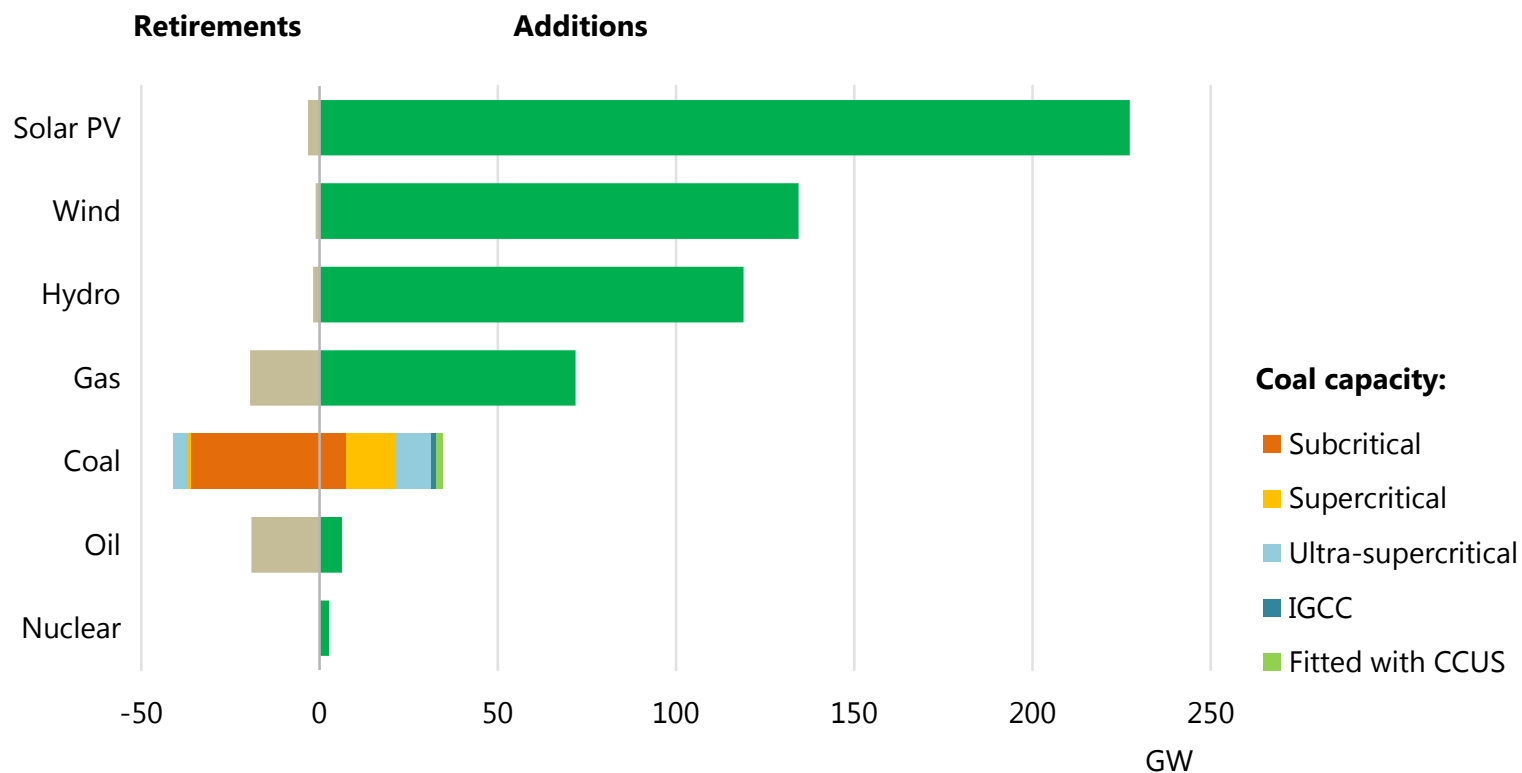
Installed generation capacity by technology in Southeast Asia in the Sustainable Development Scenario



Note: GW = gigawatts; solar PV = solar photovoltaics.

Coal plants have a lesser role and subcritical plants are retired in a remix of power generation

Total power capacity additions and retirements in Southeast Asia in the Sustainable Development Scenario, 2019-2040



Note: IGCC = integrated gasification combined-cycle; CCUS = carbon capture, utilisation and storage; solar PV = solar photovoltaics.

The power sector undergoes a profound transformation

With electricity's share in final energy consumption set to approach one-third by 2040 in the Sustainable Development Scenario, the power sector plays a critical role in meeting sustainability goals. In particular, accelerated deployment of renewables is a key driver of CO₂ emission reductions in the region. This measure alone makes up 50% of the emissions gap between the Stated Policies and Sustainable Development scenarios.

In 2018, renewables accounted for one-quarter of total power generation in Southeast Asia. The share of renewables in generation triples in the Sustainable Development Scenario to around 70% in 2040. Solar PV, hydropower and wind are the biggest contributors with combined capacity additions of over 450 gigawatts (GW) to 2040.

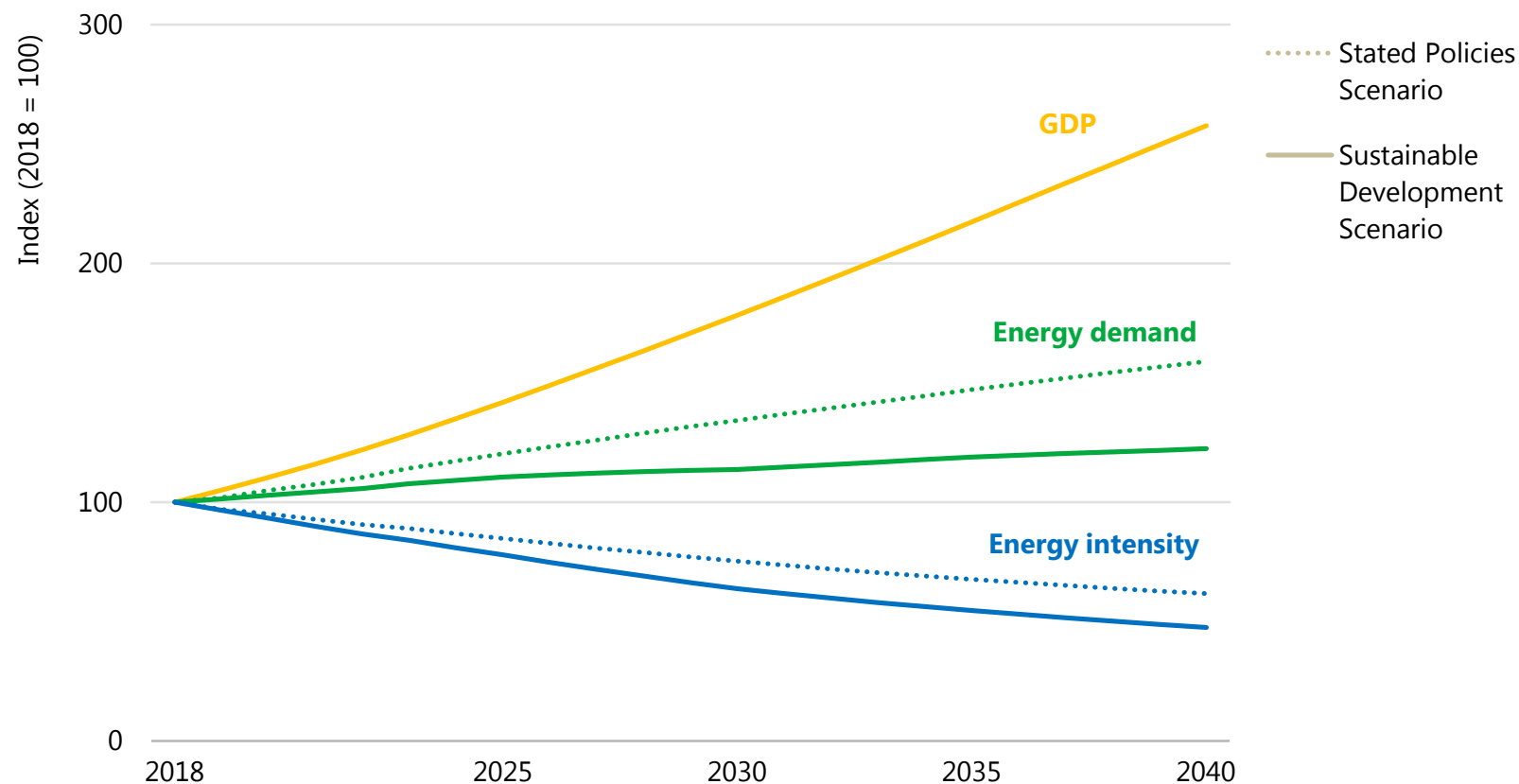
The very high share of generation from renewables by 2040 would not only require the right kind of policy support and regulatory framework to attract investment but also a flexible power system to keep supply and demand in balance and ensure system stability. Enhanced regional power trade and policy frameworks that encourage investment in a low-carbon mix of renewables, dispatchable generation and storage (notably batteries) are key enablers.

Meeting sustainability targets also points towards much lower reliance on coal-fired power generation and increased retirements of inefficient coal plants. By 2040, coal-fired electricity generation is 90% lower in the Sustainable Development Scenario than in the Stated Policies Scenario.

The remaining coal technologies are considerably more efficient than in the Stated Policies Scenario. Between 2019 and 2040, installed capacity from coal plants using subcritical technologies decreases by almost 30 GW, while capacity from more efficient supercritical, ultra-supercritical or IGCC coal power plants increases by 20 GW. Some coal plants are repurposed to provide additional flexibility: others are fitted with CCUS technology in order to make their operation compatible with climate goals.

While GDP more than doubles by 2040, an enhanced focus on energy efficiency moderates energy demand growth

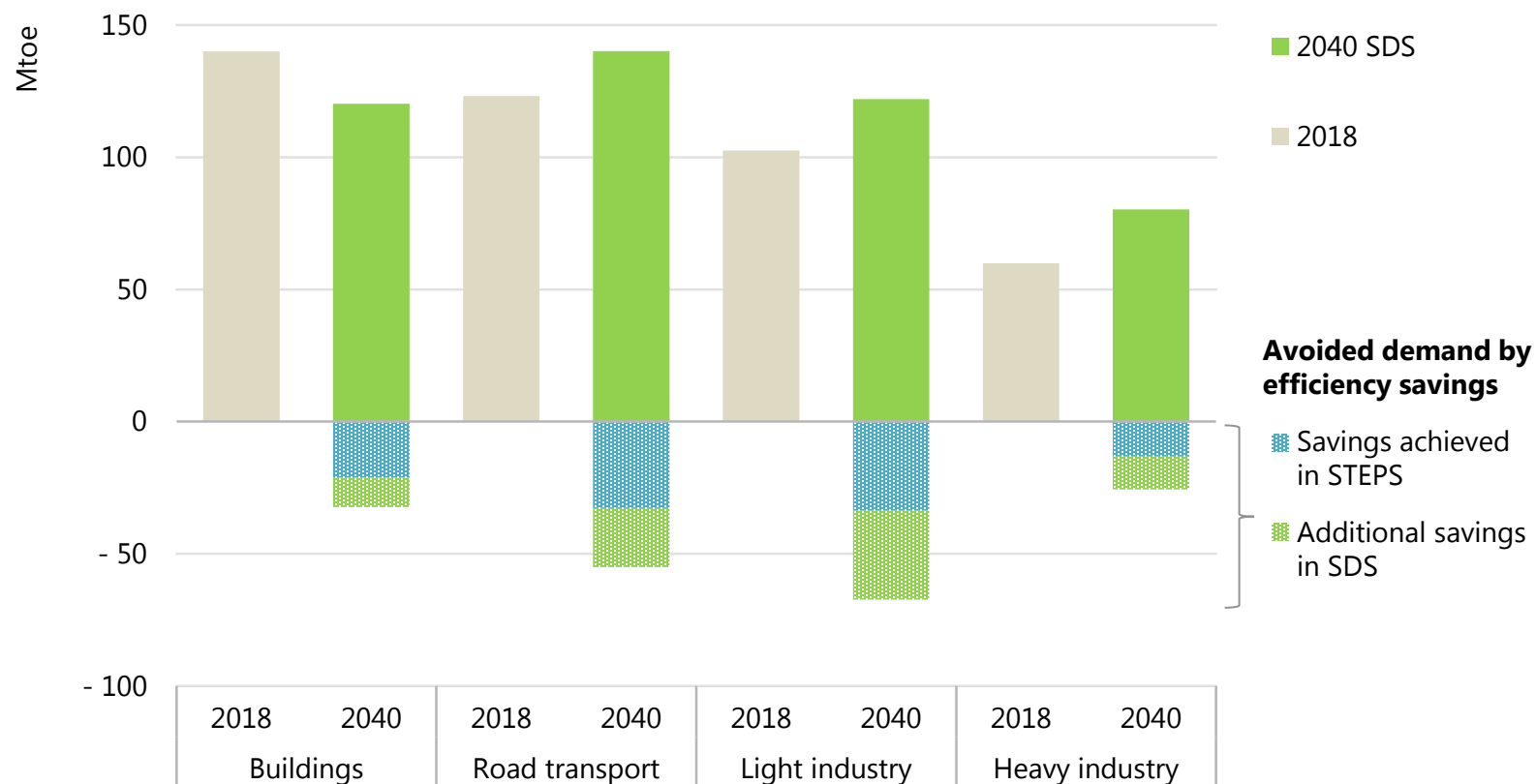
GDP, energy demand and energy intensity by scenario in Southeast Asia



Note: GDP = gross domestic product (\$2018, purchasing power parity).

Southeast Asia can achieve much higher efficiency gains

Final energy consumption and avoided energy use through energy efficiency in the Sustainable Development Scenario



Notes: Mtoe = million tonnes of oil equivalent; STEPS = Stated Policies Scenario; SDS = Sustainable Development Scenario. Light industry includes manufacturing. Heavy industry includes iron and steel, chemicals, cement, paper and aluminium.

Improvements in energy efficiency simultaneously address energy security, affordability and environmental concerns

Energy efficiency is an essential component of Southeast Asia's energy transition. It contributes about 30% of the CO₂ emissions reductions in the Sustainable Development Scenario relative to the Stated Policies Scenario. It also eases energy security concerns by curbing import growth, while keeping consumer energy bills in check.

Energy intensity, the ratio of primary energy supply to GDP (one of the indicators used to track progress on energy efficiency), would need to fall by an annual average of 3.3% to be consistent with the Sustainable Development Scenario. The annual average rate of improvement in energy intensity is 2.2% under the Stated Policies Scenario. Governments of Southeast Asian nations are increasingly pursuing energy efficiency measures, but enhanced efforts – including establishing performance standards and labelling, sharing information, and providing incentives and market-based instruments – would be vital to accelerate improvements in efficiency.

Efficiency plays a major role across all sectors in the Sustainable Development Scenario. In transport, road passenger vehicles use almost 50% less fuel per kilometre travelled in 2040 compared with today, supported by strengthened fuel economy standards and larger uptake of

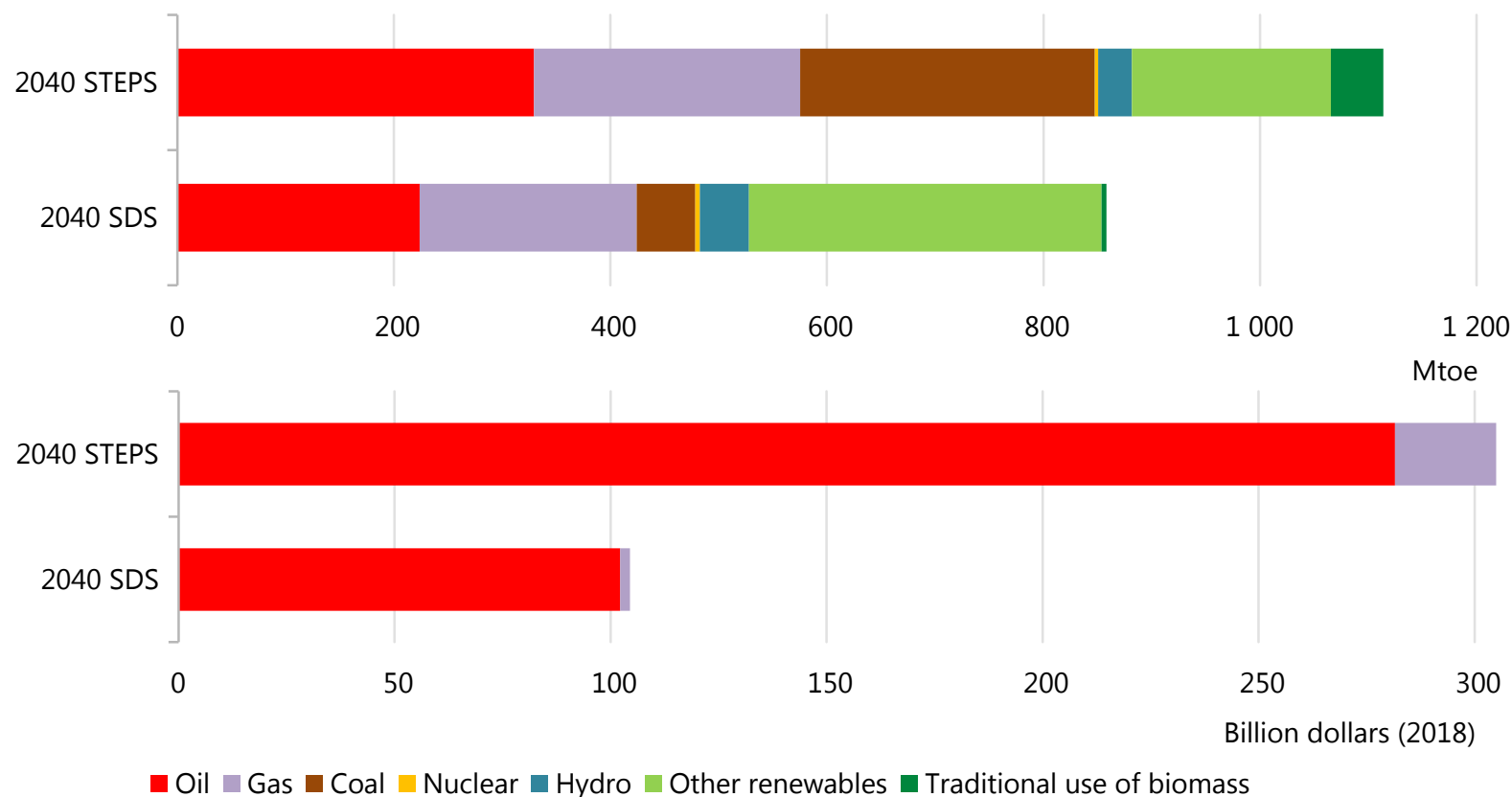
electric vehicles. Efficiency gains avoid more than 20 Mtoe of fuel consumption in road transport in the Sustainable Development Scenario relative to the Stated Policies Scenario in 2040.

In the industry sector, the average energy intensity decreases by 50% from today's levels, thanks largely to increases in recycling rates and equipment efficiency. This contributes to cutting industrial energy demand by almost 30% in the Sustainable Development Scenario relative to the Stated Policies Scenario in 2040.

In the buildings sector, energy efficiency measures save an additional 10 Mtoe in the Sustainable Development Scenario relative to the Stated Policies Scenario in 2040. This reflects more stringent MEPS for appliances and particularly for cooling equipment, (discussed in detail in the Future of Cooling section, slides 121-136).

Lower fossil fuel imports yield annual savings of more than \$200 billion on the region's energy import bill by 2040

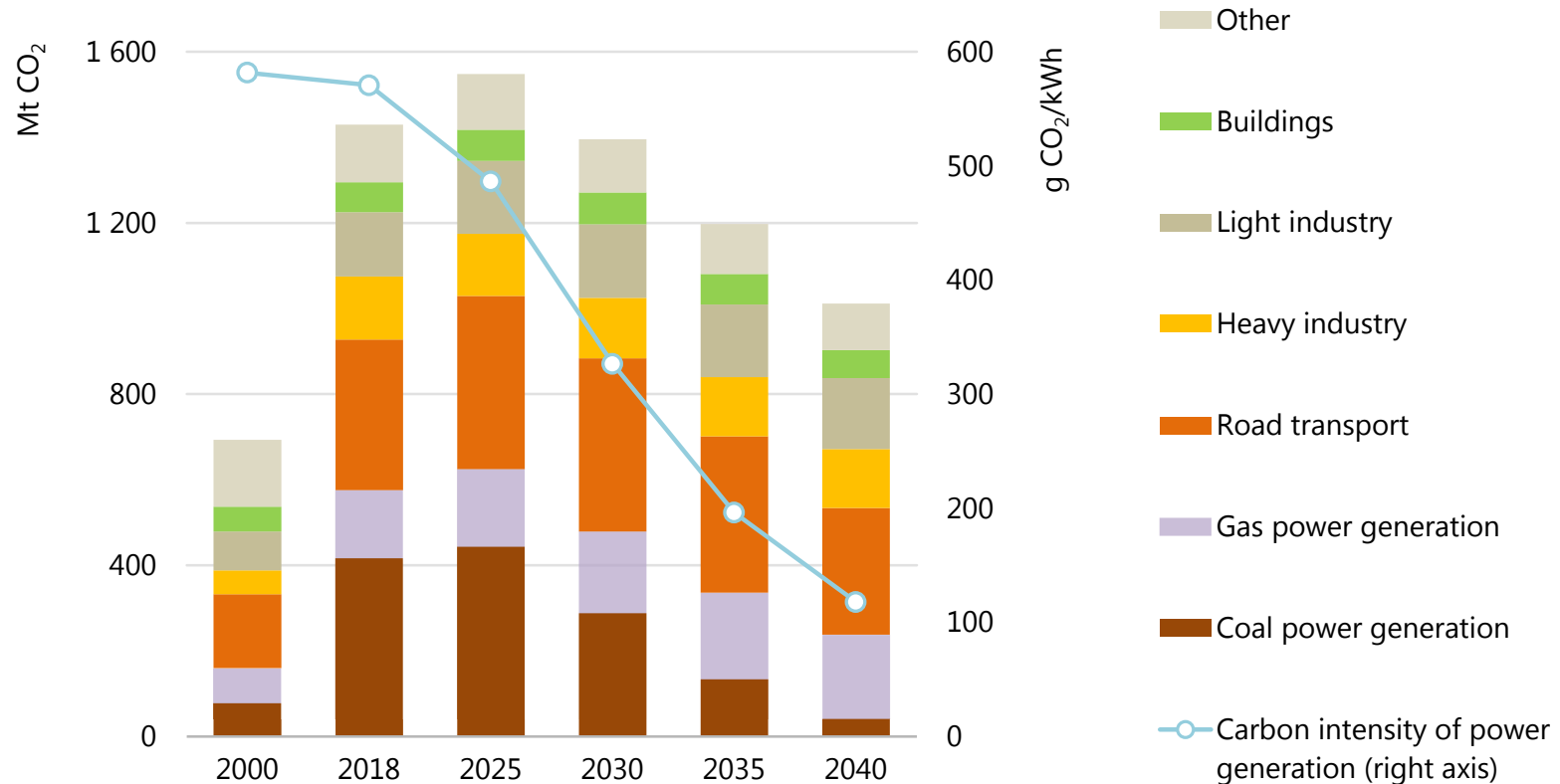
Total primary energy demand (top) and energy import bill (bottom) by scenario in Southeast Asia



Notes: STEPS = Stated Policies Scenario; SDS = Sustainable Development Scenario; Mtoe = million tonnes of oil equivalent. Other renewables include solar photovoltaic, wind, geothermal and modern use of bioenergy.

CO₂ emissions peak before 2025 and the carbon intensity of electricity generation decreases nearly 80% by 2040

CO₂ emissions from selected sectors and carbon intensity of power generation in the Sustainable Development Scenario in Southeast Asia



Notes: Mt CO₂ = million tonnes of carbon dioxide; g CO₂/kWh = grammes of CO₂ per kilowatt-hour. Light industry includes manufacturing. Heavy industry includes iron and steel, chemicals, cement, paper and aluminium.

Higher investment requirements are offset by lower import bills, fuel costs, health impacts and climate risks

A shift towards low-carbon sources of supply, coupled with higher levels of energy savings, yields pronounced security benefits in the Sustainable Development Scenario. These benefits offset the higher investment requirements of that pathway (on average over \$140 billion annually from 2019 to 2040), which are a quarter more than in the Stated Policies Scenario.

Efficiency measures and electrification contribute to an overall 30% decrease in oil demand which reduces dependence on oil imports by one-third in 2040. Combined with a 90% decrease in natural gas imports, Southeast Asian economies save nearly \$200 billion annually on fossil fuel imports in 2040 compared with the Stated Policies Scenario.

A lower carbon primary energy mix also significantly reduces Southeast Asia's contribution to global energy-related CO₂ emissions. In the Sustainable Development Scenario, CO₂ emissions peak before 2025 and pare to near 1 Gt in 2040, almost 30% below the level of 2018.

The power sector makes the biggest contribution to reduced emissions, as coal-fired generation rapidly loses ground to renewables and, to a lesser extent, natural gas. In 2040, the

carbon intensity of power generation in the region is almost 80% lower than in 2018.

Emissions from the three major air pollutants (SO₂, NO_x and PM_{2.5}) decline sharply from current levels in the Sustainable Development Scenario, despite a modest rise in energy demand. As a result, human health prospects are dramatically improved; premature deaths linked to outdoor and household air pollution together are lower by almost 500 000 compared to the Stated Policies Scenario.

In the Sustainable Development Scenario, universal access to both electricity and clean cooking facilities is also achieved by 2030, in line with the objectives of the United Nations Sustainable Development Goals. Achieving universal clean cooking access in Southeast Asia relies on the deployment of liquefied petroleum gas (LPG), natural gas and electricity in urban areas. In total around 90 million people gain access via improved biomass stoves or electric stoves, while LPG and biogas provide for the remaining 130 million people. The investment required for clean cooking facilities is relatively modest, amounting to an annual average of \$360 million from today to 2030.

Addressing Southeast Asia's energy priorities

Overview

Three aspects of the energy outlook for Southeast Asia are examined in detail in the following sections:

How does **rising demand for cooling** strain the region's electricity systems and which targeted policies can mitigate the impacts?

How can **regional electricity trade** help to meet demand cost-effectively, while facilitating efforts to increase the share of wind and solar in power supply?

What are the **investment needs** to provide reliable, affordable and sustainable electricity and what strategies are available to encourage an increase in capital flows to the sector?

These important topics reflect the priorities for co-operation between ASEAN and the International Energy Agency that were included in the joint ministerial statement of the 36th ASEAN Ministers of Energy meeting, which took place in Singapore in October 2018.

At this meeting, the ministers discussed the global energy landscape and ways to address ASEAN's challenges of

rising energy demand, improving grid connectivity and enhancing energy efficiency. Ministers supported building stronger institutional ties with the IEA to assist the region to meet its energy priorities, and mentioned in particular the importance of regional power system integration, renewables integration, energy efficiency for cooling/air conditioning, investments and digitalisation.

Ministers continued their dialogue with IEA in September 2019 at the 37th ASEAN Ministers of Energy meeting in Bangkok, including an advance discussion of key findings from this report. Ministers reviewed the extensive range of collaboration between ASEAN and the IEA and noted that the Agency is a key strategic partner in helping the region tackle its energy challenges across all fuels and all technologies.

Future of cooling

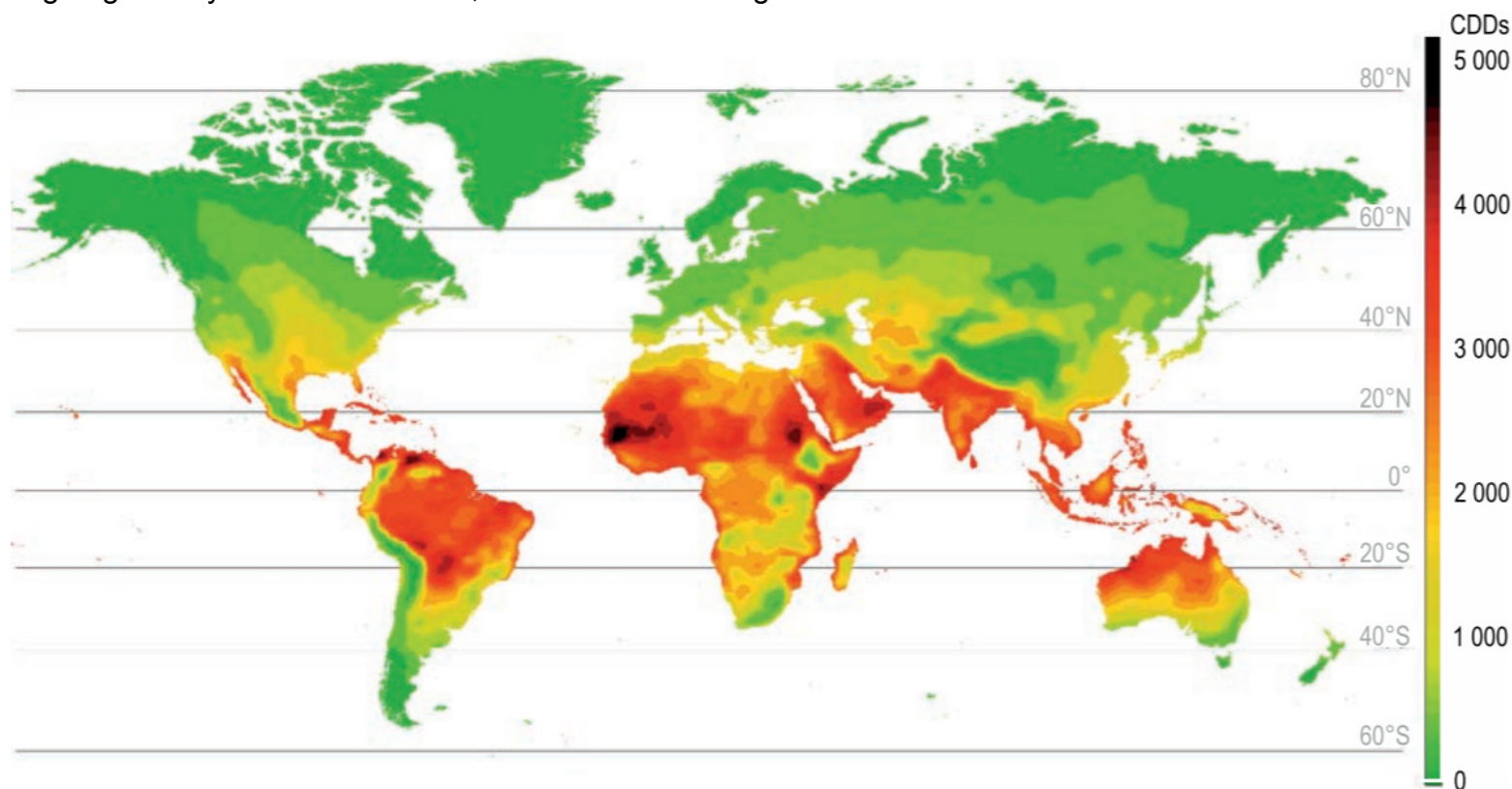
Historical trends and factors shaping the energy outlook (121-125)

Outlook for cooling (126-133)

Roadmap to improve energy efficiency of cooling equipment (134-136)

The need for space cooling in Southeast Asia is high

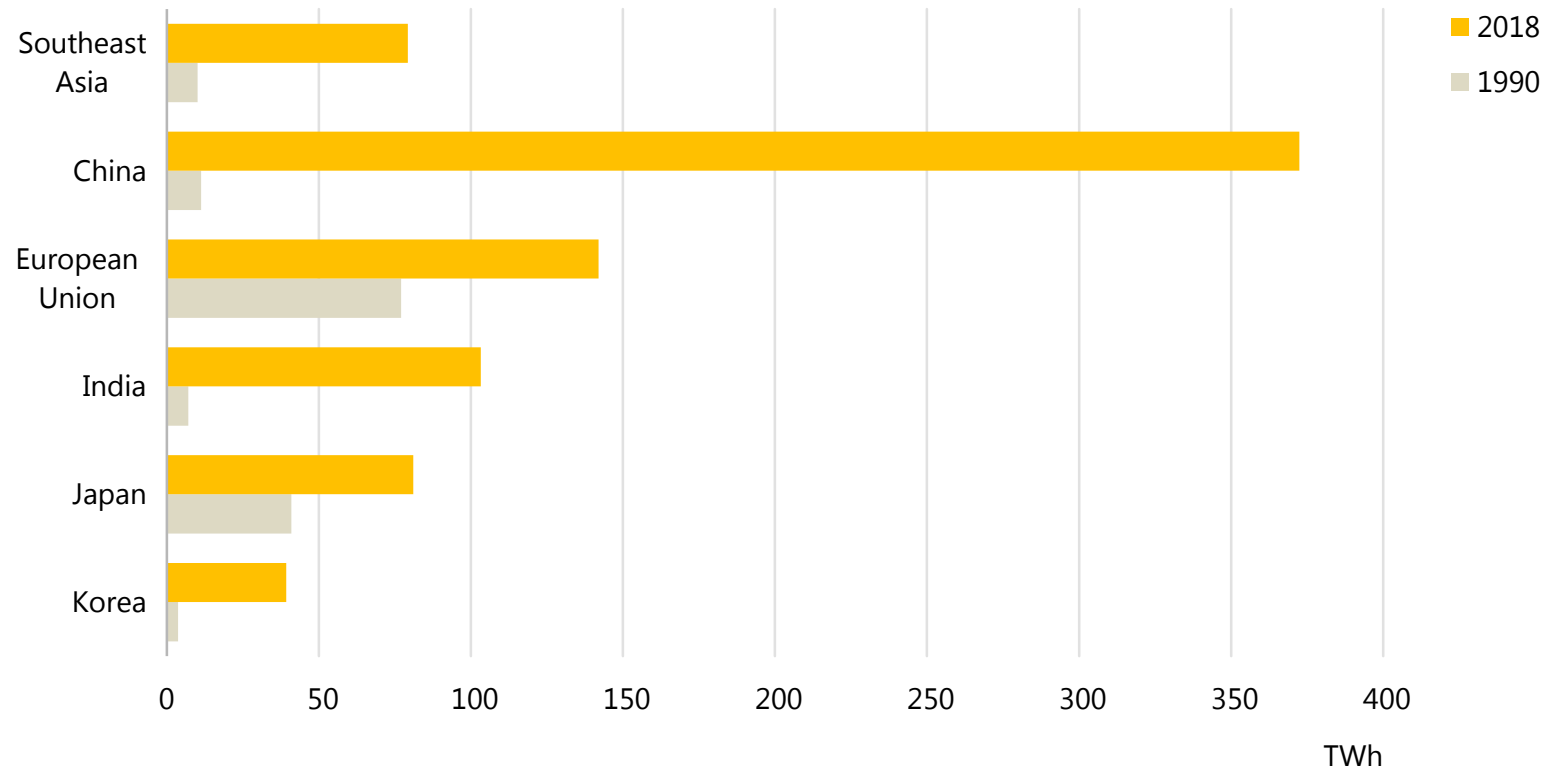
Cooling degree days across the world, mean annual average 2007-17



Notes: A degree day measures how cold or warm a given location is by comparing the mean of the high and low outdoor temperatures recorded each day to a standard temperature. For the purpose of this report, cooling degree days (CDD) are measured in degrees Celsius (°C), standardised to 18 °C in all countries. CDD measure how much the mean temperature exceeds the standard temperature each day over a given period. To account for the influence of humidity, a heat index is used, which corrects CDD by combining air temperature and relative humidity in order to determine the temperature as perceived by humans. The resulting number is weighted by population across a country or region and the entire year.

Energy consumption for cooling is on the rise in Southeast Asia

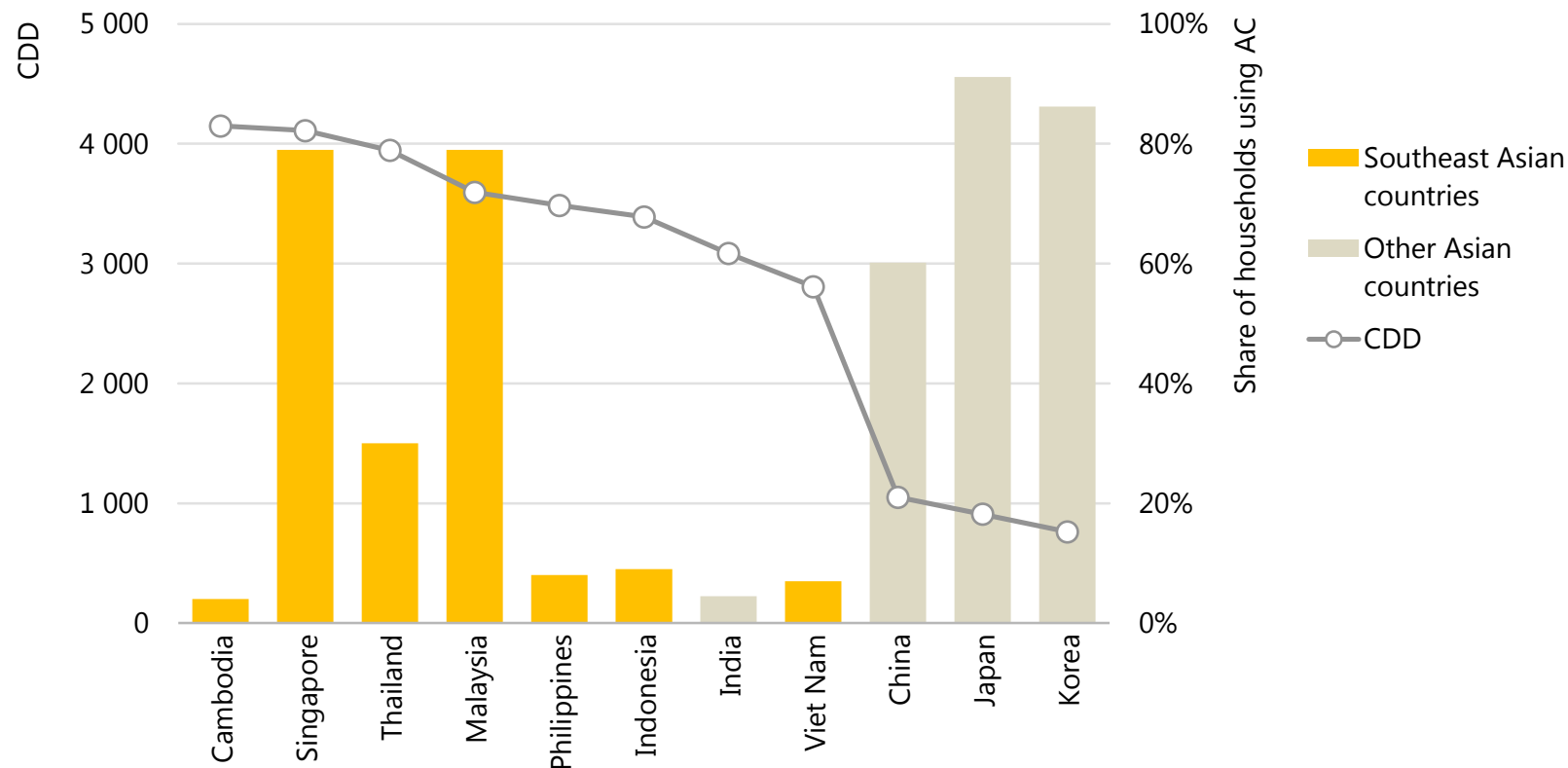
Electricity consumption of air conditioning systems in residential and commercial buildings by country/region



Note: TWh = terawatt-hours.

... however, most households in Southeast Asia have yet to purchase their first air conditioner

Cooling degree days and share of households using air conditioning by country, 2017



Note: CDD = cooling degree days; AC = air conditioner.

The region is set for a rapid increase in cooling demand

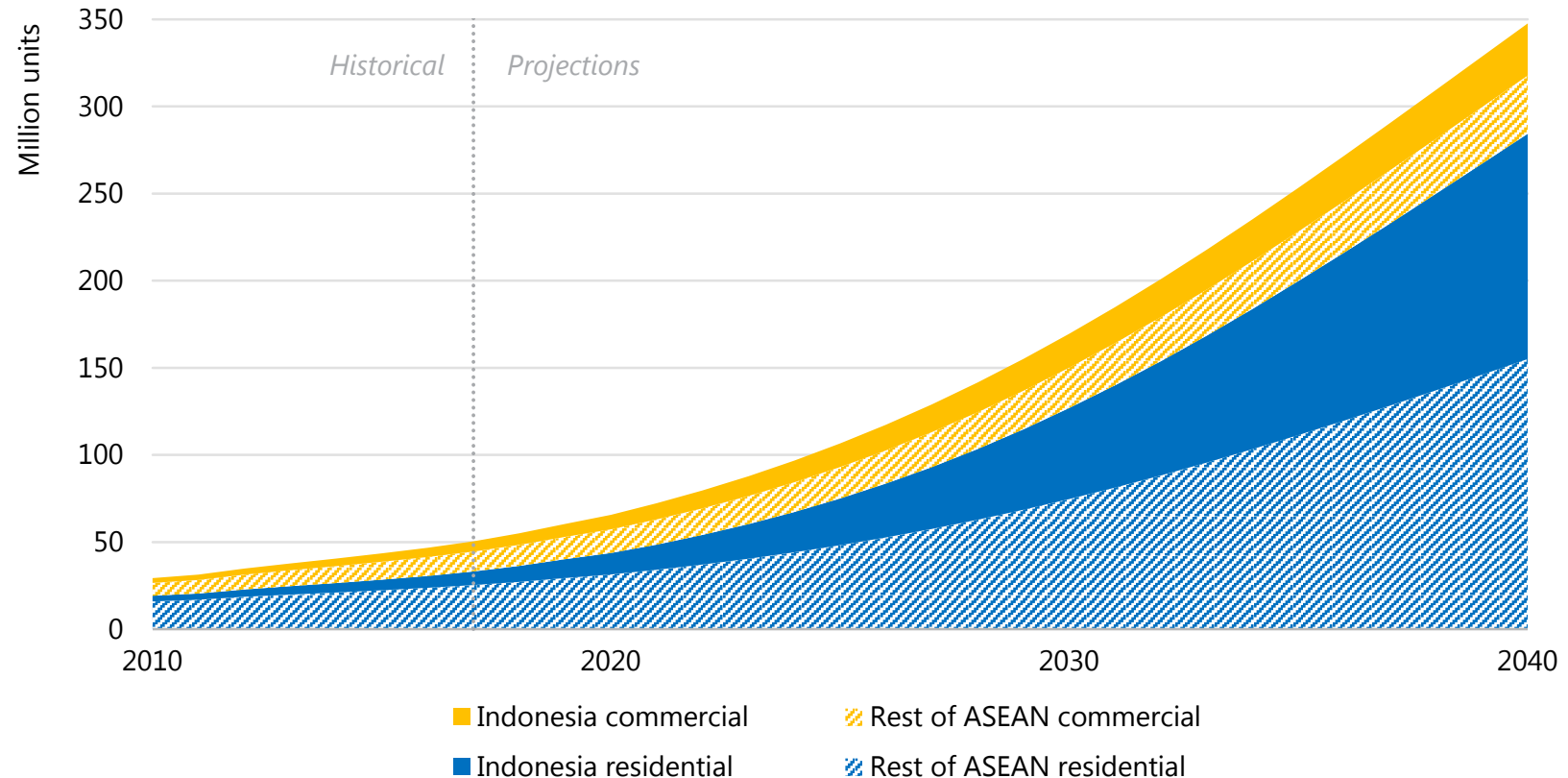
Space cooling is the fastest-growing use of electricity in the buildings sector worldwide. Electricity use for cooling in buildings in Southeast Asia increased from 10 terawatt-hours (TWh) in 1990 to almost 80 TWh in 2018. Over the same period, the share of space cooling in total electricity use in Southeast Asia rose from 8 to 9%.

Today only 15% of households in Southeast Asia have an air conditioner (AC) compared with more than 80% of households in some wealthier countries with less challenging climates. There are also large differences in ownership across the region with almost 80% of households in Singapore and Malaysia having air conditioning compared to less than 10% in Cambodia, Indonesia, Philippines and Viet Nam. This disparity highlights the significant potential for increased adoption of air conditioning in major markets.

As incomes rise, access to electricity improves and prosperity becomes more widespread, air conditioning is becoming affordable for more people across Southeast Asia. Increasing urbanisation accentuates the increase in demand for space cooling, as incomes (and temperatures) tend to be higher in urban areas. In addition, the region is set to see an increase in the number of air conditioning units per household

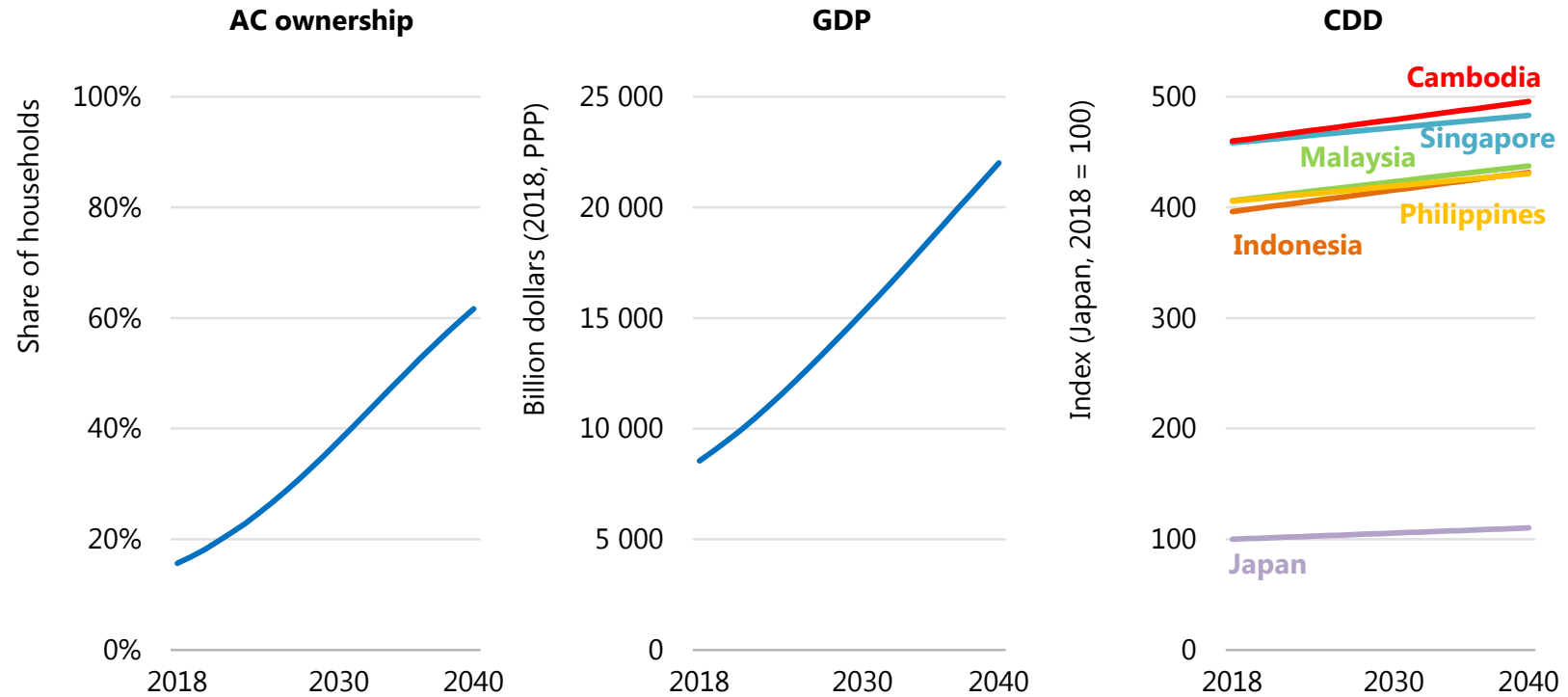
In the Stated Policies Scenario, the use of air conditioning across Southeast Asia grows rapidly...

Stock of air conditioning units in Southeast Asia in the Stated Policies Scenario



...driven by higher incomes and higher temperatures

Share of households with air conditioning, GDP and number of cooling degree days in selected Asian countries in the Stated Policies Scenario



Notes: AC = air conditioning; GDP = gross domestic product (\$2018 PPP). Cooling degree days (CDD) are relative to a base temperature of 18 °C.

Projected trends in Southeast Asia should push cooling up the policy agenda

In the Stated Policies Scenario, the number of air conditioners in Southeast Asia skyrockets from almost 40 million units in 2018 to 350 million in 2040, mostly for use in residential buildings. Residential AC units are projected to make up more than 80% of the total stock by 2040. Indonesia sees the biggest expansion and accounts for almost 50% of all air conditioners in the region by 2040.

Increasing demand for space cooling in Southeast Asia is underpinned by rising incomes and urbanisation, which increase both the share of households owning air conditioners and the number of units owned per household. By 2040, 60% of households in Southeast Asia have air conditioning, possessing on average almost two units each.

Rising temperatures and humidity are also set to affect patterns of AC use. The number of cooling degree days today in Southeast Asia is over four-times as high as in Japan, and most Southeast Asian countries are projected to see an increase in their already high number of cooling degree days by up to almost 10% above 2018 levels.

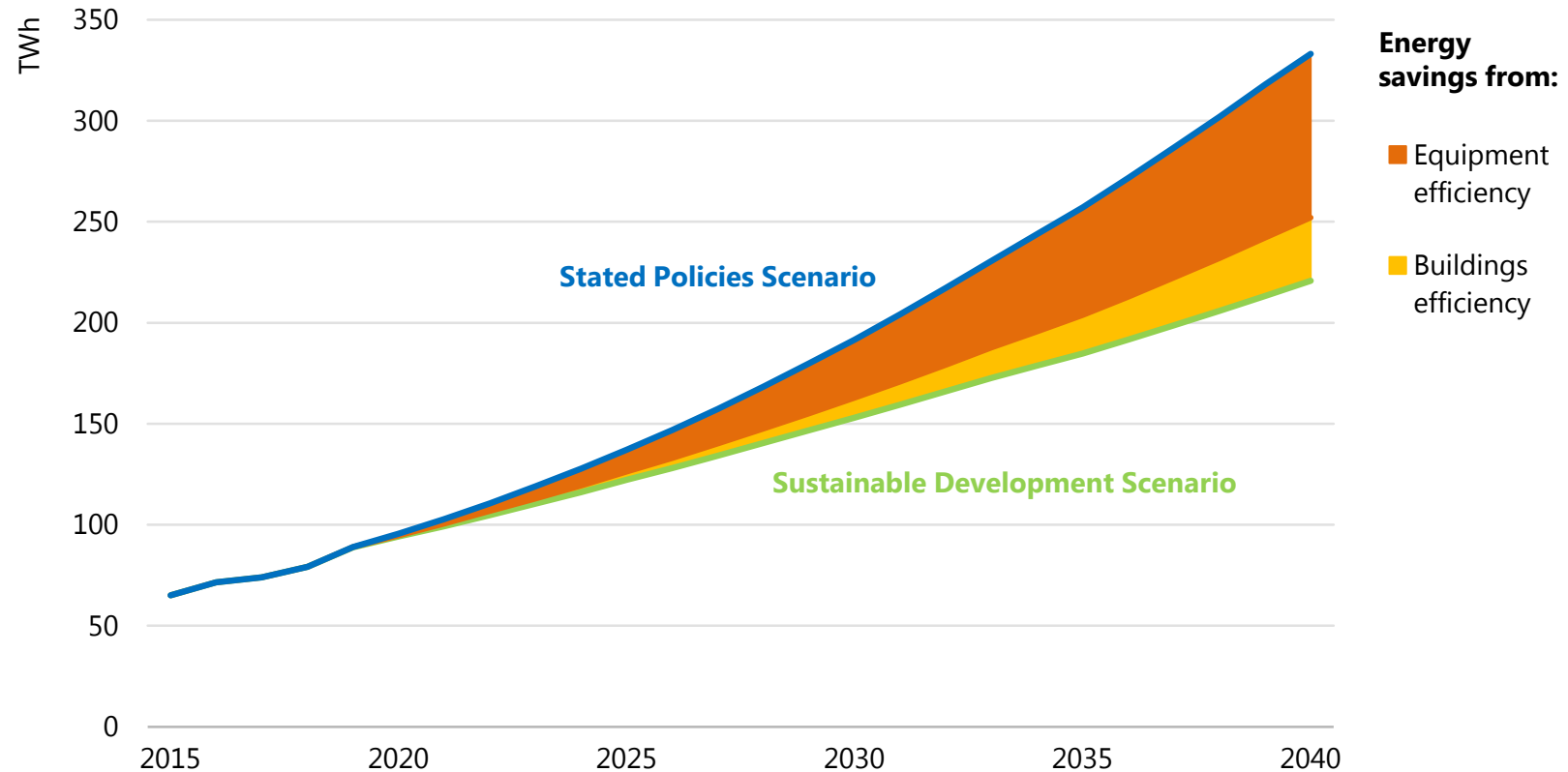
As a result, the consumption of electricity for cooling shoots up to around 330 TWh by 2040 from almost 80 TWh in 2018, bringing the share of cooling in total electricity consumption in Southeast Asia to almost 16%, up from 9% in 2018.

Increased air conditioning loads not only raise overall electricity demand. The daily and seasonal profile of cooling demand is such that increased load also pushes up peak demand. In the Stated Policies Scenario, cooling is responsible for almost 30% of peak electricity demand by 2040 in Southeast Asia, up from around 10% today.

Without stronger measures to encourage the uptake of more efficient AC units, rising electricity demand from cooling alone would require around 150 gigawatts (GW) of additional generation capacity by 2040.

More efficient air conditioners and buildings would bring huge benefits

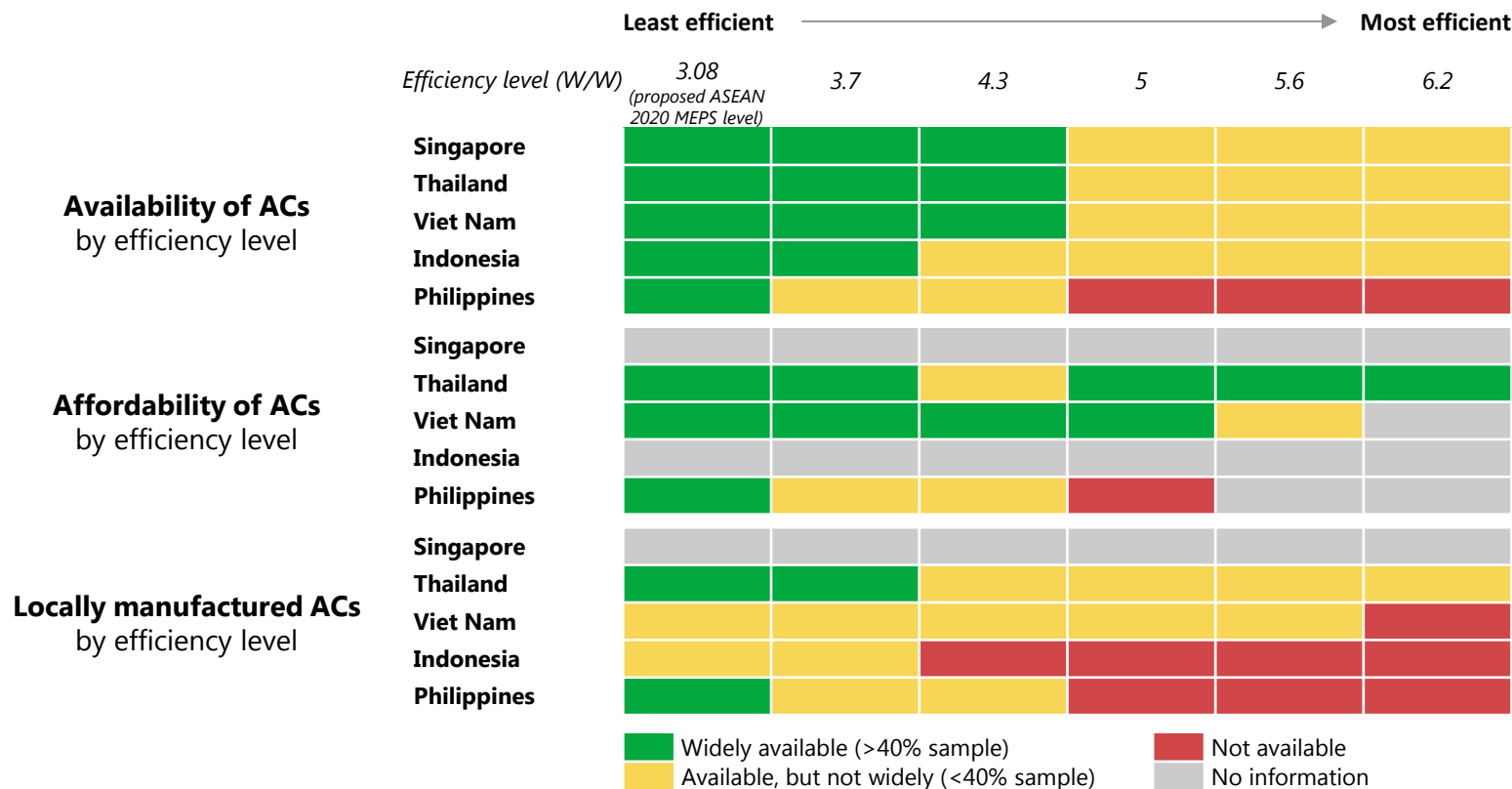
Reduction of energy demand for cooling in residential and commercial buildings in the Sustainable Development Scenario relative to the Stated Policies Scenario



Note: TWh = terawatt-hours.

More efficient air conditioners are not always more expensive or necessarily imported

Results of IEA air conditioning market analysis in selected Southeast Asian countries



Notes: AC = air conditioner; W/W = watts per watt; MEPS = minimum energy performance standards. Results shown for models with cooling capacity <15,000 British thermal units per hour. Efficiency level defined in terms of seasonal energy efficiency ratio (SEER) where higher values equal higher efficiency. *Widely available* means that at least 40% of models in the sample were higher efficiency than the efficiency tested. "Technically available" means that models exist on the market which have an efficiency higher than the efficiency tested. *More affordable* means that models with efficiency higher than the efficiency tested are available at a price that is lower than the average price of models in that category. Price has been normalised by capacity. *Available by local manufacturer* means that models with efficiency higher than the efficiency tested are available by a manufacturer from that country.

Sources: IEA analysis based on data from CLASP, Kigali Cooling Efficiency Program, national registration databases of Indonesia and Singapore.

The average efficiency of air conditioners sold today is well below the efficiency of the best-performing models in each market

Efficiency of air conditioning units in selected markets in Southeast Asia, 2017



Notes: W/W = watt per watt. Results shown for models with cooling capacity <15 000 British thermal units per hour. SEER = the ratio of output cooling to electrical energy input, adjusted for the overall performance of the device for the weather over a typical cooling season in each country. CSPF = cooling seasonal performance factor (higher values equal better efficiency). EER = the ratio of the output of cooling energy to input energy. Weighted COP = 0.4 x COP at 100% capacity + 0.6 x COP at 50% capacity, where COP = coefficient of performance.

There are affordable, available and often locally manufactured ways for countries to raise their cooling profile...

The seasonal energy efficiency ratio (SEER) rating of a unit is the cooling output during a typical cooling season divided by the total electric energy input during the same period. The higher the unit's SEER rating the more energy efficient it is. Today the average SEER of air conditioners in the Southeast Asia market is approximately 3.2 watts per watt (W/W). This is 50% higher than in 1990, yet significantly lower than the global average of 4.2 W/W.

The best available technology in the countries analysed is 50% more efficient than the market average, indicating a large untapped potential to promote more efficient cooling in the region. Indeed, more efficient air conditioners are not only readily available but can be less expensive than the average model and often are locally manufactured.

For instance, models as efficient as 6.2 W/W are available in all the markets analysed (except for the Philippines). Yet in these markets, less efficient models of at least 3.7 W/W make up about 60% of the market. Moreover, in all markets where retail price data were available, models that are far more efficient than the current MEPS and even than the market average are available at prices at or below that of the average unit.

For example, in Thailand consumers can purchase a unit as efficient as 7.2 W/W, 50% above the market average, without paying more than the average price of an air conditioner in that market. Across the board there is little correlation between retail price and efficiency, with significant variations in efficiency for the same price and capacity.

This situation is not stimulating the uptake of more efficient air conditioners, in part due to the ineffectiveness of labelling programmes. In many of the Southeast Asian countries, the majority of air conditioning units are already in the top category. This means that consumers are not able to identify the most efficient products.

Notably, all the markets analysed have locally manufactured models with an efficiency of at least 3.7 W/W and up to 5.6 W/W in Thailand and Viet Nam. This suggests, that within one manufacturing production cycle, local manufacturers could have the technical capability to increase the efficiency of their products significantly. This evidence should reassure governments that they can significantly raise MEPS without harming local industry and without raising the cost to consumers.

¹ SEER is a commonly used measure of the efficiency of cooling equipment that takes into account changes in operating conditions throughout the cooling season

... and cut projected electricity demand growth for cooling by half

Improving building and equipment efficiency through more stringent MEPS are a key action that policy makers can undertake to reduce the increase energy demand for cooling. This would ease upward pressure on Southeast Asia's power supply needs.

In the Sustainable Development Scenario, the average energy performance of the stock of residential ACs in Southeast Asia, as measured by the SEER, reaches 7.4 W/W by 2040. As our analysis demonstrates, models that meet such targets are already available in the region.

In the Sustainable Development Scenario, the deployment of more efficient ACs is coupled with other efficiency measures in buildings, such as envelope measures like improved windows, insulation in external walls and roofs, air tightness and solar shading. Together, equipment and building efficiency improvements reduce cooling-related electricity consumption by 35% in the Sustainable Development Scenario relative to the Stated Policies Scenario in 2040.

The much smaller increase in electricity needs for cooling in the Sustainable Development Scenario also results in the need for fewer additions of power generation and network capacity to support the higher demand. As a result incremental generation capacity needs for cooling are around 100 GW through to 2040, about 70% of the

additional capacity needs in the Stated Policies Scenario. Clearly, this offers significant cost savings.

Improved efficiency, coupled with a shift towards low-carbon fuels in the Sustainable Development Scenario, also contribute to reducing CO₂ emissions in the buildings sector. By 2040, these emissions are almost 30% less compared to the Stated Policies Scenario.

A roadmap to improve the efficiency of room air conditioners across Southeast Asia is highlighted in the following slides. These actions would be vital to move the region closer to achieving the Sustainable Development Scenario.

Other key actions to reduce the energy consumption for space cooling include increasing the performance of new and existing building envelopes, prioritising passive or hybrid strategies and raising awareness of the impacts of consumer behaviour. Critical actions in the commercial sector, aside from improving the performance of equipment such as chillers and their water systems, include the incorporation of thermal storage technologies and hybrid cooling systems, smart controls, and effective energy management and operation.

Minimum energy performance standards and secure demand for efficient products can “push” and “pull” the market...

PUSH

Why?

- Remove inefficient products from the market.
- Regular and predictable replacement of less efficient air conditioners allows for a smooth transition for manufacturers.

How?

Minimum energy performance standards (MEPS) ladder

- Allow countries to choose a starting point and commit to defined steps and timeframe to transition.
- Build on existing activities in the region led by Energy Efficiency and Conservation - Sub-Sector Network, for example ASEAN Shine proposals.
- Progressive MEPS have consistently been found to be effective in increasing efficiency of products on the market while not impacting long-term purchase price. (Sources: IEA, SEAD, 4E).
- Aggregate markets for efficient products to reduce cost for all.

PULL

Why?

- Provide certainty of demand for more efficient products.
- Assure market demand reduces risk to manufacturers and lowers prices of more efficient goods for consumers.

How?

Equipment list and high energy performance standards (HEPS)

- Method for defining and updating HEPS related to MEPS ladder.
- List of energy efficient air conditioners meeting HEPS for endorsement.
- Allows for price competition among listed products.

Public sector procurement

- Requirements for governments to buy the most efficient equipment.
- Linked to HEPS and equipment lists.

Incentives

- Loans, rebates and/or tax incentives linked to HEPS and equipment lists.

Bulk procurement

- Mass purchase of more efficient goods for lower prices.
- Performance linked to HEPS.

... alongside other actions to facilitate and smooth the process

FACILITATE

Why?

- Eases the process for consumers and manufacturers by providing information, capacity and incentives.
- Alleviates the pressure caused by push factors and supports the gains made by pull factors.

How?

Registration systems

- Co-ordinated databases allow for easy verification and regular analysis of market.
- Can be managed through applications (e.g. QR code) to provide additional consumer information.

Labels

- Allows consumers to choose based on their own financial needs.
- Must be regularly analysed to make sure the rating system reflects lowest to highest based on market population.

Awareness and capacity building

- Campaigns to highlight value of sustainable air conditioners and their efficient operation.
- Capacity building for testing and verification to ensure correct value placement.

Incentives

- On-bill financing to encourage consumers to invest and actually reduce energy use.
- Early replacement incentives to avoid lock-in of inefficient appliances.
- Industry transformation grants.

A roadmap for improving minimum energy performance standards

The IEA has developed a set of policy recommendations to transform the Southeast Asian room air conditioner market. This provides a roadmap, to which all countries across the region can commit, to boost minimum energy performance standards for air conditioners.

The suggested medium-term target for all Southeast Asian countries is to reach MEPS of CSPF 6.2 W/W for room air conditioners by 2030, almost double today's levels. This is paired with a target to reach an efficiency of 7.5 W/W average on the market by 2040. Notably, several markets across the region already have AC units that meet these minimum standards which are manufactured locally and can be purchased at no extra cost at the retail level.

The roadmap targets were suggested based on analysis of market data from five Southeast Asian countries that were collected through retail surveys and registration databases. It showed that all the markets analysed have the potential to increase MEPS at no additional cost to consumers or local industry.

In particular, all analysed markets can go beyond what Southeast Asian countries have already proposed as a regional-level MEPS with the ASEAN SHINE initiative, which has set an efficiency target of CSPF 3.08 W/W to be enforced by 2020.

Recognising that the Southeast Asian countries and their markets for air conditioners are varied, the roadmap supports specific applications. Each country may adopt its own starting point and timeline fitting to its circumstances, as well as different aspirational 2030 targets, which may also be more ambitious than the proposed 6.2 W/W.

Further engagement with individual countries can define the appropriate MEPS level and roadmap, as well as a supportive suite of policies.

Regional power trading

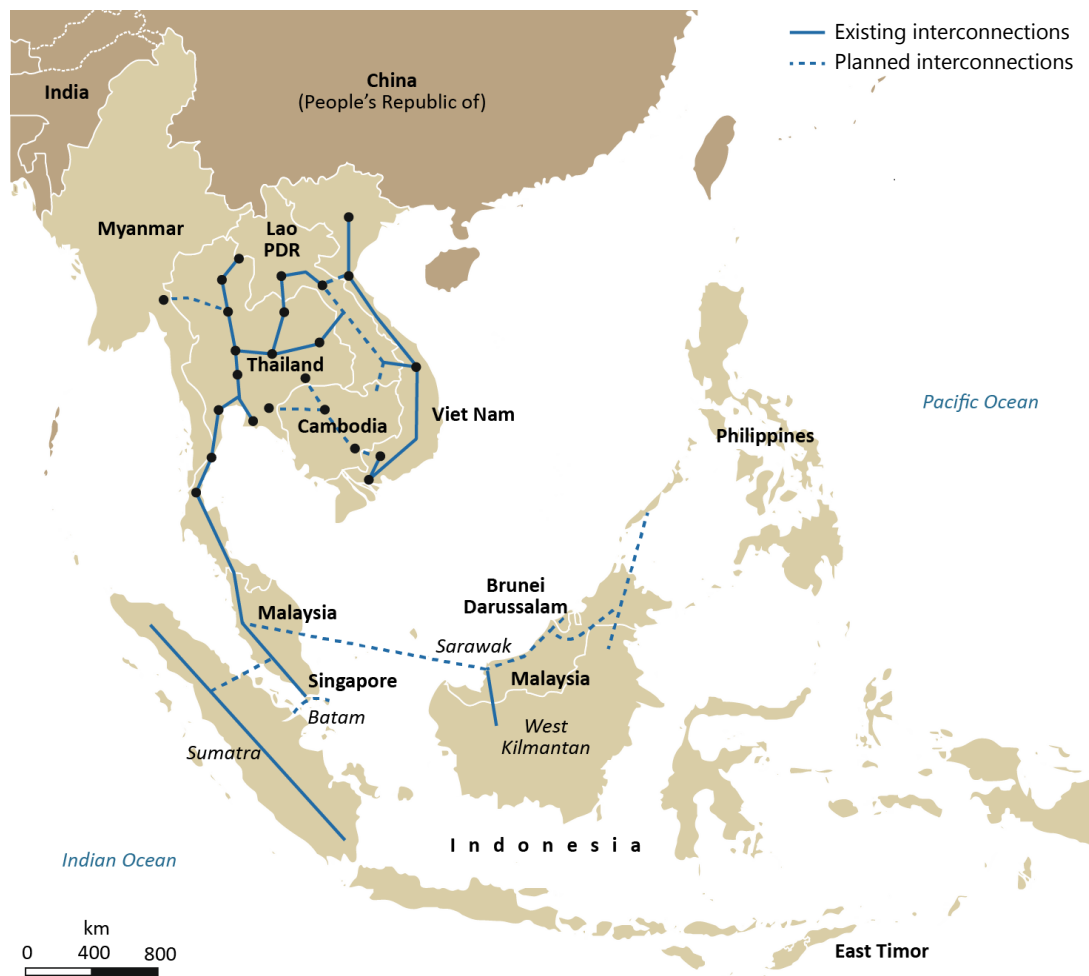
Historical trends (138-143)

Benefits of multilateral power trading: A case study (144-148)

Stepwise approach to multilateral power trading (149-159)

Power systems across Southeast Asia would interconnect in the ASEAN Power Grid concept

Southeast Asia power grid plans



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.

Regional power trading would fulfil a long-standing ambition of the ASEAN community

The scope for integration of power systems and regional power trading are most fully articulated in the ASEAN Power Grid (APG) plan. Agreed by ASEAN countries in 1997, the APG would play a number of roles including bolstering energy security, improving the economics of power system development, expanding access to electricity, integrating variable renewables and as a valuable tool to stimulate and support regional economic growth and development.

The plan for regional power systems interconnection has enjoyed strong support at the ASEAN level. However, developments on the ground have been primarily bilateral in nature, including both transmission infrastructure and power trade. Progress with a multilateral approach has been hampered in part by differing opinions at national levels on the possible implications of increased cross-border electricity integration.

As things stand, eight of the ten ASEAN member countries have interconnections of some kind. Further development of the ASEAN Power Grid is underway. The trade arrangements are mainly limited to unidirectional power trades via long-term power purchase agreements or bi-directional trading of electricity without financial compensation.

In recent years, ASEAN members have reinvigorated their push to implement the power grid concept in full, including the establishment of multilateral power trading. This involves a pilot multilateral trading project between Lao PDR, Malaysia, Thailand and Singapore, as well as an IEA-led study on pathways to develop multilateral power trade in the region. The key findings of this IEA in-depth analysis are summarised in this section of the *Southeast Asia Outlook*.

Cross-border interconnections in Southeast Asia today are limited...

Today's electricity interconnections and trading partners in Southeast Asia

Country	Interconnection(s) with...	Trade with...	Domestic market structure*
Brunei Darussalam	None		Vertically integrated
Cambodia	Lao PDR, Thailand, Viet Nam	Export to Thailand. Import from Lao PDR, Thailand, Viet Nam.	Vertically integrated
Indonesia	Malaysia (from West Kalimantan)**	Mainly export to Malaysia.	Vertically integrated
Lao PDR	Cambodia, Myanmar***, Thailand and Viet Nam	Export to Cambodia, Malaysia (via Thailand), Thailand and Viet Nam.	Vertically integrated
Malaysia	Indonesia (to West Kalimantan)**, Singapore**, Thailand	Import from Lao PDR (via Thailand), Thailand. Bidirectional, non-financial exchange with Singapore.	Vertically integrated
Myanmar	Lao PDR***, Thailand***		Vertically integrated
Thailand	Cambodia, Lao PDR, Malaysia, Myanmar***	Import from Cambodia and Lao PDR. Wheeling between Lao PDR and Malaysia.	Vertically integrated
Philippines	None		Restructured market
Singapore	Malaysia**	Bidirectional, non-financial exchange with Malaysia.	Restructured market
Viet Nam	Cambodia, Lao PDR	Export to Cambodia. Import from Lao PDR.	Vertically integrated

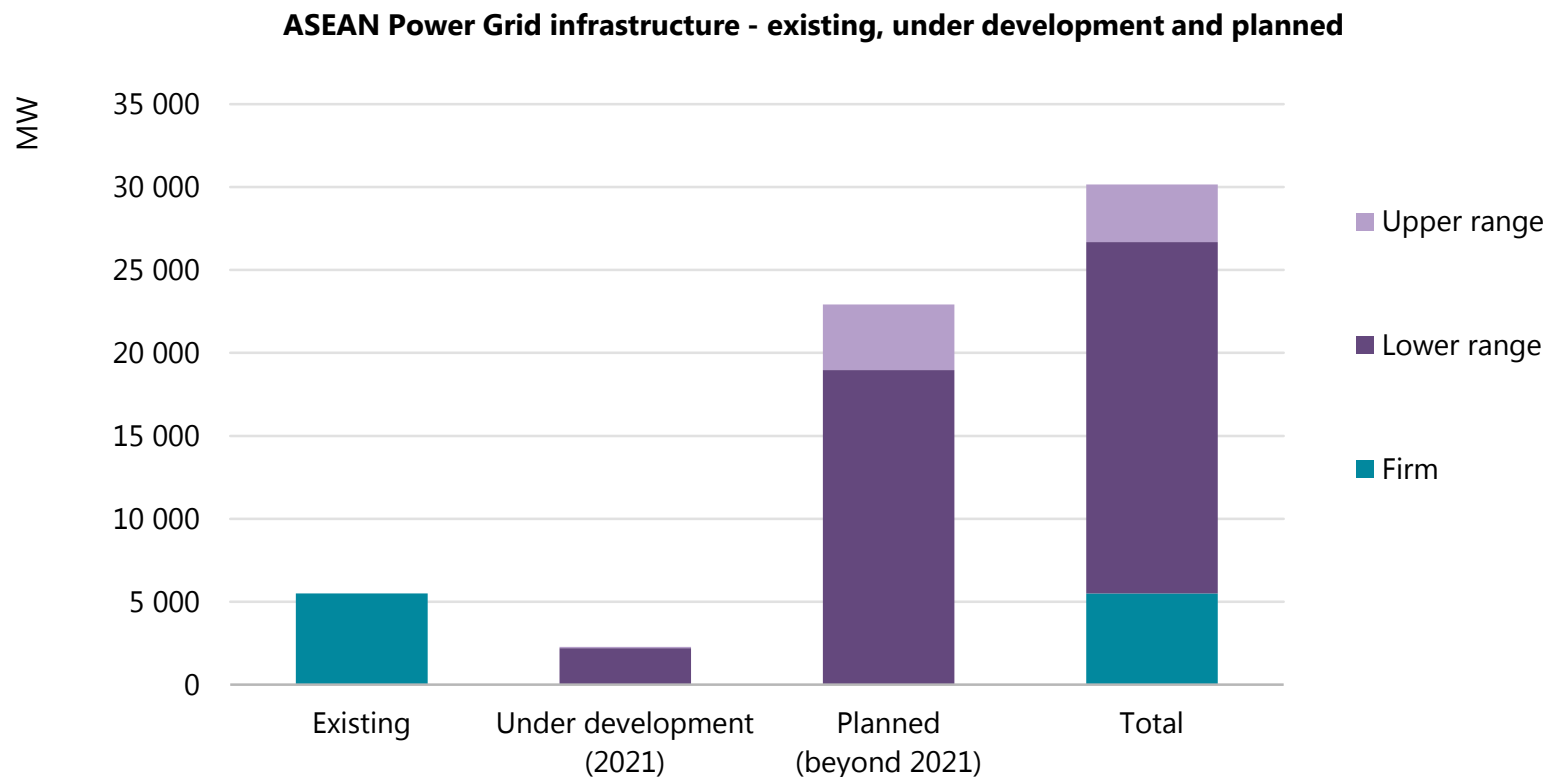
* All vertically integrated markets allow for independent power producer generation, but state-owned enterprises remain dominant.

** Used primarily for security and back up.

*** Distribution level connection servicing rural areas.

... but more are in development and many more are planned

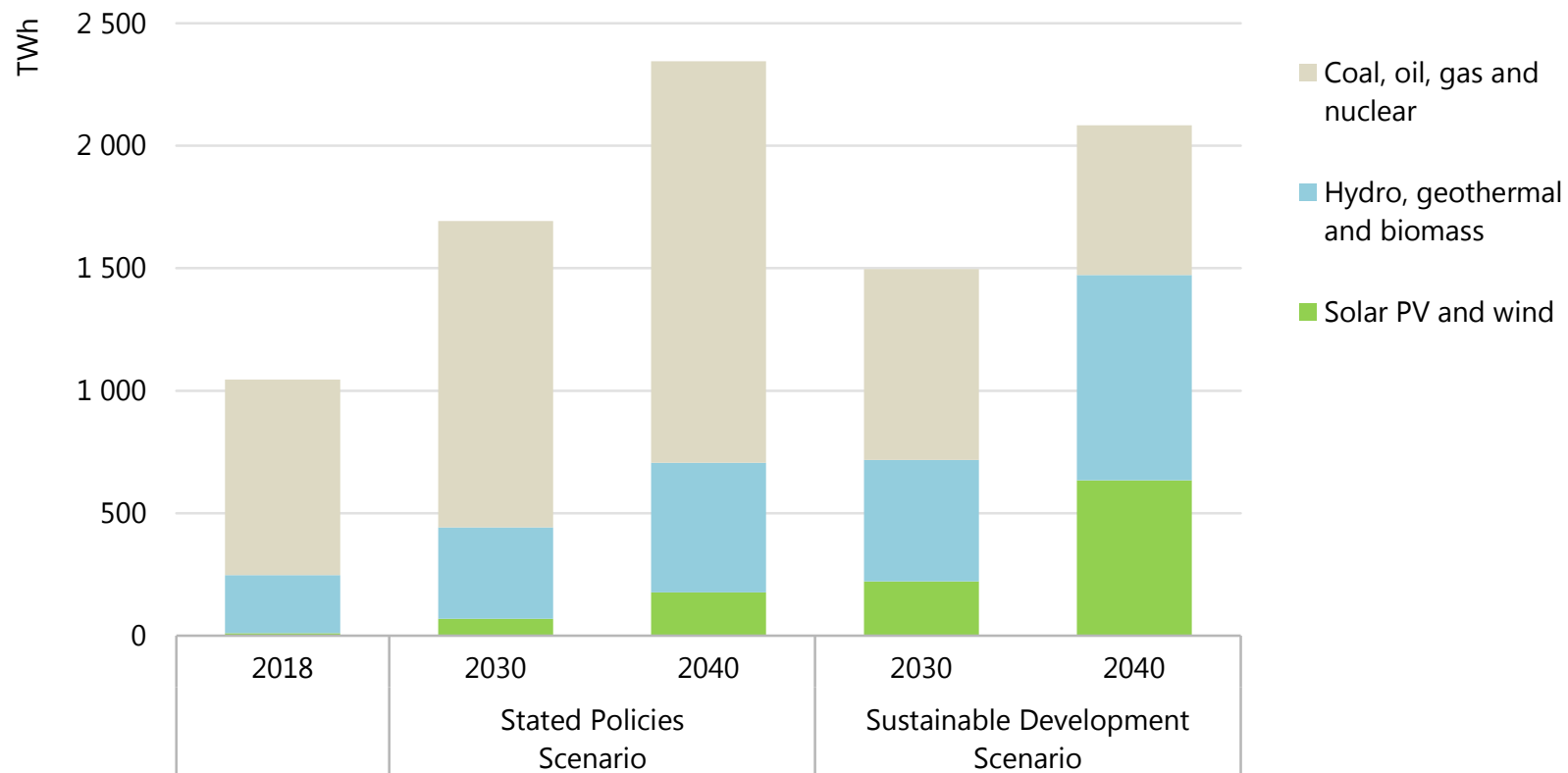
Southeast Asia cross-border electricity transmission capacity: existing, under development to 2021 and planned



Note: MW = megawatt.

Rapid growth of variable renewable sources of generation are increasing the flexibility needs of power systems

Electricity generation by source and scenario in Southeast Asia



Note: TWh = terawatt-hours.

Robust regional power infrastructure and trading arrangements support enhanced flexibility

The existing model of bilateral trade between neighbouring countries has enabled the development of low-carbon resources, hydropower in particular, which otherwise would have been uneconomic. An example is hydropower development in Lao PDR supported by increased trading with neighbouring countries such as Thailand.

Most of the interconnection projects in the region have been developed under long-term power purchase agreements as a way of diversifying the supply of power. This has stimulated the development of low-carbon electricity, even if that was not the primary objective.

As costs for key renewable energy technologies continue to fall, their share of generation in Southeast Asia is set to rise. This is already visible in the Stated Policies Scenario, and even more so with the stronger policy push that accelerates the transformation of the power mix in the Sustainable Development Scenario.

Regional power system integration is a vital enabler of growth in renewable sources of generation, in particular from wind and solar PV, for two main reasons:

- Interconnecting with neighbouring grids taps into their differing supply and demand patterns, and reduces the system variability of wind and solar output, which is smoother when individual plants are aggregated over larger geographic areas.
- It allows access to a larger pool of flexible resources, including flexibility on the supply side (from sources such as hydro or gas-fired power) as well as the demand side in order to balance the market.

Optimising both variable renewable and flexible resources across multiple countries requires a strong degree of co-ordination. Multilateral power trading allows for the more efficient use of regional resources, while keeping decision making in the hands of the participating countries.

Case study: assessing the value of cross-border interconnections for the integration of variable renewables

How can cross-border trade help to accommodate rising shares of variable renewables? This illustrative case study, based on hourly dispatch modelling, highlights various operational, economic and policy-related considerations. It examines trade between four regions in Southeast Asia, with detailed representation of their connections and trade flows. These regions have existing cross-border interconnections, but trading, at present, is mostly limited to bilateral power purchase agreements:

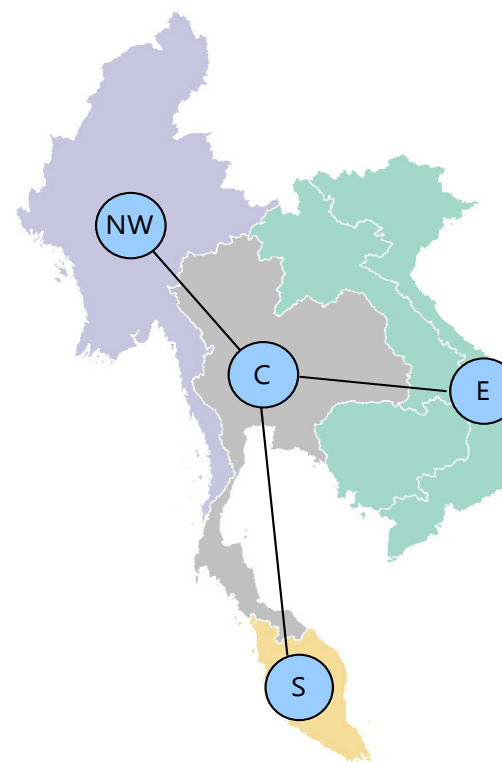
The regions are: **C** - Central (Thailand); **E** - East (Cambodia, Lao PDR and Viet Nam); **NW** - Northwest (Myanmar); **S** - South (Malaysia and Singapore).

We examine two scenarios, one in which the share of variable renewables approaches 10% by the 2030s (a representation of the Stated Policies Scenario) and the second in which it reaches 25% (as in the Sustainable Development Scenario). For each of these scenarios, we model three cases:

- Bilateral trade (BT): the existing model of bilateral trade continues, with no new interconnections.
- Optimised trade (OT): power flows are optimised across the regions, with no new interconnections.

- Optimised and expanded trade (OT+): power flows are optimised and cross-border transmission capacity is expanded.

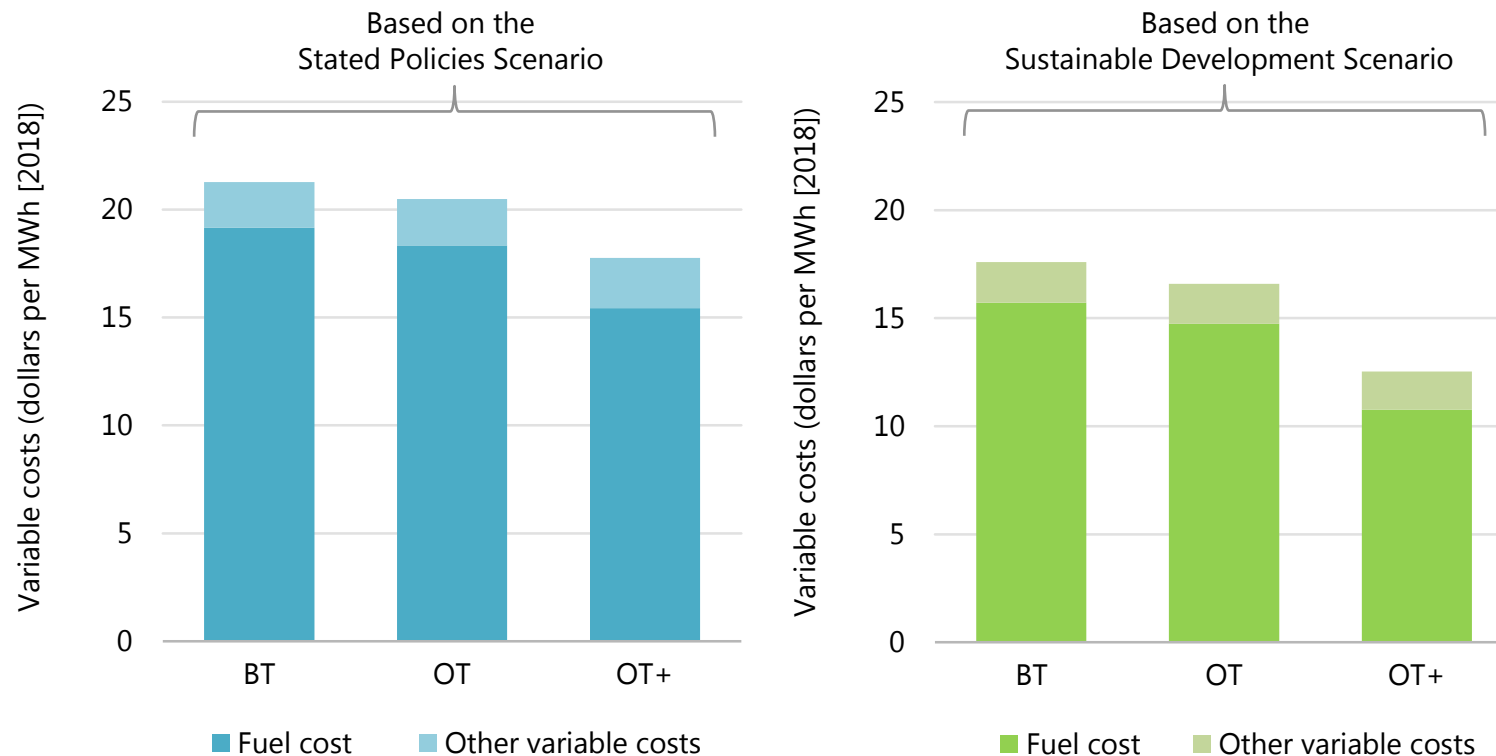
Four selected transmission zones in the case study



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.

Case study: multilateral power trade and expansion of cross-border transmission lead to lower system operational costs

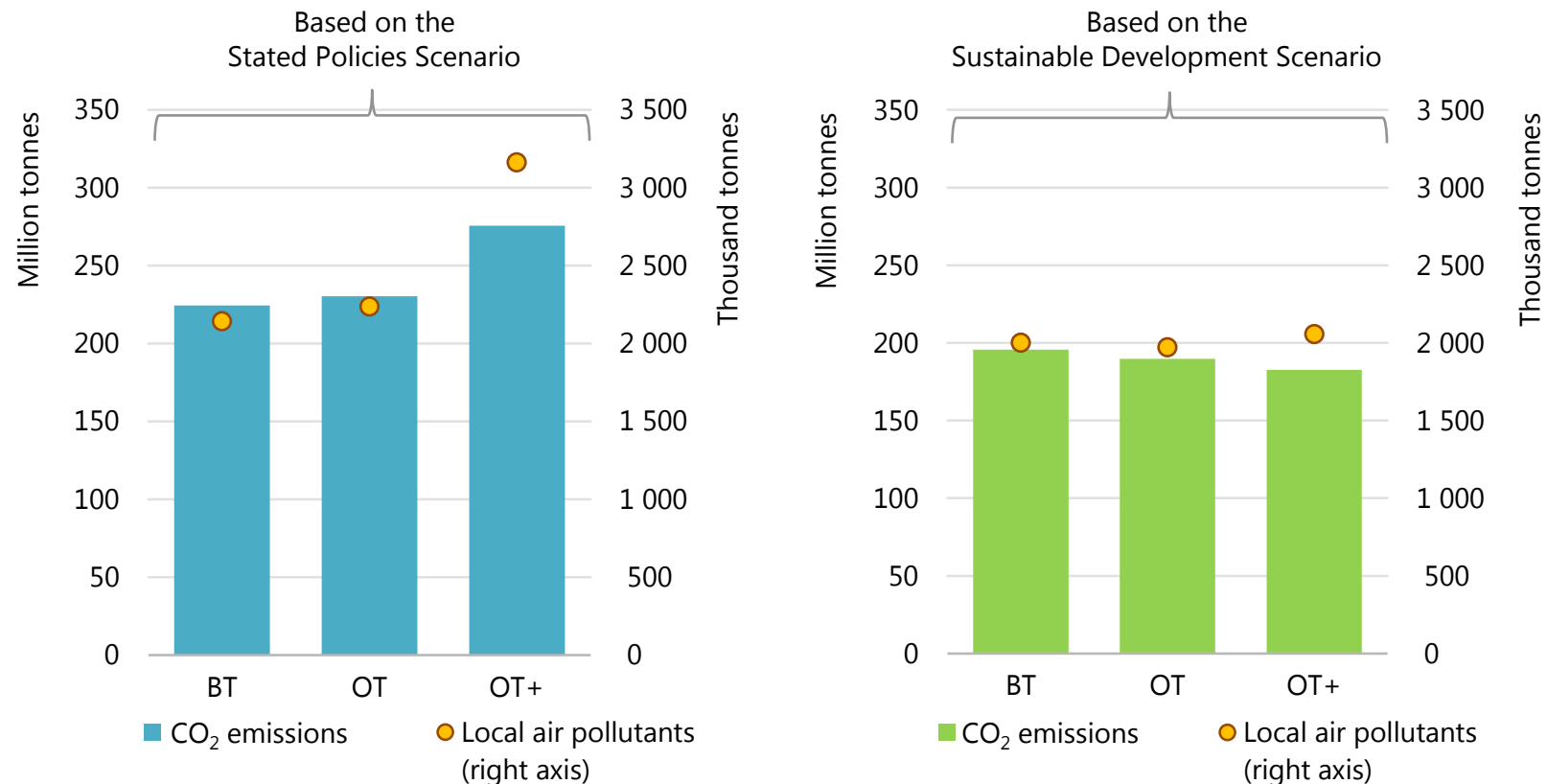
Annual operational costs in 2035 by illustrative scenario and case



Note: MWh = megawatt-hour; BT = bilateral trade; OT = optimised trade; OT+ = optimised and expanded trade.

Case study: cross-border interconnection can lead to increased emissions in the case of low renewable generation without additional measures

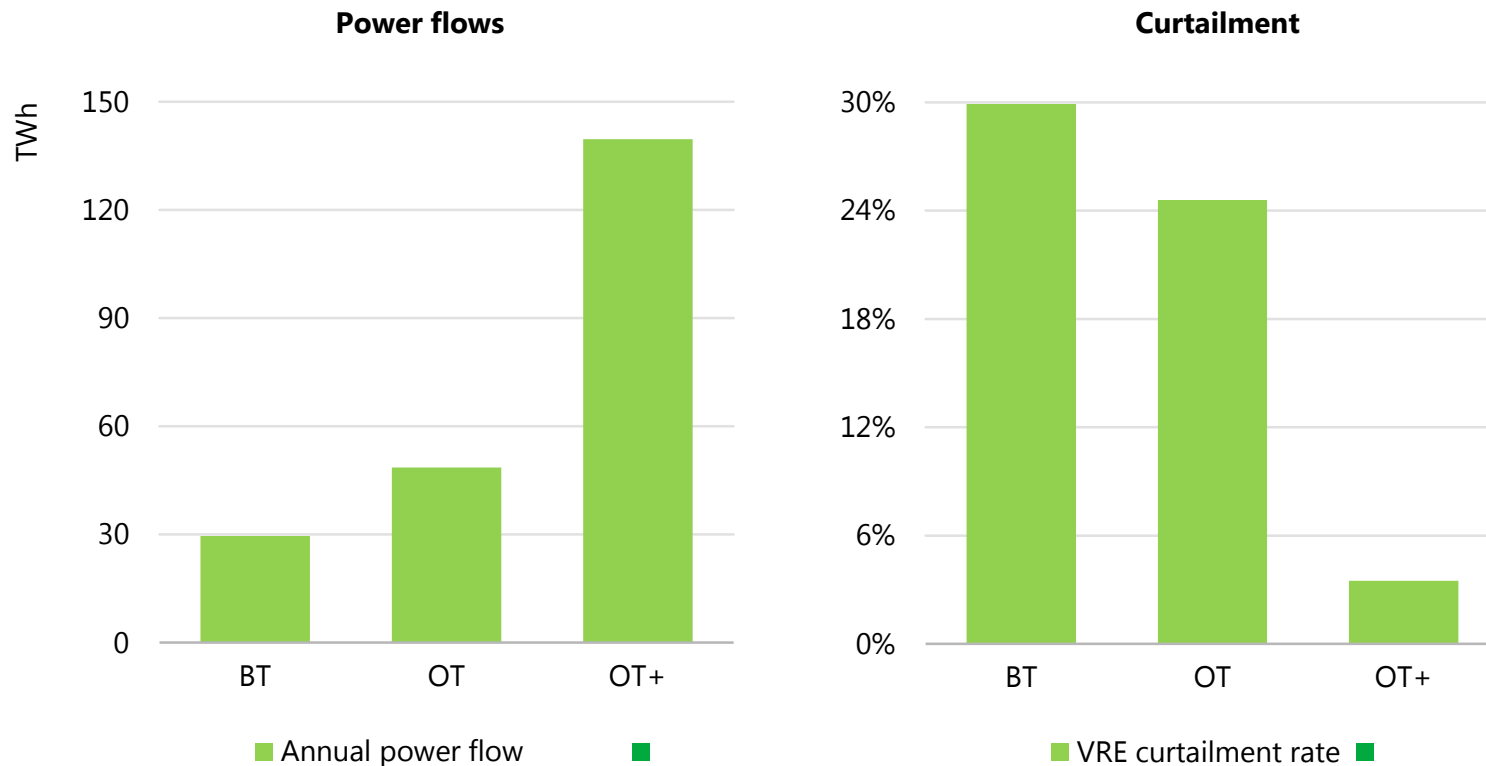
CO₂ and air pollution emissions in 2035 by illustrative scenario and case



Note: BT = bilateral trade; OT = optimised trade; OT+ = optimised and expanded trade.

Case study: with high shares of wind and solar PV, expanded cross-border trade is essential to avoid excessive curtailment of renewable output

Annual power flows from east to central region (left) and curtailment of variable renewable output (right) by case in 2035 based on the Sustainable Development Scenario



Note: TWh = terawatt-hours; BT = bilateral trade; OT = optimised trade; OT+ = optimised and expanded trade; VRE = variable renewable energy.

Case study: regional electricity trade is a strong ally of Southeast Asia's push for reliable, affordable and sustainable power

Our case study of the effect of multilateral electricity trade and cross-border interconnections shows that these are powerful instruments in the hands of ASEAN policy makers.

In all of the cases examined, optimising cross-border flows through multilateral trade – even without any new interconnections – resulted in significantly lower operating costs for the system as a whole via more cost-effective use of the existing transmission links. Reductions in total operating costs of \$1-3 billion per year correspond to a reduction in supply costs of around \$1-3 per megawatt-hour (MWh).

Expanding interconnection capacity as well as promoting multilateral trade produces much larger effects, although these vary depending on the envisaged power mix. In an illustrative case that broadly corresponds to the Stated Policies Scenario, i.e. with a modest expansion of wind and solar and a continued high share of coal-fired generation, the outcome is higher emissions of both CO₂ and local air pollutants. This highlights the importance of additional measures to limit emissions from coal-fired power generation and to increase the share of low-carbon electricity.

Expanded cross-border connections, together with multilateral trade, are critical to enable cost-effective integration of wind and solar output in the Sustainable Development Scenario. Low-cost wind and solar displace thermal generation, further bringing down operational costs. Power flows increase from regions with lower generation costs in the east (Cambodia, Lao PDR and Viet Nam), notably from hydropower and variable renewables. With additional flexibility in the system, curtailment of wind and solar output is cut dramatically.

The total system costs, including additional investment costs in transmission, are lowest if trade is optimised and expanded. Together with an expansion of low-carbon generation, this results in a system that promotes the effective use of resources for common regional benefits, including economic, security, operational and environmental aspects that are relevant for all.

Power integration efforts in Southeast Asia are gathering pace

Various power integration efforts are underway across Southeast Asia. A subset of ASEAN members have established a pilot project to act as a “pathfinder” for the region: the *Lao PDR-Thailand-Malaysia-Singapore Power Integration Project*. Phase I, which has been in operation since 2018, involves the sale of power from Lao PDR to Malaysia via Thailand. Phase 2 is expected to increase the volume of trade and also include Singapore. It may also allow for multidirectional trading among the four participating countries.

Much of the technical work of this pilot project is relevant to Southeast Asia as a whole. It includes the first methodology for power wheeling – the transfer of electricity through the grid from one service area to another – in the region. The development process was inclusive, demonstrating it is possible for ASEAN members to play an active role in this aspect even if they do not initially participate in trading. It also demonstrated the value of a clear timeline for the project, complete with specific deliverables and milestones.

Another ongoing initiative aims to promote integration among the *Greater Mekong Sub-region* countries, which include five ASEAN member countries plus China. This effort has made notable progress on technical tasks such as the development of harmonised grid codes, underlining the importance of data sharing and common standards to facilitate trade. However, this initiative has made less progress in other areas, for example on institutional development.

A third noteworthy effort that fosters cross-border electricity integration is the *Brunei Darussalam-Indonesia-Malaysia-Philippines ASEAN Growth Area*. It was established in 1994, with enhanced connectivity among its key strategic pillars. The focus is on building the physical infrastructure for cross-border trade; at present interconnections among the co-operating countries need further development. If realised, this effort could help to bring forward the sub-region’s large hydro resources and reduce today’s dependence on thermal generation.

A step-by-step approach to establish multilateral power trading in Southeast Asia

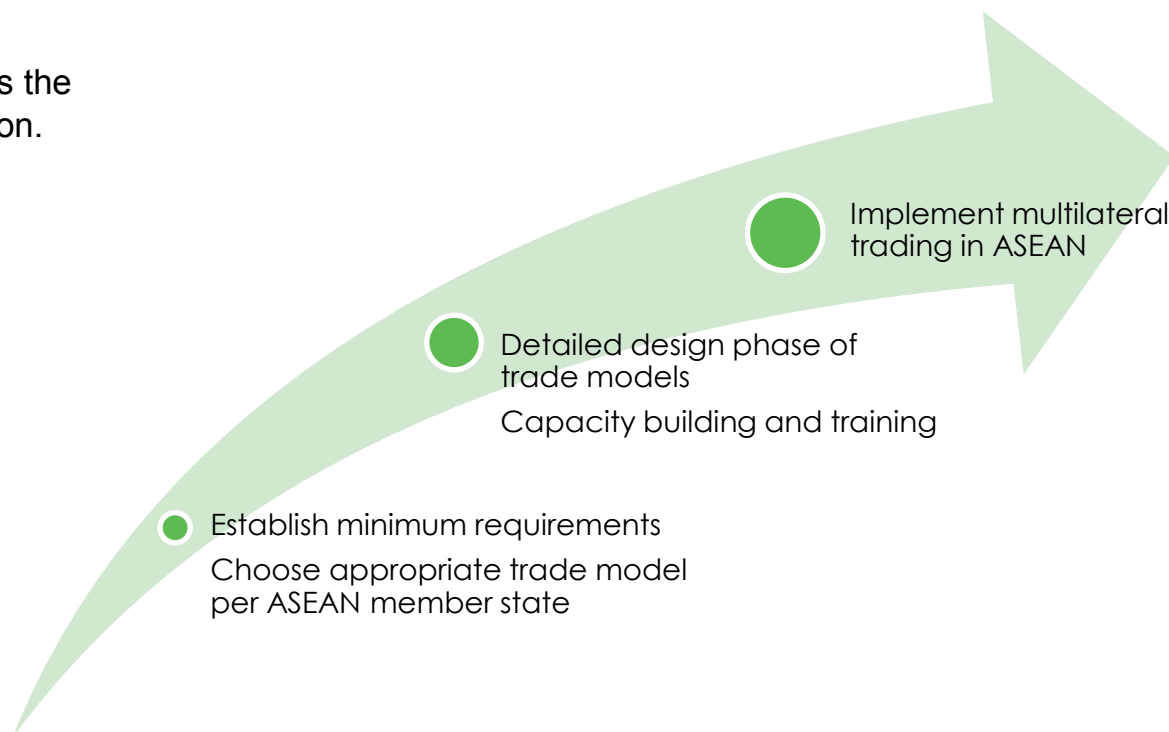
Southeast Asia has made significant progress in developing the ASEAN Power Grid, but more work is necessary to establish multilateral trading.

As part of its co-operation with ASEAN, the IEA has analysed international best practices and has developed a set of concrete recommendations.

A key principle guiding these recommendations is the principle of voluntary, step-by-step implementation.

Three phases are critical:

1. Establish and meet minimum requirements (policy, technical, institutional).
2. Design trade models.
3. Implement trade models.



Minimum requirements need to be met to provide foundations for successful multilateral trade



Policy

- Political will
- Intergovernmental agreement(s)
- Common working language



Technical

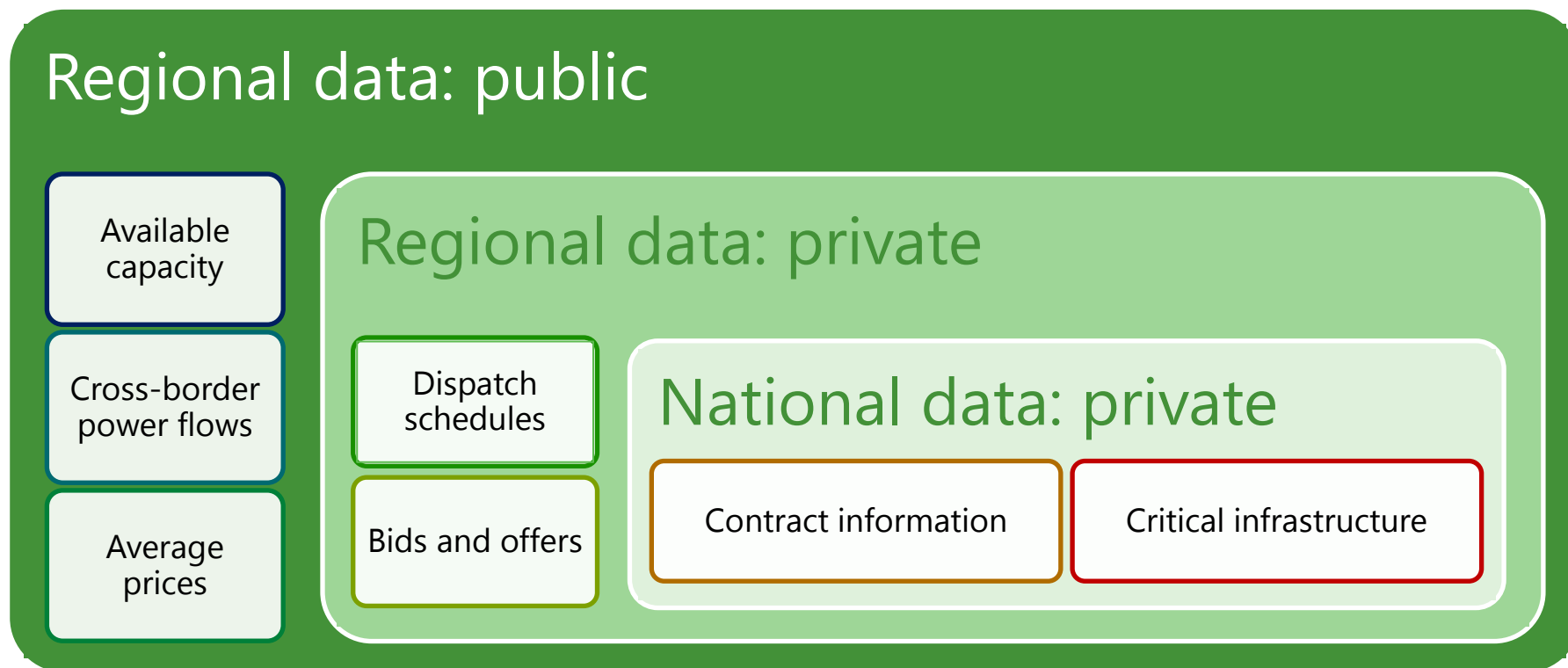
- Harmonised technical standards (grid codes)
- Wheeling methodology
- Non-discriminatory access to grids for cross-border trading
- Data and information-sharing standards
- Interconnector capacity calculation methodology



Institutional

- Settlement and payment mechanisms

The need for transparent market data can be balanced with privacy and security concerns



Possible models for electricity trade in Southeast Asia

Once the minimum requirements are met, it would be possible to establish multilateral power trade in the region. We consider three models of power trade, each summarised in the following slides.

Model 1: Harmonised bilateral trading (near-term).

Model 2: Establish “secondary” regional power trading (medium-term).

Model 3: Establish “primary” regional power trading (long-term).

These models should not be seen as a specific development pathway, to be followed sequentially or at an identical pace among all participants. Each ASEAN member can and should decide which model is appropriate for their participation.

These models are, to some extent, compatible with each other, i.e., it is possible for more than one model to exist in parallel.

International power systems can provide practical examples of the design and implementation of these models. Six countries in Central America, for example, have established an interconnection for national power grids (SIEPAC) that puts in place a secondary regional power trading arrangement similar to Model 2. Examples of Model 3 primary regional power trading include Nord Pool in Northern Europe and PJM Interconnection – a regional transmission organisation that co-ordinates the movement of wholesale electricity in 13 states and the District of Columbia in the eastern United States.

Model 1: Harmonised bilateral trading

Model 1 builds on existing bilateral arrangements by developing three key elements:

- Standardised framework for bilateral trade.
- Standard wheeling methodology.
- Development of an enabling institution.

The role of the enabling institution:

- Collect and share information on available transmission capacity.
- Platform to connect potential buyers and potential sellers (“Announcement Platform”).

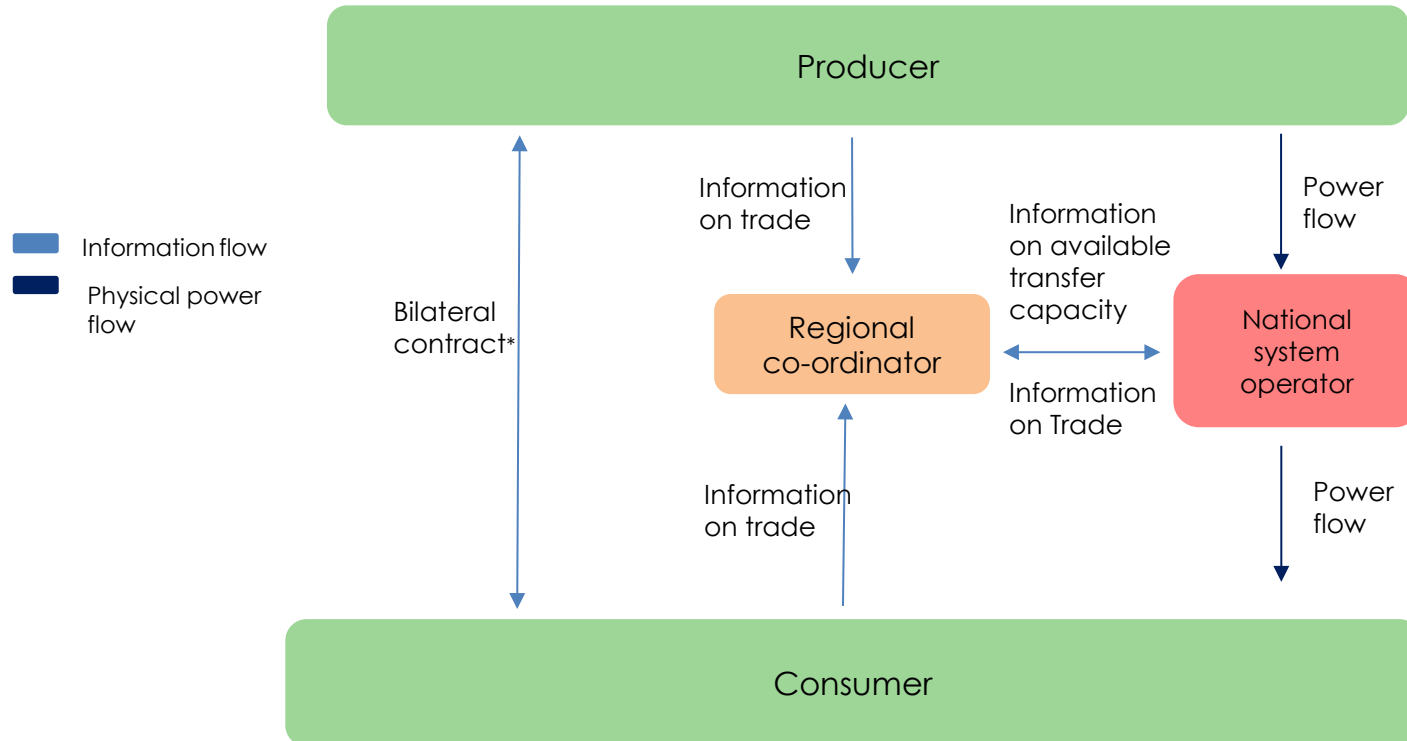
In combination, this will lead to:

- More efficient trading.
- Ability for any two participating ASEAN members to trade in any direction, even if they do not share a border.

This model can be established relatively quickly. Each ASEAN member can choose whether and how to participate, e.g. each can designate a market participant.

Model 1: Market information is made public via a regional co-ordinator, enabling more efficient bilateral trading

Harmonised bilateral trade



* Monetary flow is agreed in a bilateral contract including terms of who pays the system operator for transmission.

Model 2: Establish “secondary” regional power trading

Model 2 establishes a multilateral trading framework that unlocks the day-ahead market to trade excess volumes between participating countries.

This secondary trading model is complementary to the harmonised bilateral trading model. These two models can co-exist.

This model requires establishment of a regional market that participating ASEAN states can use in addition to domestic markets/system operations:

- Domestic markets/systems clear first.
- Only trade excesses and gaps.

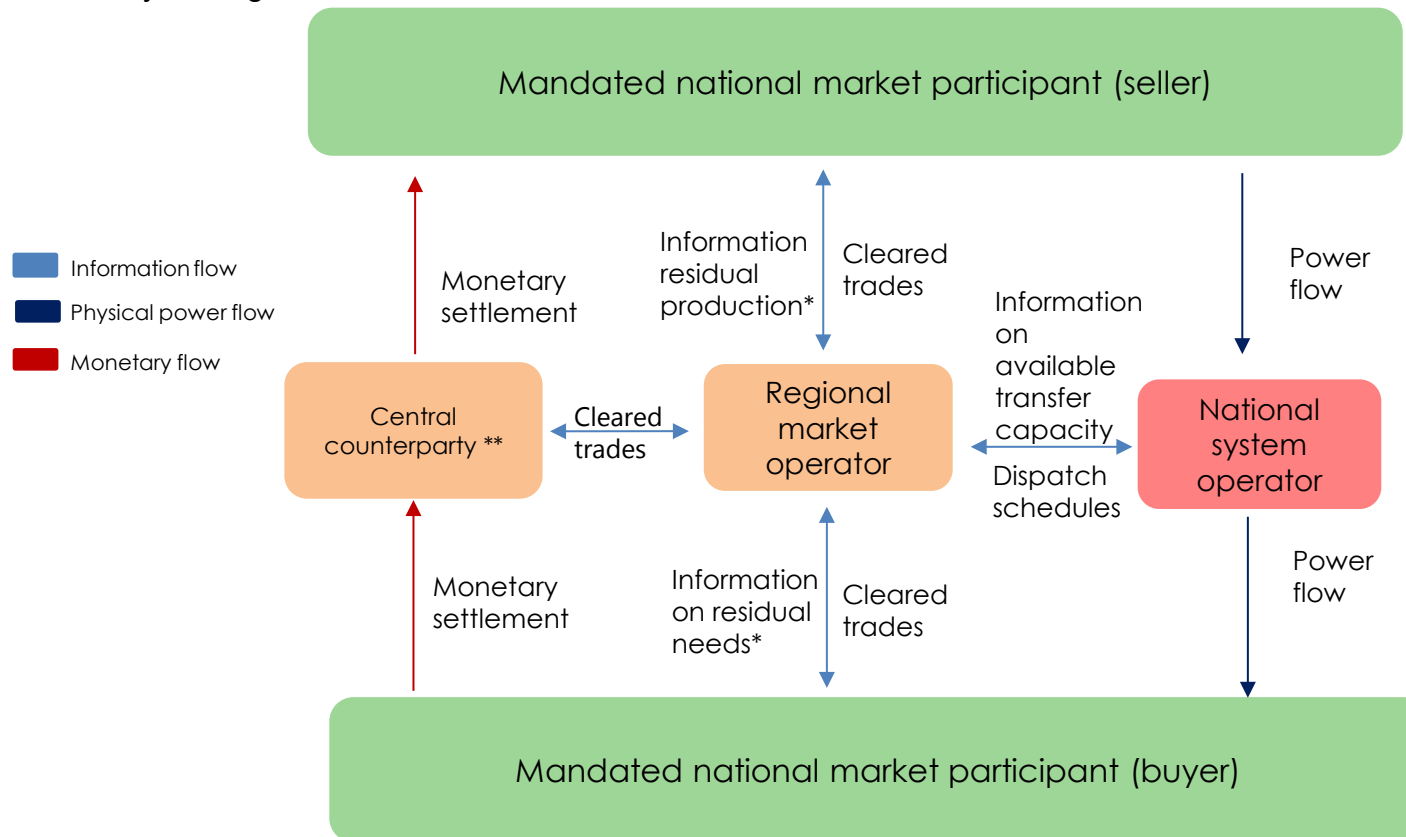
Key components:

- Introduction of regional day-ahead market (and eventually an intra-day market).
- Implicit allocation of interconnector capacity.
- Introduction of a central settlement mechanism (a “central clearing party” function).

Restructuring of national power markets is not essential for this model and harmonised bilateral trading can continue.

Model 2: Excesses and gaps in domestic supply are matched by the regional market operator to facilitate trade

Secondary trading model



* The information is only exchanged after national markets have cleared.

** The central counterparty can be within the market operator or as a separate institution.

Model 3: Establish “primary” regional power trading

Establish a regional market that is used as the primary mode of trade:

- All generation clears in the regional (day-ahead) market.
- There are no national markets within the participating ASEAN member states.

The primary trading model is a highly integrated regional trading model:

- Requires a high level of technical, regulatory and policy harmonisation.

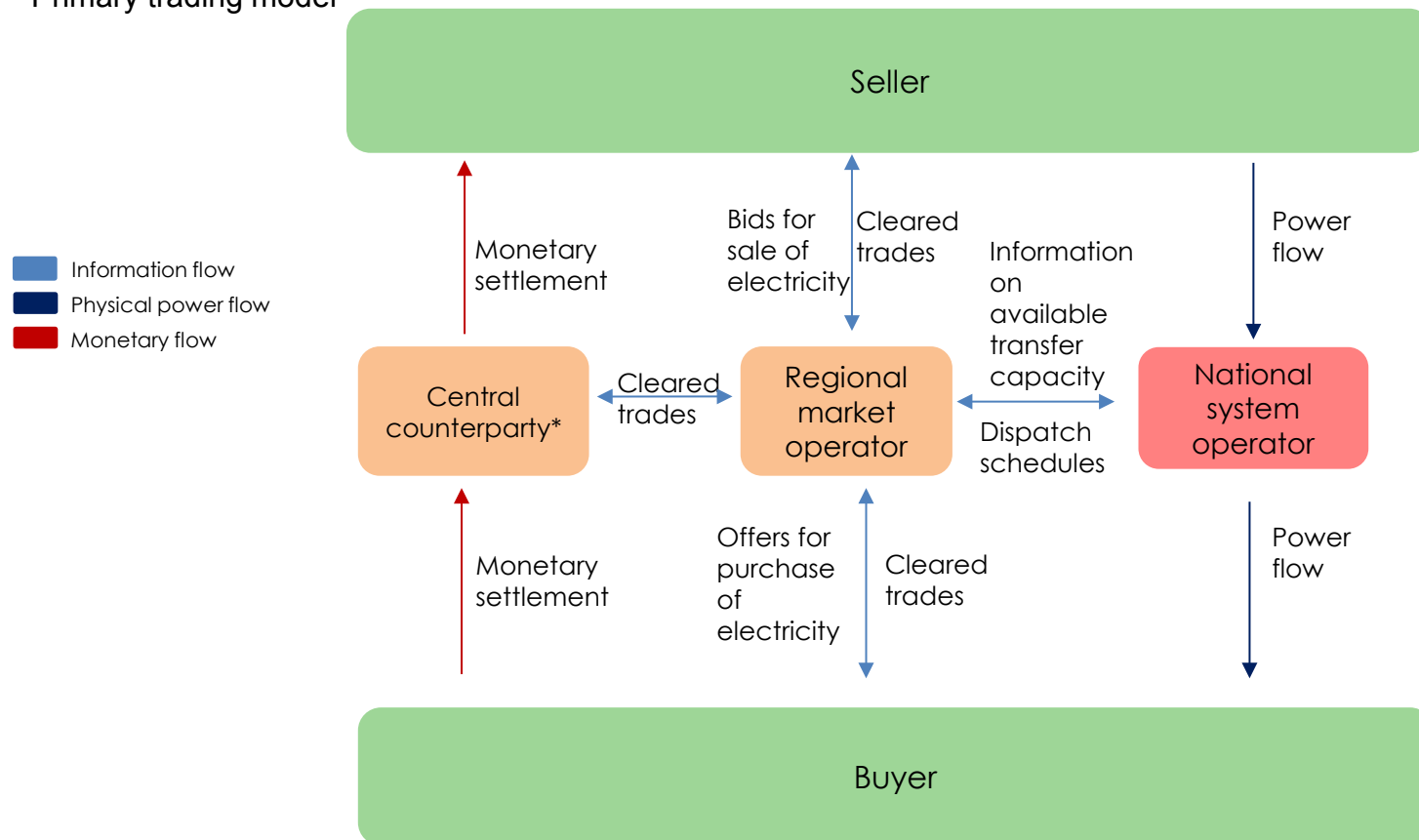
Harmonised bilateral trading can continue, but secondary trading model would be replaced among participating countries. Restructuring of national markets would be required.

Key components:

- Central algorithm to match trades.
- Central clearing party to settle trades.
- Least cost dispatch sent to national system operators after clearing.

Model 3: All buyers and sellers bid directly to the regional market operator, which optimises resources across participating countries

Primary trading model



* The central counterparty can be within the market operator or as a separate institution.

Investment in reliable, sustainable and affordable power

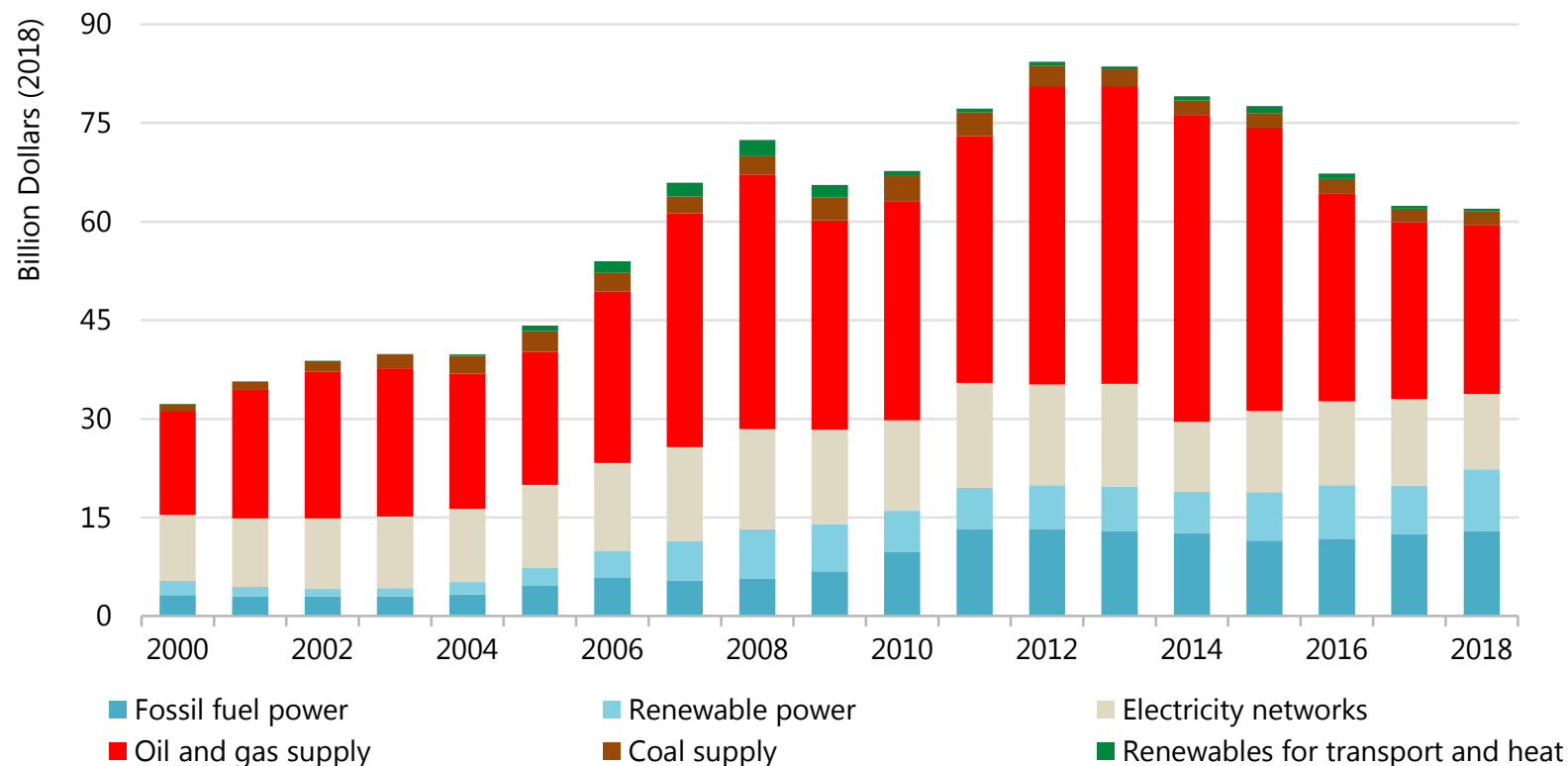
Trends in investment and sources of finance (161-168)

Investment projections (169-170)

Priorities and strategies for investment (171-190)

Energy sector investment in Southeast Asia has trended downwards over the past decade; the power sector now accounts for over half of spending

Energy supply investment in Southeast Asia by sector

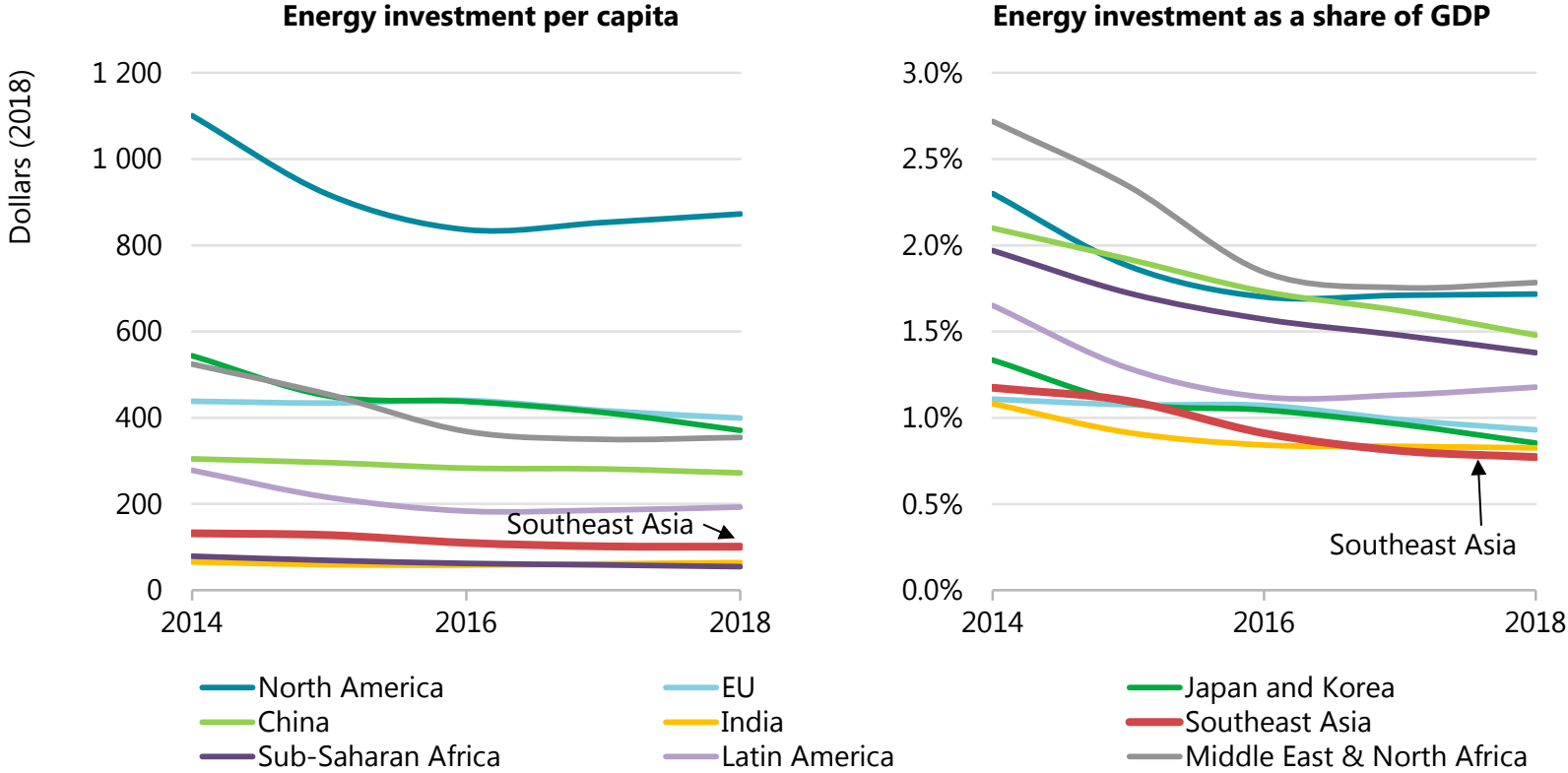


Note: Investment is measured as ongoing capital spending in energy supply capacity.

Source: IEA (2019b).

Energy investment is low on per capita and GDP bases, and the region has invested less of its economic output in energy over time

Energy investment per capita and as a share of GDP in selected countries and regions



Notes: EU = European Union. GDP expressed in year-2018 dollars and purchasing power parity (PPP) terms.
 Sources: Calculations for population based on UN Population Division databases; calculations for GDP based on IMF (2019).

While indicators suggest insufficient energy capital spending, the location and types of investments – both in supply and demand – matter significantly

Investment in Southeast Asia's energy sector was around \$65 billion in 2018. The level has trended downwards for much of the past decade. Since 2015, capital spending has declined by almost one-fifth. Relative to other regions, Southeast Asia's energy investment level is low on a per capita and a GDP basis.

This suggests the region may not be investing enough to support its accelerating energy demand and to meet sustainability goals. Given Southeast Asia's geography and nascent level of regional integration, the location and types of investments matter significantly. For example, in some areas (e.g. Central and East Java in Indonesia) high power reserve margins are indicative of capacity that is more than ample to serve demand and provide energy security, while in remote locations there is a lack of access to serve even basic needs.

Among the different elements of energy investment, most of the recent decline is related to oil and gas supply, which is down more than 40% since 2015, on the back of lower oil prices. More than one-third of this fall was in Indonesia. Although global oil and gas demand picked up in 2018, spurring more project approvals in many parts of the world, there are fewer indications of an uptick in upstream activity in Southeast Asia.

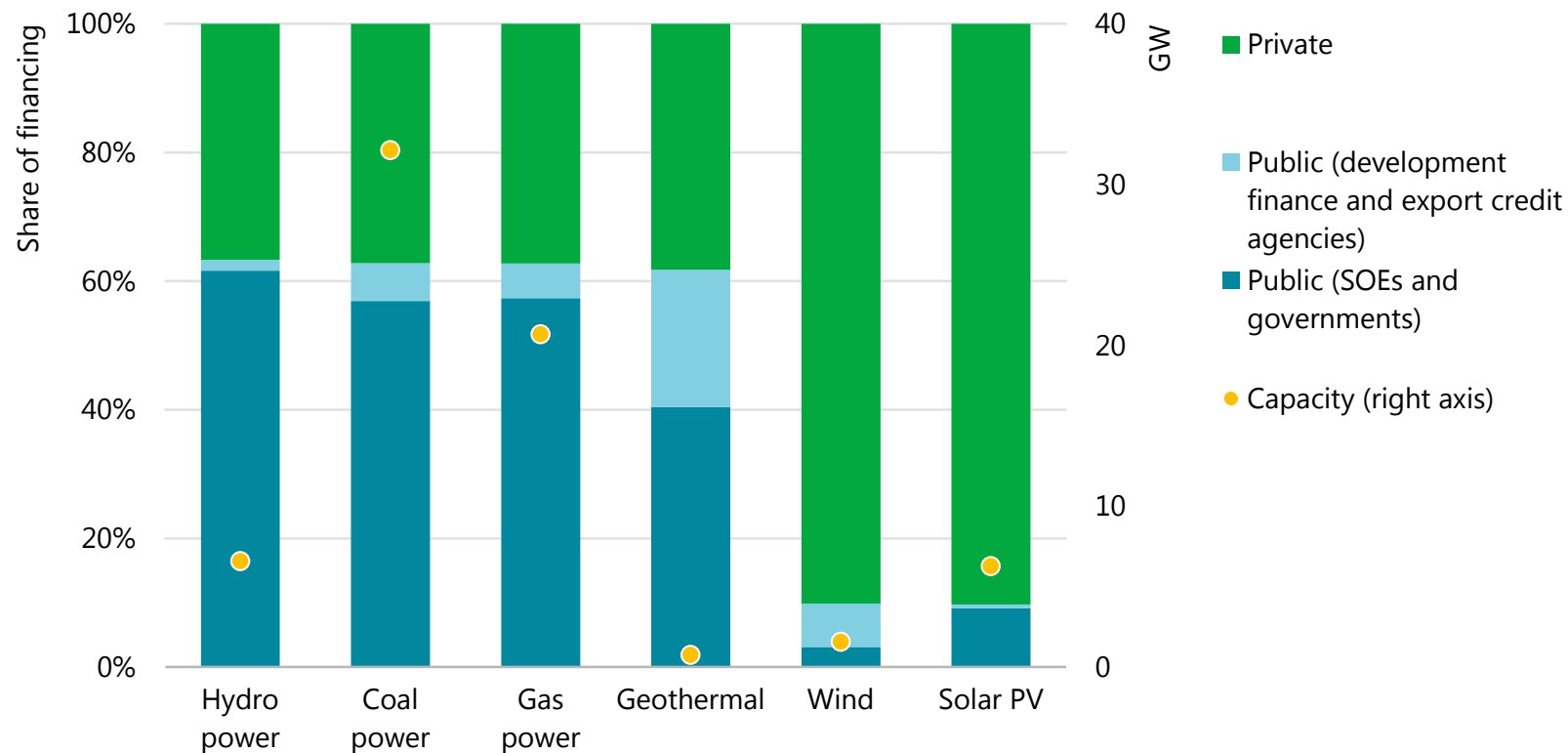
Regional energy spending has shifted towards the power sector, which now accounts for more than half of total investment in energy supply, in order to meet growing electricity needs. Investment in renewables has picked up, although thermal plants (coal- and gas-fired) still make up the majority of investment in new power generation capacity. Investment related to the power grid – critical for access and system integration – has trended downwards since 2010, and is lower than at the start of the decade.

There have been notable shifts in other areas as well, though with less impact on the overall picture. Coal supply spending has halved since 2010, but has levelled off since 2015. Investment in biofuel production capacity has also halved since 2010, though it is supported by domestic blending rules in Thailand, Malaysia and Indonesia.

Energy efficiency is a cost-effective way of deferring or avoiding supply investments, but accounts for only around 5% of Southeast Asia's energy investment (despite some increases in recent years), with slow progress in expanding policy coverage and support measures.

State-backed capital has played an important role in power generation investment in Southeast Asia

Sources of finance for power generation investment in Southeast Asia by type of capital provider
(final investment decision in years 2014-2018)

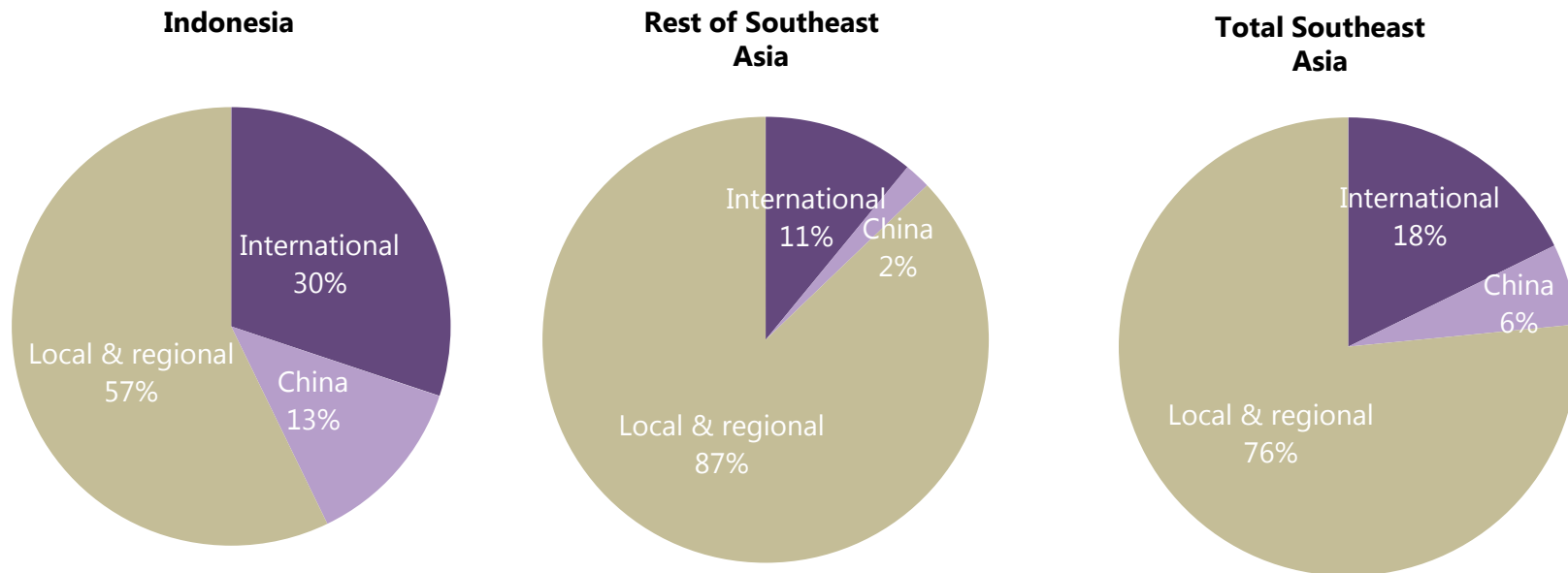


Notes: SOEs = state-owned enterprises; GW = gigawatts; solar PV = solar photovoltaics. Includes only utility-scale projects ≥ 25 megawatts.

Source: Calculations based on World Bank (2019a).

Local and regional sources have provided the bulk of power sector financing

Sources of finance for power generation investment by origin of capital provider
(final investment decision in years 2014-2018)

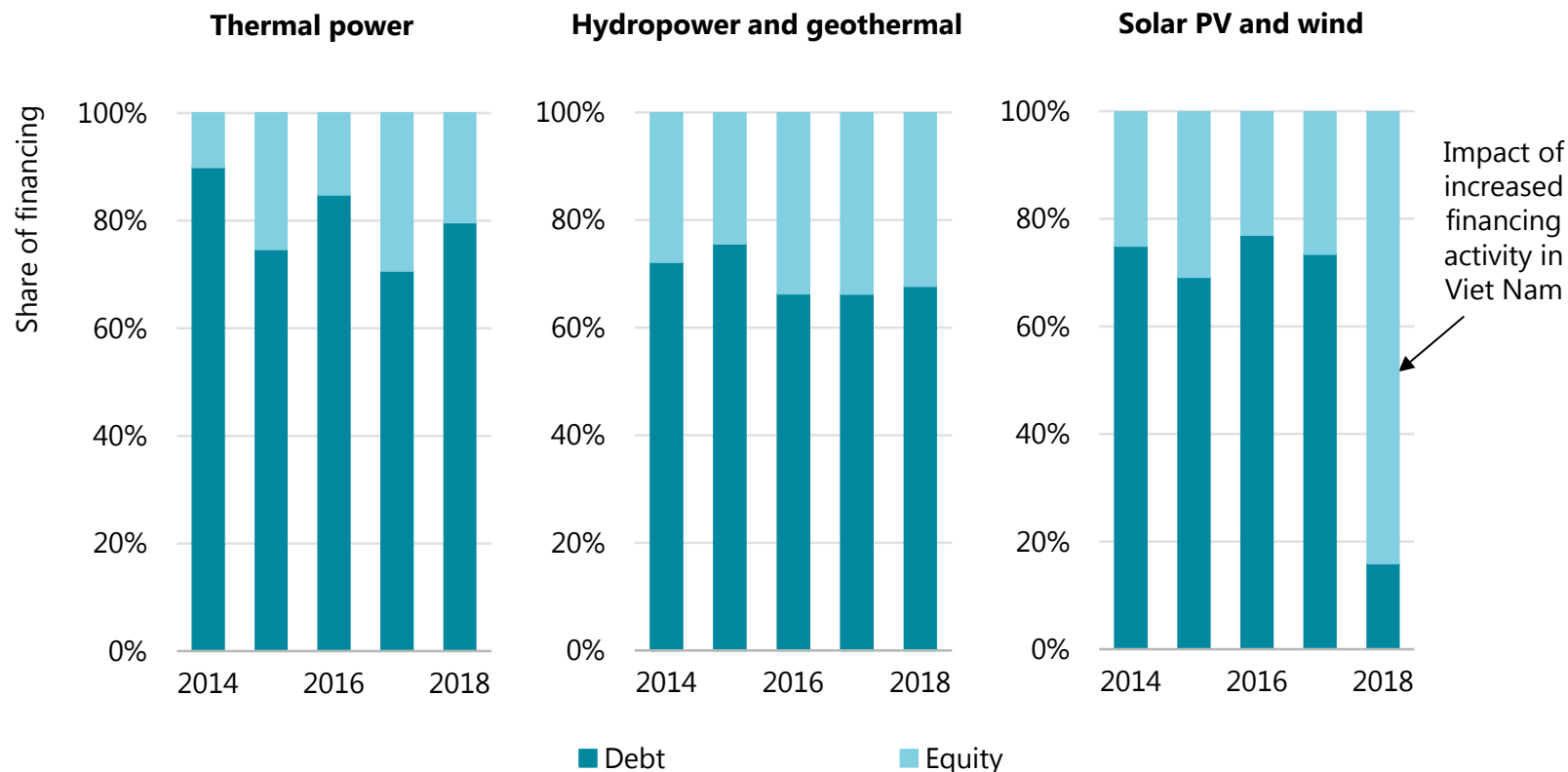


Notes: Local and regional sources of finance include domestic institutions and financiers in the Southeast Asia region. Includes only utility-scale projects ≥ 25 MW.

Source: Calculations based on World Bank (2019a).

Debt plays an important role in power generation investment with private sector involvement; in less mature markets/sectors, more costly equity may be the norm

Capital structure for power generation investment with private participation in Southeast Asia by year of final investment decision



Notes: Includes only utility-scale projects ≥ 25 MW and excludes projects that are fully financed by a public entity (e.g. balance sheet investments made by state-owned enterprises).

Source: Calculations based on World Bank (2019a).

A diversity of actors to finance power plants...

The sources of finance for spending on power generation provide an indication of the level of maturity and the ease of investment in a given market. Economies with a high-level of maturity for financing (e.g. United States, some countries in Europe) tend to have full and balanced access to international and domestic sources of finance (private developers and banks), alongside well-developed markets for secondary financing through capital markets and institutional investors. Public sources tend to play a strategically important but relatively small role in these cases.

In Southeast Asia, an evaluation of power generation projects that reached final investment decision in recent years shows that the sources of finance depend strongly on the type of project and underlying market and policy conditions. A number of developers and commercial banks within Southeast Asia have emerged to provide capital, which suggests good progress in developing regional financing sources. Nevertheless, public finance still plays a large role and many markets in the region have not yet sufficiently addressed investment risks to the degree required to attract balanced levels of local and international private capital.

In terms of the split between public and private sources, the participation of state-owned enterprises, development finance institutions, export-credit agencies and other public entities has tended to be concentrated in thermal power investments and in large-scale renewables with sizeable upfront capital needs – e.g. hydropower and geothermal, where the project development phase can also present complex risks.

Regional wind and solar PV projects have been financed to a larger degree with private finance, particularly given the focus of regional state-owned utilities on dispatchable thermal power. However, within the region, these technologies face persistent investment risks and have not reached the level of market maturity to attract sustained and balanced levels of international and local private capital. Public institutions have played roles in helping to encourage private sources in key instances. For example, financiers for Indonesia's two largest wind farms include the US development institution, Overseas Private Investment Corporation, and the Asian Development Bank.

...but attracting more balanced sources of private international capital will depend on how policy makers address investment risks

Regarding the balance between international and local/regional sources, most power generation investment in markets such as Thailand, the Philippines and Singapore has come about from private developers and commercial banks which are based within the market or in the region. These markets tend to have mature regulatory frameworks for investment by independent power producers (IPPs) and relatively developed financial systems.

In **Viet Nam**, where these features are less developed, investments have tended to rely more on domestic public sources of financing. There, overall public debt is close to a state-mandated ceiling of 65% of GDP, pointing to a need for private sources to play a much bigger role in future. A current ramp up of private finance (not shown in the graphs) reflects recent strong interest in solar PV development – much of it in 2019 – though this has been mostly led by local and regional players, rather than international investors, which are less comfortable with the risk environment.

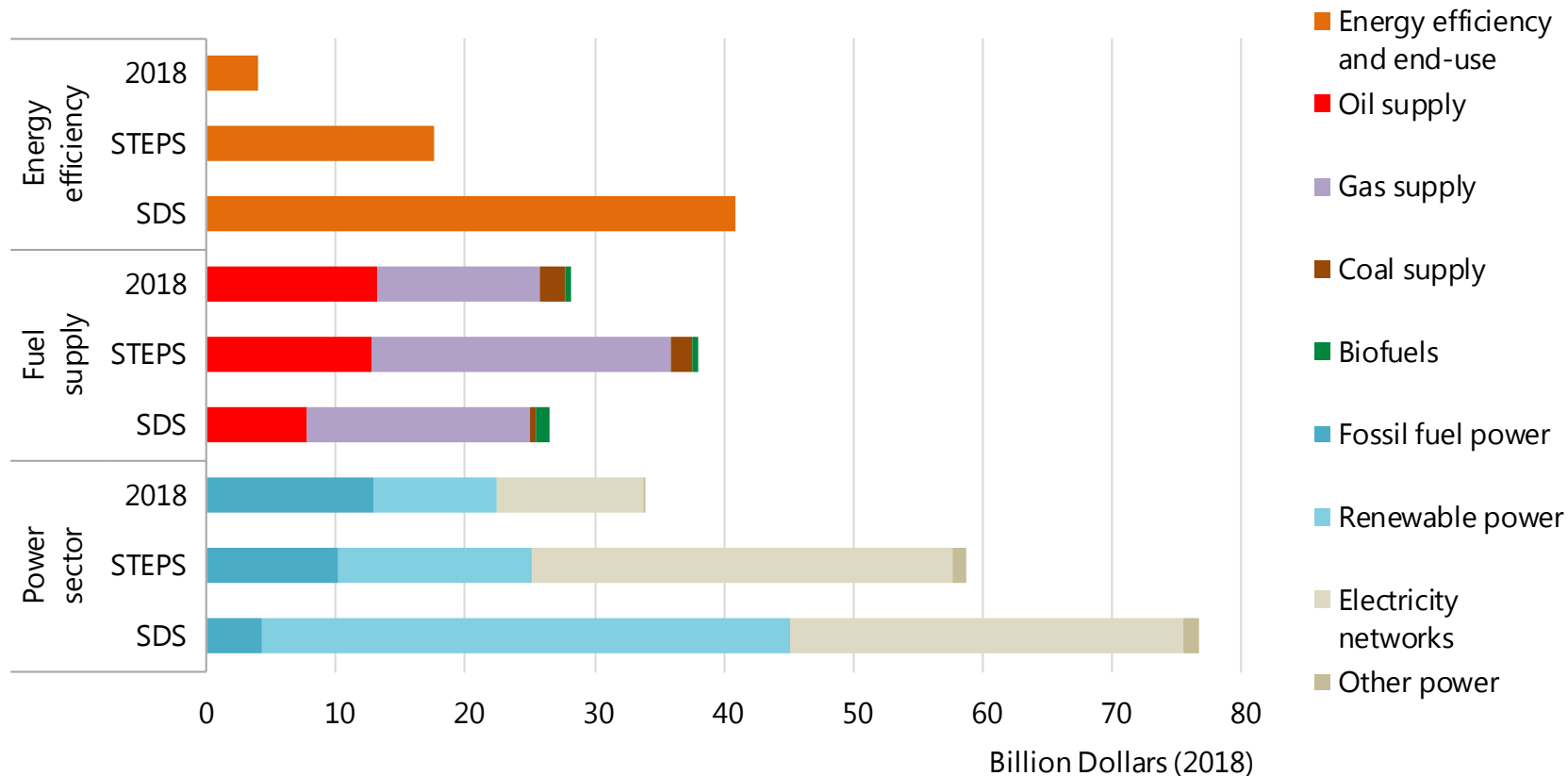
Financing in **Indonesia** is more varied with relatively high participation by international sources, including international public finance institutions and sources from China, which tend to be backed by the state, as well as commercial interests from elsewhere in Asia (e.g. Japan, Korea). This

international involvement reflects Indonesia's large market size and opening to IPPs, with the backdrop of a relatively underdeveloped domestic financial system. Still, the bulk of power investment has been carried out by the state-owned vertically integrated utility (PLN), whose financial position has become increasingly strained. Where private sources have financed investment, a degree of public finance participation has been important to reassure investors in the face of persistent risks related to the creditworthiness and reliability of power purchase by PLN.

In terms of capital structure, projects with private participation have generally attracted high shares of debt, reflecting a degree of maturity for certain technologies and the complementary role of public finance in reducing risks. In newer areas, equity can predominate, as in Viet Nam where there are lender concerns over the bankability of contracts for solar PV and wind. Nevertheless, a high feed-in-tariff for utility-scale solar PV projects has attracted substantial interest from investors and developers in Viet Nam.

Increased investment in energy is required in any scenario: reaching sustainability goals would mean a major capital reallocation to low-carbon supply and efficiency

Current energy investment in Southeast Asia by sector compared with annual average investment in the Stated Policies and Sustainable Development scenarios, 2019-2040



Notes: STEPS = Stated Policies Scenario; SDS = Sustainable Development Scenario. Projected investment is expressed as the annual average over the 2019-2040 period. Other power includes investment in battery storage and nuclear. Fossil fuel power includes both plants with and without carbon capture, utilization and storage technology.

Current investment trends are not aligned with stated policies and are well out of step with a sustainable path

Whichever way Southeast Asia's energy sector develops in the future, investment needs to increase significantly. However, the specific requirements and gaps differ starkly by sector and scenario, reflecting variations in the pathways for energy security and sustainability. Under the Stated Policies Scenario (STEPS), cumulative investment needs over 2019-40 total over \$2.5 trillion; in the Sustainable Development Scenario (SDS) they rise to near \$3.2 trillion.

The lower levels of oil spending seen since 2014 would need to taper further to be consistent with the Sustainable Development Scenario, i.e. a trajectory consistent with the Paris Agreement. Current investment levels are more aligned with a pathway of continued strong demand growth, as in the Stated Policies Scenario. For natural gas supply, current investment levels fall short of both scenarios, while for coal the opposite is the case: current spending exceeds the levels required in both scenarios.

In the power sector, today's investment falls short of the projected needs in the Stated Policies Scenario but is more than 50% lower than required in the Sustainable Development Scenario. Both scenarios would require a sizeable reallocation of capital; this is particularly visible in the Sustainable Development Scenario, which would require renewable-based power spending to quadruple and a boost

to spending on electricity networks.

While a shift in spending is required in energy supply, investment needs also rise for demand, particularly in more efficient cooling systems, buildings and vehicles. Moreover, while purchases of more efficient air conditioners, for example, do not necessarily require huge amounts of new upfront capital, success in attracting more investment in energy efficiency helps to keep capital needs in check on the supply side (see section on cooling).

Increased investment needs are broad-based. The role of Indonesia, which accounts for one-third of investment needs, similar to today, remains consistent under both scenarios. Across most markets, the role of power, efficiency and other end use rises, but particularly in the Sustainable Development Scenario, where the share increases from around 60% today to 80% by 2030.

The higher investment needs of the Sustainable Development Scenario are compensated by savings elsewhere, notably in fuel supply. For example, while average annual capital spending is over \$140 billion over 2019-40 (compared with around \$110 billion in the Stated Policies Scenario), Southeast Asian economies save nearly \$200 billion annually on fossil fuel imports by 2040.

Roadmap for enhancing regional capabilities to attract investment and develop sustainable financing models

The IEA and Singapore Energy Market Authority have developed a Capacity Building Roadmap on Clean Energy Investment and Financing, which was endorsed by ASEAN energy ministers in 2018.





























Current enabling environments and investment frameworks in Southeast Asia often are not conducive to wide-scale financing of renewables and energy efficiency. The roadmap aims to address this gap by enhancing regional capabilities to attract investment in clean energy and develop sustainable financing models.

The roadmap identifies priorities for Southeast Asian countries that need to be addressed to reduce investment risks and encourage financing in line with the goals of the Sustainable Development Scenario. The roadmap has four key elements:

- optimising investment frameworks;
- designing investment grade policies and measures to create financing opportunities;
- ensuring an adequate supply of finance and
- implementing integrated policy approaches for investment.

Reducing risks and improving policy and market approaches around four priority areas is critical to meet future power investment needs

Investment: current frameworks, key priorities and risks for power markets in Southeast Asia

Market	Main investment framework	Investment Priorities			
		Financial health of the system	Project bankability	Financing and cost of capital	Integrated approaches
Indonesia	State-owned single buyer with IPPs; utility-owned grid with retail regulation.				
Malaysia	Regulated single buyers with IPPs; utility-owned grid with retail regulation.				
Philippines	Wholesale market with IPPs; partial retail competition and grid unbundling.				
Singapore	Wholesale market with IPPs; retail competition and grid unbundling.				
Thailand	State-owned single buyer with IPPs; utility-owned grid with retail regulation.				
Viet Nam	State-owned single buyer with IPPs; utility-owned grid with retail regulation.				
Other (Cambodia, Lao PDR, Myanmar)	State-owned single buyer with IPPs; utility-owned grid with retail regulation.				

 Low risk/supportive factor for investment

 Potential risk factor/barrier for investment

 High potential risk factor/barrier for investment

Note: IPPs = independent power producers.

Efforts needed across four priority areas, while recognizing that market conditions and underlying risks differ starkly by country

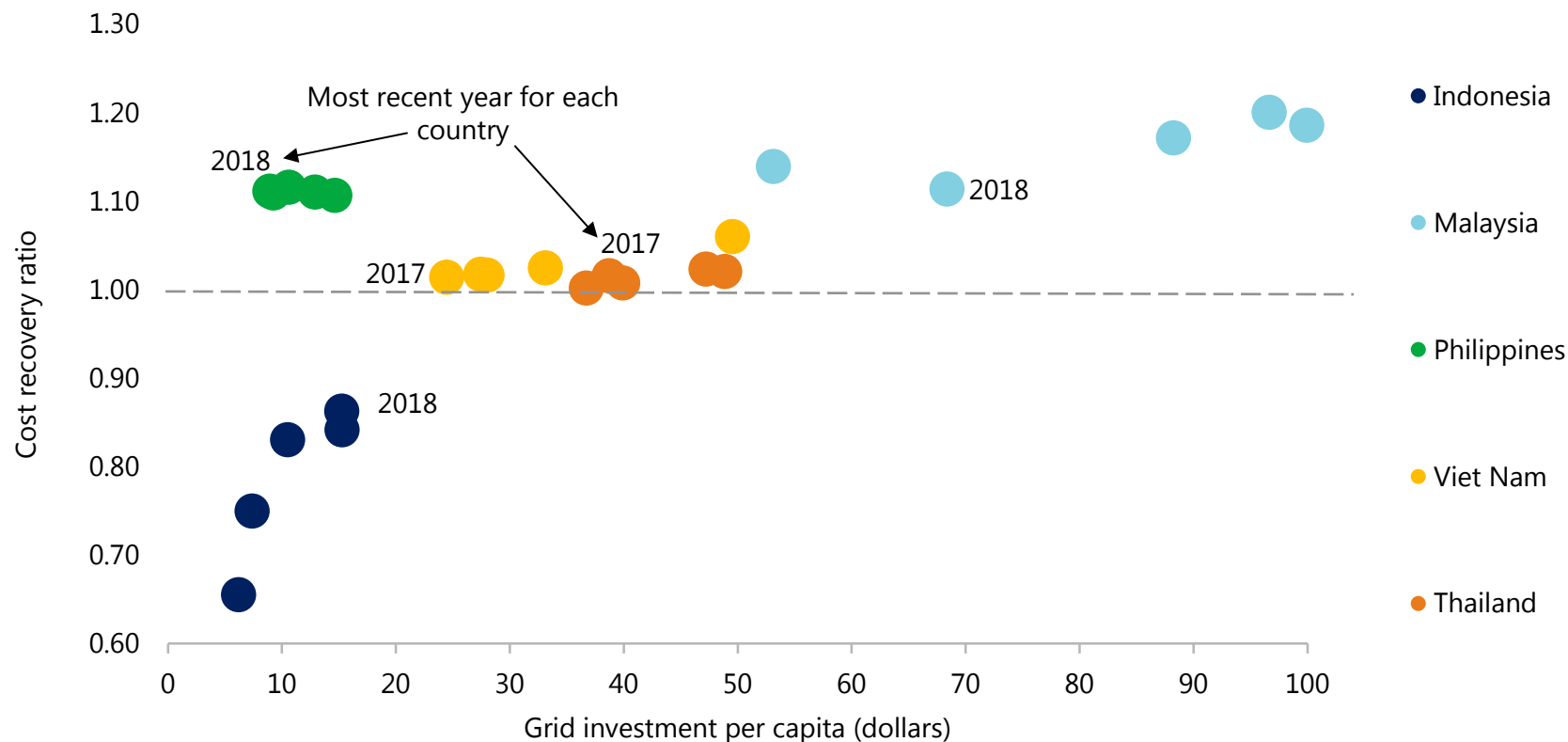
Southeast Asian countries have very different risk profiles concerning these priority areas, as summarised in the previous slide.

Investment priorities for Southeast Asia examined in the following slides include -

- **Enhance the financial sustainability of power systems:** improve the investment capacity of utilities as the main investors in grid infrastructure and their role as creditworthy purchasers of power (investment frameworks element).
- **Improve the bankability of power projects:** design and implement robust procurement frameworks and well-designed contracts with adequate tariffs and price competition that improves the affordability of investment (investment grade policies element).
- **Improve the availability of financing and cost of capital:** create a supportive financial ecosystem that attracts a diversity of financing sources and reduces the cost of capital (adequate supply of finance element).
- **Promote integrated approaches for investment:** establish planning, policies, business models and financial tools that support investment in demand-side activities and seek to better align energy and financial system goals (integrated approaches element).

Priority 1: Financial sustainability – the creditworthiness and investment capacity of utilities depends on their profitability and ability to recover costs

Electricity grid investment per capita versus utility cost-recovery ratios in Southeast Asian markets (most recent five years)

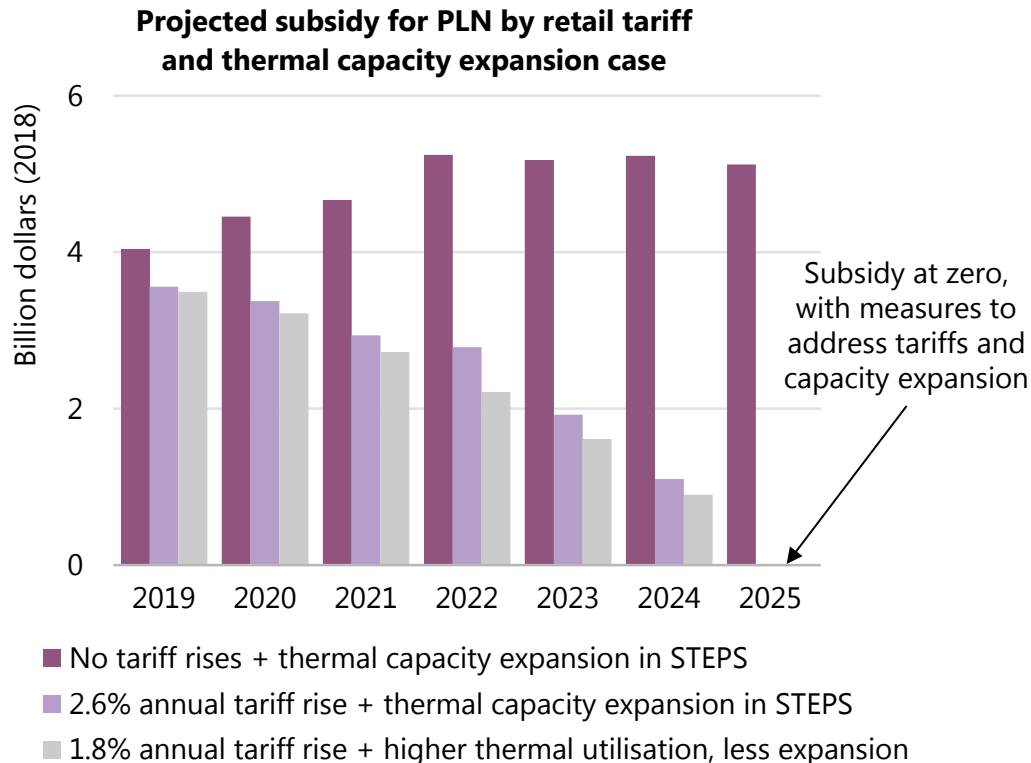
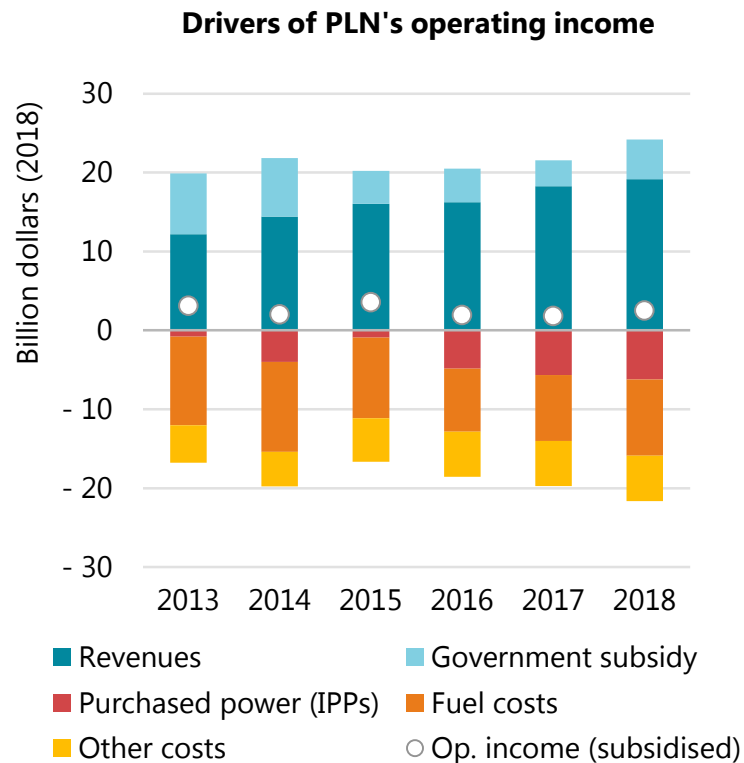


Note: Cost recovery is measured as the ratio of total operating revenues to total operating costs (including depreciation) plus net financing costs for reference utilities and excluding explicit subsidy payments.

Source: IEA analysis with calculations for cost recovery based on financial statements of reference utilities in each market.

In Indonesia, without efforts to raise retail tariffs or manage rising capacity payments to thermal generators, PLN's subsidy burden continues to rise

Indonesia's state-owned utility, PT PLN (Persero): operating income and projected annual government subsidy burden



Notes: Op. = operating income; STEPS = Stated Policies Scenario. Purchased power from IPPs includes variable payments for electricity production and fixed payments for thermal power capacity that is remunerated under long-term take-or-pay agreements. Projected subsidy assumes constant basic cost of electricity production taking the most recent five-year average as reported in PLN statistics.

Source: IEA analysis based on PT PLN (Persero) company reports.

Financial sustainability of Southeast Asia power systems requires effective regulatory frameworks for planning, pricing and payments

Financial sustainability of utilities and investment levels are strongly linked, as shown in the analysis of cost recovery ratios – the ratio of revenues to costs, including operating costs, depreciation and financing – across Southeast Asia markets. The cost recovery ratio is largely determined by the number of connected consumers, operational performance and institutional capacity to set proper regulations. Policy makers face a challenge in setting retail tariff levels and providing incentives to ensure cost recovery, as well as to balance affordability of electricity for consumers.

Most regulators in the region use a cost-of-service methodology, in which end-user tariffs are set in a way that allows utilities to recover their fixed investment and variable costs and earn a reasonable return on equity. In Malaysia, for example, reforms to electricity tariffs have boosted the cost recovery picture for the main utility even as investment and financing costs increased.

In some markets, however, cost recovery remains less reliable. In Viet Nam, the vertically-integrated utility (EVN) received its first credit rating (“BB”) in 2018. This facilitates borrowing from international bond markets. Retail power tariffs were raised in 2019 to cover rising production costs. Yet, EVN’s finances remained tied to government decisions

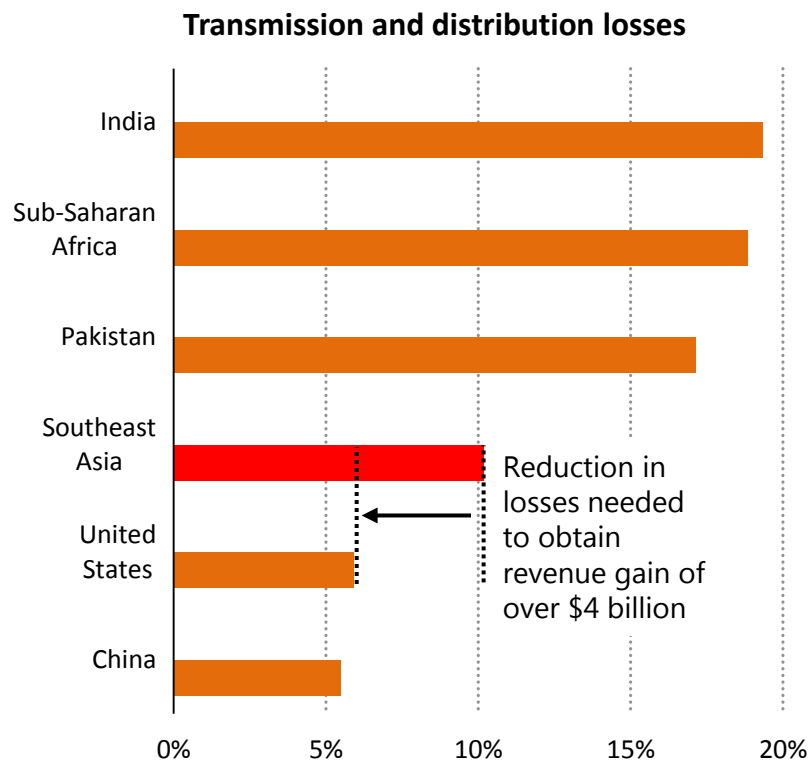
on electricity prices, which remain low by international standards. Grid investment remains insufficient for the integration of an expanding field of new renewable capacity.

Following several years of improvement, increased financial pressure on PLN, Indonesia’s utility, due to rising power purchase and fuel costs in the face of frozen retail tariffs, prompted a year-on-year boost in subsidies provided by the government in 2018 (equivalent to 3.2% of total state spend and 0.14% of GDP) to maintain positive operating income.

Looking ahead, PLN’s increasing take-or-pay contract obligations with IPP thermal generators combined with persistently low retail prices mean that this subsidy would be over \$5 billion annually in the coming years in order to maintain the 2018 operating result. Without further effort to tackle operating costs, average annual retail tariff increases of more than 2.5% would be needed to reduce the subsidy burden by 2025. However, tariff increases could be softened considerably with system planning that seeks better utilisation of existing generation assets, more focus on slowing demand growth and less dramatic expansion of capacity with contractually onerous terms. With higher plant utilisation and lower capacity expansion, retail tariffs would need to rise by less than 2% annually to eliminate the subsidy burden.

Reducing grid losses is an important measure to enhance financial sustainability...

Average transmission and distribution losses (left) and existing and planned cross-border lines in Southeast Asia (right)



Note: MW = megawatt. Generation cost assumed to calculate revenue gain = \$90/MWh (estimated average long-run marginal cost for the region).

Source: Calculations based on World Bank (2019b).

Cross-border lines: existing, planned and sources of finance

Existing cross-border lines	~15 lines, ~5 500 MW
Future cross-border lines	~2 250 MW (under development by 2021) ~20 000 MW (planned post 2021)
Financing characteristics of current cross-border lines	
<ul style="list-style-type: none"> Mostly publicly funded, between two neighboring utilities or transmission companies. Debt-heavy investments. Some cross-border projects have raised substantial shares of commercial debt; others are more reliant on direct financial investment (e.g. Sarawak/West Kalimantan line ~ \$155 million). Power purchase agreements underlying the investments. 	

...and to enhance utility revenues, facilitating investment in networks and integration

On average, transmission and distribution (T&D) losses in Southeast Asia are at relatively manageable levels compared to other emerging economies, where losses account for up to a fifth of the power generated. However, there are significant variations across the region: losses are around 20% in Cambodia and Myanmar, while Singapore is near 2%.

Higher T&D losses translate into lower revenues for utilities. Technical losses (e.g. inadequate maintenance) and non-technical losses (e.g. commercial inefficiencies like poor metering or theft) create mismatches between the power fed into the system with that billed and collected. Reducing average T&D losses in Southeast Asia to best practice levels (~6%) would improve revenues by over \$4 billion per year – equivalent to almost twice the region's total investment in utility-scale solar PV in 2018.

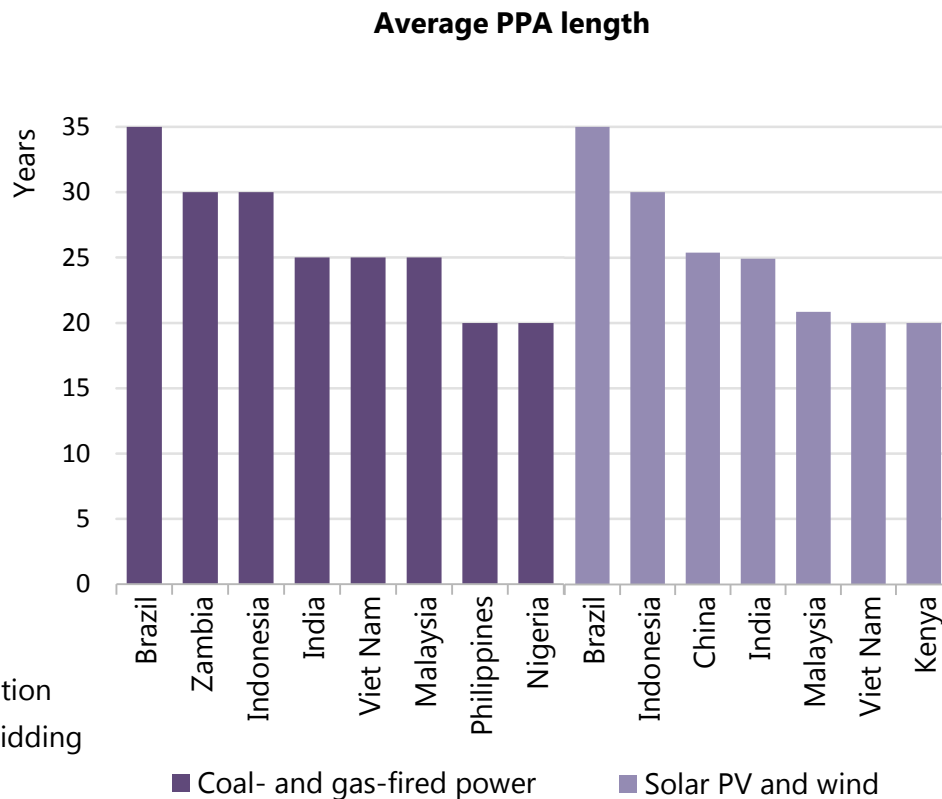
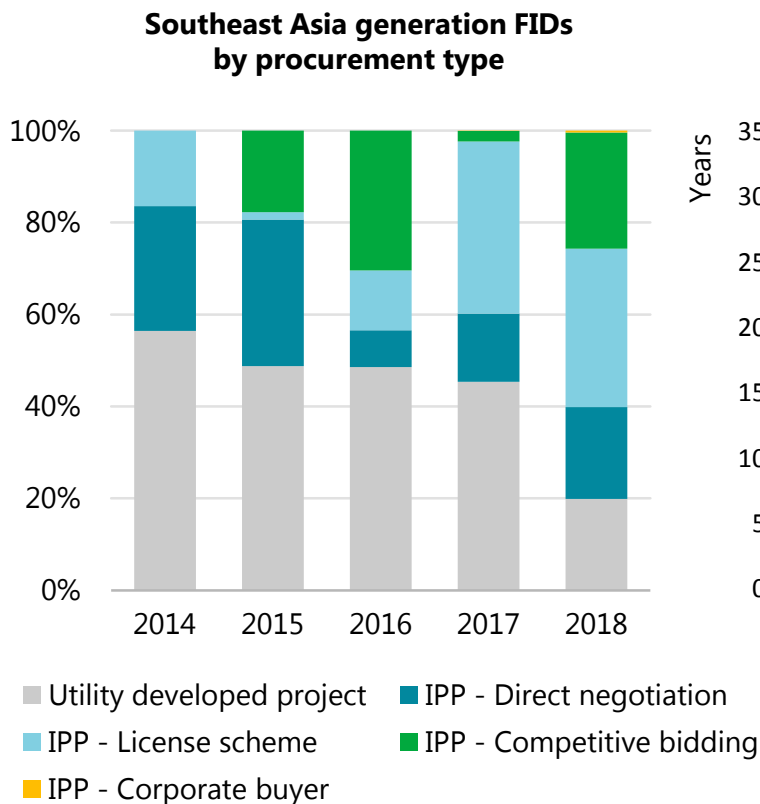
This additional income would help to improve the financial position of utilities, allowing for increased investment in the grid. Enhanced creditworthiness of utilities also improves their ability to raise funds and helps to attract higher private sector participation. This would enhance the efforts of utilities across the region to make progress with the ten cross-border interconnections that are under development, which would add 40% more capacity for intra-regional trade.

Investment in transmission across the region is almost all publicly funded, except in the Philippines where a private company has a concession to operate and maintain the grid and invest in new assets. Cross-border transmission lines are no exception – neighbouring utilities sign a power purchase agreement and finance the line to the border. For example, PLN and Syarikat SESCO (Malaysian state-owned utility) signed a 20-year power agreement in 2012, which underpins the Sarawak–West Kalimantan transmission line (a 275 kilovolt, 83 kilometre line between Malaysia and Indonesia). The agreement would enable PLN to import up to 230 megawatt (MW) of power, part of it on a take-or-pay basis.

As examined in slides 143-148, regional power integration can reduce system costs by facilitating access to lower cost generation and sharing reserves, and increase resilience and the ability to manage seasonal and short-term shocks. The investment in the Sarawak–West Kalimantan line allows PLN to access low-cost hydropower from Sarawak, which is also complementary to their thermal-based generation.

Priority 2: Bankable projects - most investment in power generation has been from state-owned utilities and direct negotiation, but competitive bidding is increasing

Generation final investment decisions by procurement type (left) and maximum average power purchase agreement length for selected countries (right)



Notes: FIDs = final investment decision; IPP = independent power producer; PPA = power purchase agreement. Competitive bidding is a competitive, public award method to procure capacity based on price. License scheme is an administrative process to allocate licenses or price premiums (e.g. feed-in tariffs). Direct negotiation is an award method based on direct agreement between private and public parties without a competitive process. Corporation is direct procurement by a non-energy company. The left graph includes only utility-scale projects ≥ 25 MW.

Frameworks for power have evolved considerably, but further reform – including adequate tariff levels and increased competition – would enhance investment

Robust procurement frameworks and well-designed contracts are crucial for project bankability. To date, decision making by state-owned utilities has driven most power investments in the region. In some markets, e.g. Indonesia, Viet Nam and Myanmar, most generation has been built, owned and operated directly by the utilities.

IPPs have long played a role in Malaysia, Philippines, Singapore and Thailand, and are increasing in other markets. This takes pressure off stretched utility balance sheets. But many IPP investments have been developed through direct negotiation with the utility, which can be a cumbersome and non-transparent process. Most power purchase agreements have been long-term in nature, but their terms and bankability vary considerably.

New procurement frameworks have recently emerged. Renewable incentives (e.g. feed-in tariffs) awarded through licensing schemes drove most investment in bioenergy and geothermal, as well as some solar PV and wind. But design and implementation of incentives is not always effective.

In Indonesia, feed-in tariffs were set at levels capped by the local price of coal power to avoid additional economic burden on PLN. These levels have been too low to attract sustained investment at current project costs. In remote areas, where renewables are attractive versus expensive

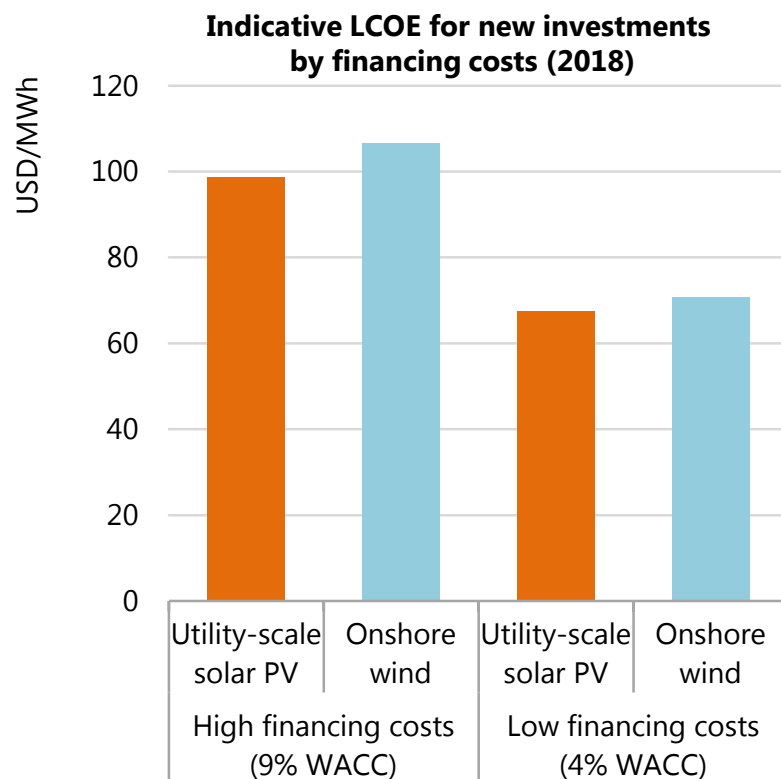
diesel generation, lack of local industrial capacity and supply chains have stymied development. Overall, with persistent challenges in licensing and land acquisition, renewables have far underachieved their potential in Indonesia.

Competitive bidding schemes are small but growing for renewables, mostly in Malaysia, Thailand and Indonesia (geothermal). Such frameworks provide transparent price discovery, and with contracts with appropriate risk allocation, have helped drive down power purchase prices for renewables around the world. Their success depends on having achieved a certain level of market maturity (e.g. local supply chains), and the capacity of governments to design auctions and enforce power purchase contracts.

There is an increasing global trend of corporations procuring renewable-based power directly from projects, independent of government and utility plans (IEA, 2019b). While nascent in Southeast Asia, there is rising interest given the region's role as a manufacturing hub. Companies in Singapore and Thailand (e.g. Apple and Asia Pacific Breweries) signed long-term PPAs for almost 150 MW of distributed solar PV over 2017-19. Scaling up corporate sourcing requires more progress in regulations allowing for third-party grid access, contracting and reselling of power, utility reforms and certification (to ensure that corporate procurement actually leads to additional capacity being developed).

In Viet Nam, renewables face challenges about the bankability of power purchase contracts and potential risks arising from local integration challenges...

Levelised cost of electricity for new solar PV and wind and key risk factors for bankability of investments in Viet Nam



Key risks that impact the bankability of solar PV and wind projects for international investors in Viet Nam

Risk	Allocation of risk within PPA or policy
Unreliable dispatch	No take-or-pay or minimum purchase agreement; generator takes risk for grid non-availability.
Unreliable payment	No government guarantee of EVN's obligations under the PPA.
PPA termination	Lack of clarity of how losses are compensated under termination by EVN.
Grid connection	Generator is responsible for transmission & grid connection to interconnection point.
Disputes	Dispute resolution under local law; arbitration by government rather than international body.
Currency	Payment in local currency, which is indexed to USD, but adjustment made only once per year.
Inflation	Tariff fixed for 20 years, but not inflation adjusted.

Notes: LCOE = levelised cost of electricity and is expressed on a nominal, unsubsidised basis. EVN = Viet Nam Electricity Group. USD = US dollars. Assumed capital costs = \$1 090/kilowatt (kW) for solar PV and \$2 080/kW for onshore wind. Assumed capacity factors = 17% for solar PV and 30% for onshore wind (South central Coast). Projects reflect capital structure of 70% debt/30% equity. Higher financing assumptions assume before-tax cost of debt of 6% and required return on equity of 16%. Low financing costs correspond to 3% for debt and 7% for equity.

....which is hampering the availability of low-cost international financing and the affordability of solar PV and wind

Viet Nam provides an interesting case study of some of the opportunities and challenges in developing bankable projects. The implementation of feed-in tariffs (FiT), awarded through administrative licensing, has generated a lot of interest in investing in solar PV and wind, financed primarily by local and regional banks. Recent changes to incentive levels have changed the economics of such projects, with policy provisions, such as the variation of FiT levels by region, encouraging more system-friendly deployment.

Nevertheless, financing costs are relatively high and international banks remain reluctant to lend to the sector. This is due to the allocation of certain key risks to generators, e.g. those related to dispatch, payments and potential legal disputes, in the PPAs that projects would sign with EVN and which are not mitigated by the larger policy support scheme or Viet Nam's power system.

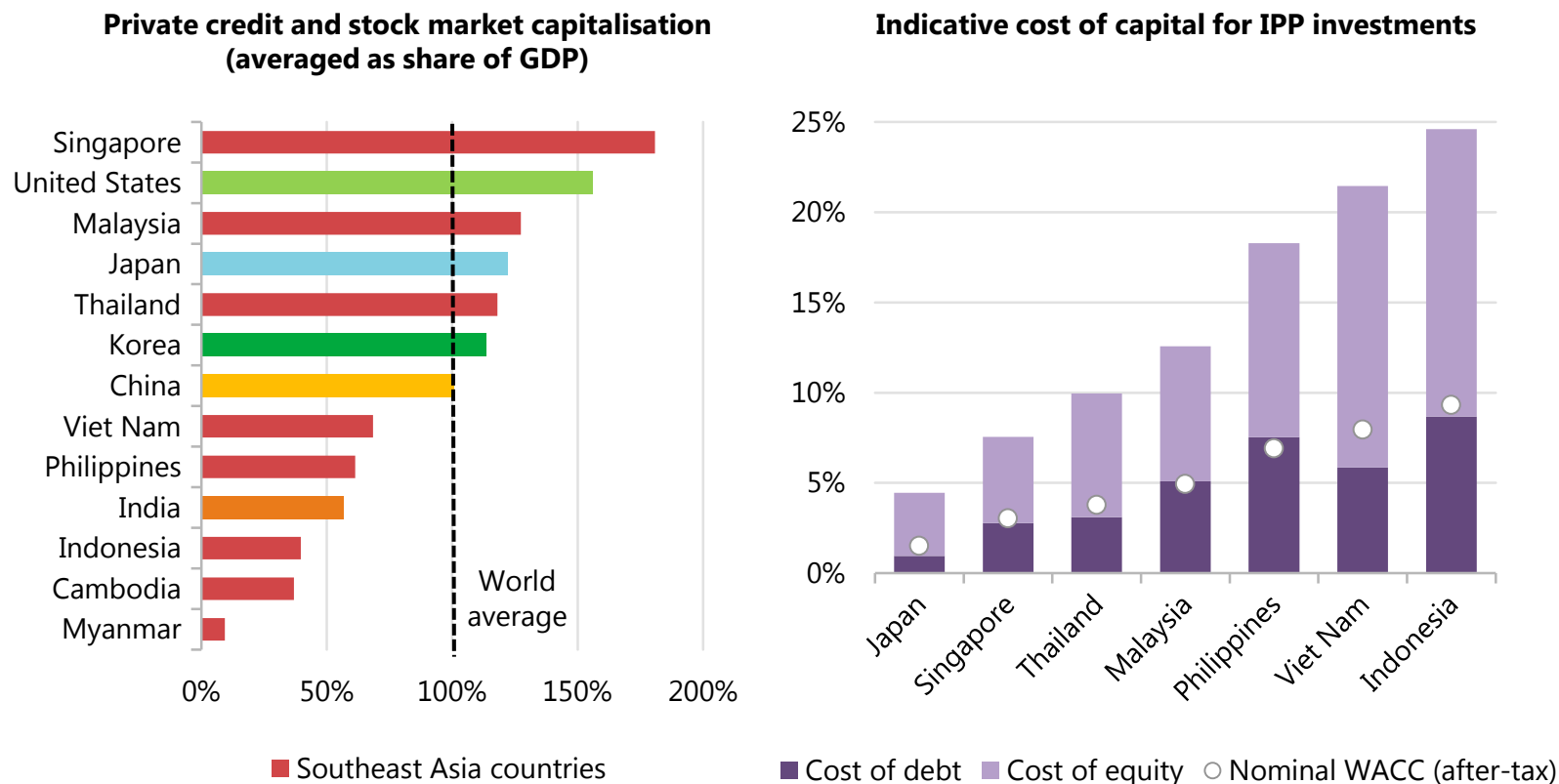
For example, a window of attractive feed-in tariffs (which transitioned to lower average rates in mid-2019) has spurred the rapid deployment of around 4.5 gigawatts (GW) of utility-scale solar PV in 2019 – more than five-times the country's target for 2020. However, the concentrated nature of deployment in relatively few provinces is raising concerns

over the adequacy of local grids to accommodate such a rapid increase in variable generation, creating risks of congestion and potential curtailment by EVN. Along with persistent financial risks (which meant that most international investors remained on the sidelines), this creates the potential for a boom-and-bust investment cycle.

Better risk management in terms of policy, system integration and financial measures could help to improve the affordability of investments. With good financing conditions the LCOE of solar PV and onshore wind could be around one-third lower than under high financing cost assumptions. To date, projects have typically been financed largely with equity, but some risk management efforts are facilitating lower cost debt. For example, a guarantee from Denmark's export credit agency to a local bank, which in turn provided a guarantee to an international lender, helped attract funding for the 33 MW Huong Linh 1 wind farm in 2018.

Priority 3: Availability of capital remains an issue in some Southeast Asian markets while country risks and financing costs vary considerably

Indicators for private capital availability (left) and IPP financing costs (right) in selected markets



Notes: IPP = independent power producer; WACC = weighted-average cost of capital expressed on an after-tax basis. Calculations for cost of capital are made using the capital asset pricing model, and country and company data. WACC estimates may not represent actual financing costs for given projects. Nominal WACC is calculated based on a uniform debt-to-equity weighting (70:30) across countries for a notional project carried out by an IPP.

Sources: IEA analysis based on data from Bloomberg (2019), Damodaran Online (2019) and World Bank (2019b).

Many dedicated public and private financing schemes support clean energy projects at different stages in Southeast Asia

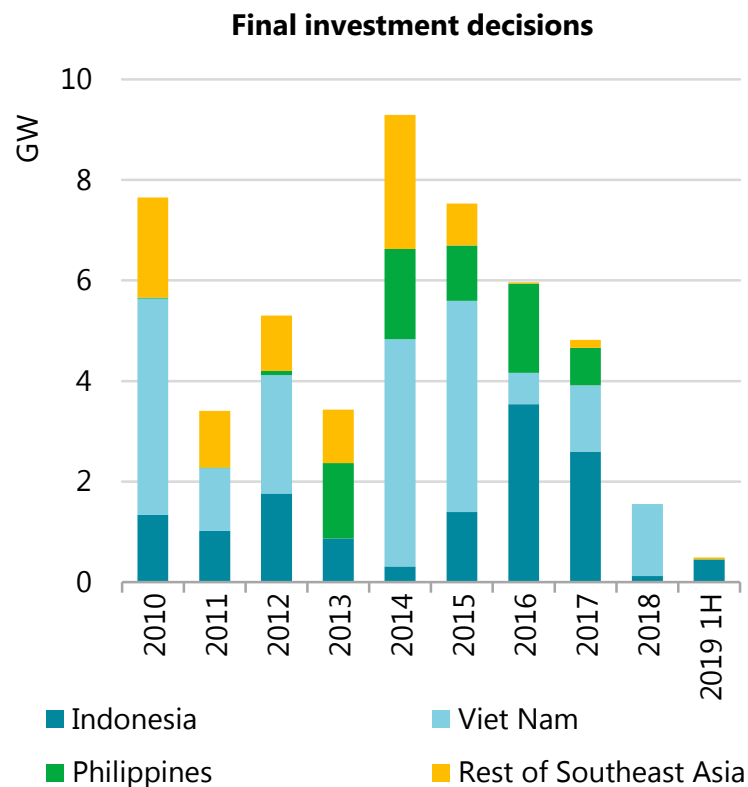
Selected financial schemes to support financing of renewables and energy efficiency projects

Type of scheme	Examples	Type of support by project/company phase		
		Preparation/early stage	Financing	Implementation
Development bank/ government fund	• Financing Utilities for Sustainable Energy Development - Development Bank of the Philippines	●	●	
	• Energy Efficiency Project Finance Program - Indonesia Eximbank and Asian Development Bank	●	●	●
	• Malaysia Government Credit Guarantee Corporation	●	●	●
	• Energy service company and Energy Efficiency Revolving Fund - Thailand	●	●	●
Financial institution	• Bank Pembangunan Malaysia Berhad High Technology Fund	●	●	
	• Sustainable Energy Finance Programme - Bank of Philippines Islands	●	●	
Impact funds, venture funds, other private funds (both for-profit and non-profit)	• Berkeley Energy Renewable Energy Asia Fund II		●	
	• Dragon Capital Mekong Brahmaputra Clean Development - Viet Nam	●	●	
	• Southeast Asia Clean Energy Facility (joint between European governments and philanthropic foundations)	●		

Source: IEA analysis with data adapted from Nexus for Development (2018).

Financing new coal power plants has become more challenging

Coal-fired power plant investments in Southeast Asia: final investment decisions and sources of debt for IPP projects



Notes: IPP = independent power producer; GW = gigawatts; 2019 1H = first half of 2019. Regional sources of finance include domestic financiers and those in other Southeast Asian countries.

Sources: IEA analysis with calculations based on McCoy Power Reports (2019) and World Bank (2019a).

Financial sector dynamics, and policy and market conditions shape financing trends by economy and power sub-sector

While power generation projects are being financed from an increasing diversity of sources, the availability of domestic private finance varies substantially across the region.

Singapore, Malaysia and Thailand all have financial systems that are relatively developed, but in other countries mobilising capital from banks and equity investors is more challenging. For example, the average duration of a loan in Southeast Asia is just over six years, making it difficult to finance capital-intensive energy and infrastructure assets that have longer operating lifetimes (UNEP and DBS, 2017).

These constraints, combined with underlying market and policy conditions and macroeconomic factors can lead to big differences in the cost of financing. For example, the estimated weighted average cost of capital for an indicative IPP investment (nominal, after-tax) can vary substantially – with estimates in Singapore, Thailand and Malaysia ranging from 3-5%, while those for Philippines, Viet Nam and Indonesia can be much higher (7-10%).

Some financing issues are sector specific. Potential investors cite limited availability of early stage project development equity and long-term construction debt for renewables in some markets, as well as constrained access to credit for small and medium-size enterprises that would invest in distributed renewables and efficiency.

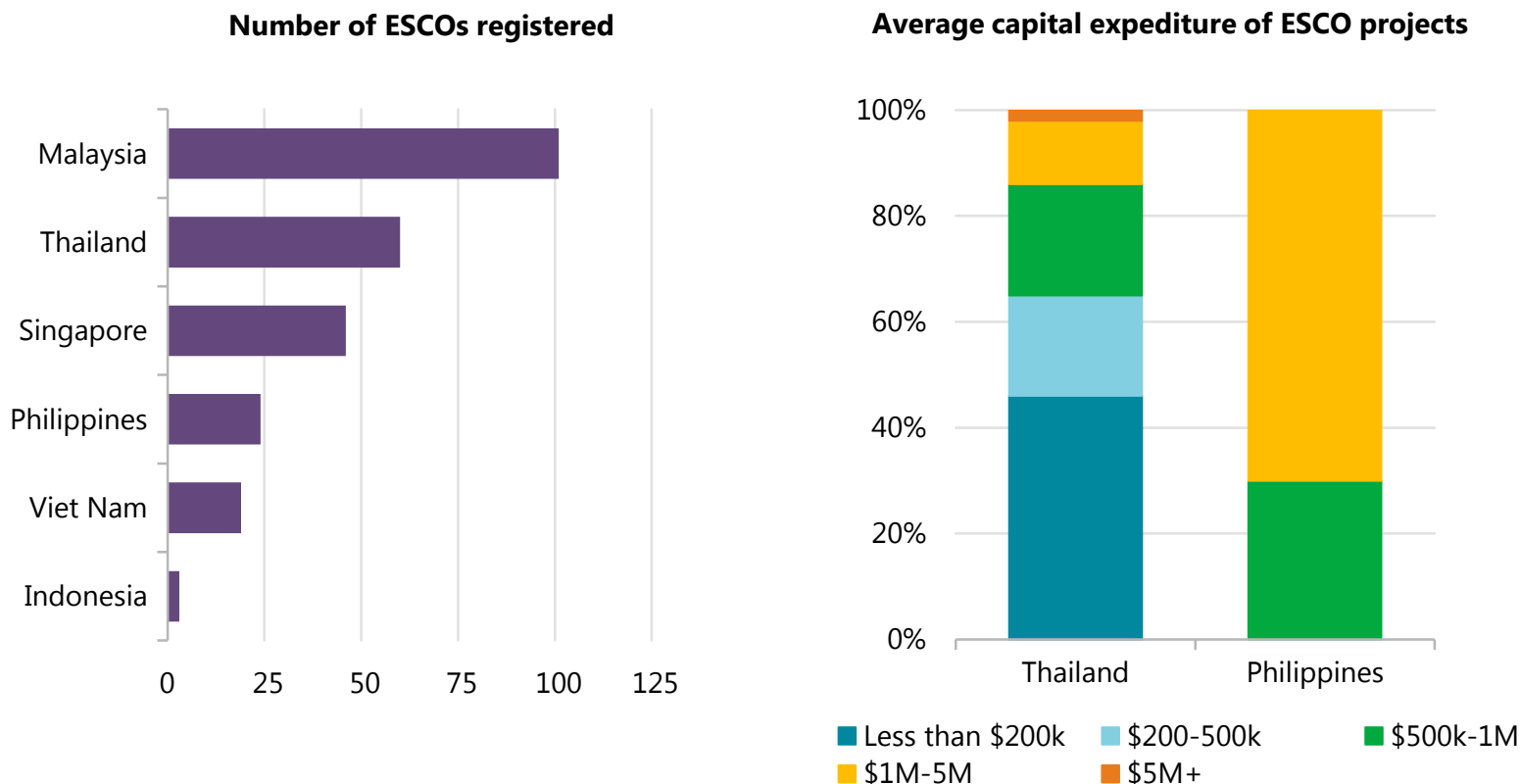
A number of public and private investment funds, with a variety of tools, have emerged to fill such financing gaps.

There is now increased scrutiny on financing coal in parts of the world. A number of financial institutions have announced intentions to restrict capital for coal power investment. In Southeast Asia, final investment decisions (FIDs) for coal power fell to their lowest level in over a decade in 2018; this also reflected overcapacity concerns after several years of intense construction of new plants. Data from the first half of the year suggest that FIDs may be even lower in 2019. FIDs remain concentrated in Viet Nam, Indonesia and Philippines where financing costs are also relatively high.

A look at financing of IPP coal plants shows a reduction in the number of financiers involved in transactions in the past three years (only one major plant reached a FID in 2018). Projects continue to rely on a high share of international finance, particularly from public sources (mostly export-credit agencies) and some financial institutions have recently announced restrictions on financing coal assets (e.g. China's State Development & Investment Corporation; Sumitomo Mitsui and Mitsubishi UFJ Financial Group in Japan; and DBS, the Oversea-Chinese Banking Corp and United Overseas Bank in Singapore).

Priority 4: Integrated investment approaches such as supporting markets for ESCOs help to address demand needs more cost effectively

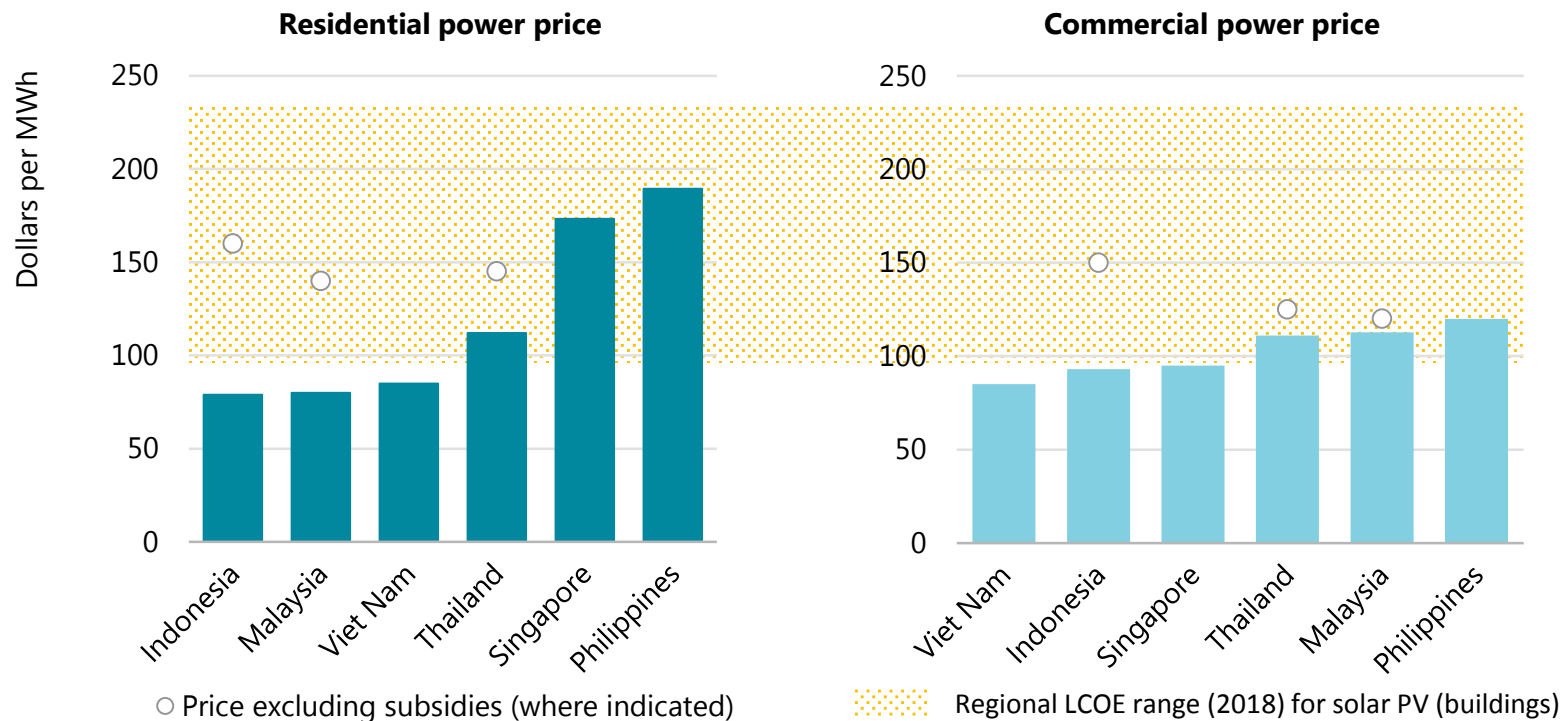
Energy service companies (ESCOs) registered and average investment size of ESCO projects in selected markets



Sources: ASEAN Centre for Energy (2017) for ESCO registrations; IEA (2018a) for ESCO project investment size.

Low and subsidised retail power tariffs can challenge the economic case for energy efficiency and distributed renewables solutions

Average retail power tariffs in selected Southeast Asia markets compared with regional range for levelised cost of electricity for distributed solar PV in residential and commercial buildings



Notes: LCOE = levelised cost of electricity; MWh = megawatt-hour; solar PV = solar photovoltaics. LCOE range is expressed in real terms.

Sources: Electricity price data is adapted from IEA (2019c); Bieri (2019).

Fewer market barriers and a stronger enabling environment would better support investment in small-scale projects, such as efficient cooling and solar PV

In Southeast Asia, energy service companies (ESCOs) provide a wide range of services, including delivering efficiency projects that are financed from energy savings, distributed supply (e.g. solar PV and bioenergy) and energy management functions. ESCOs have become well established in several markets, notably Malaysia, Thailand and Singapore. These countries have set long-term energy savings targets as well as supporting regulations for ESCO development and operation.

ESCOs play an important role in addressing the scale of the challenge associated with energy efficiency investment by providing performance-based contracting, which provides savings guarantees that make financing less risky, and aggregating projects, which facilitates financing at scale. The sizes of individual projects, which in Thailand and Philippines have ranged up to \$1 million or more, represent a large upfront expenditure for consumers, but at the same time are often too small to attract the attention of banks unless they are bundled into portfolios that can be evaluated and financed.

Addressing market barriers such as lack of information and understanding of the benefits and financial case for energy savings, and encouraging new financing models is important for more widespread adoption in Southeast Asia. Stronger effort to reduce energy subsidies in a number of markets would also improve the economics for investing in energy efficiency and distributed renewables.

Across the region, small-scale projects face difficult access to debt financing due to the size of the transactions and challenges in establishing credit ratings for end-users. In Indonesia, there are concerns by banks over the ESCO certification scheme and projects have required higher cost equity to proceed. In some markets, there are regulatory restrictions on which entities can undertake demand-side energy efficiency investments (Philippines) and energy performance contracting requirements have limited the number of ESCOs providing distributed solar PV solutions (Thailand).

Targeted public funds, financial instruments, insurance and new financing mechanisms are also important to address risks for small-scale investment

Targeted use of public funds is important to the outlook for investment in Southeast Asia. For example, in Thailand ESCOs are often too small to attract debt finance so the government has established an ESCO Fund, which provides equity and equipment leasing, and an Energy Efficiency Revolving Fund, which provides low-interest loans to banks who on-lend to project developers. These measures helped to kick-start the market. Singapore's Economic Development Board is piloting an Energy Efficiency Financing Programme through a third-party financier which provides upfront capital and guarantees for projects.

Uncertainty associated with the performance of efficiency measures inhibits third-party energy efficiency financing around the world. In response, energy savings insurance (ESI) has emerged as a solution offered by a small number of financial institutions, private and insurance companies, as a way to reduce the risk of energy efficiency projects.

As part of its Energy Efficiency Project Finance Program, Indonesia's Export Import Bank (with support from the Asian Development Bank) integrates loan instruments, capacity building for banks to evaluate energy efficiency projects, as well as ESI, which helps to reassure banks about the performance risk associated with projects and enhances the

credit capacity of facility owners. Further development of a comprehensive loan framework for energy efficiency financing in Indonesia, combined with technical assistance for project evaluation, will be important to scale up investment in efficiency.

The aggregation function of ESCOs can be a vehicle for creating project portfolios that can be issued as securities, such as green bonds. Aggregating projects facilitates the diversification of risks, which can attract lower cost finance from a bigger pool of investors.

In Southeast Asia, green bond issuances picked up in 2018 and over 40% of the bonds target low-carbon buildings. But at just \$5 billion of cumulative issuance, the region only accounts for 1% of global green bonds issued to date (CBI, 2018).

To attract much larger pools of capital from institutional investors, further work is needed in terms of aggregation and securitisation of projects and portfolios.

Acknowledgments

This report was prepared by the *World Energy Outlook (WEO)* team in the Directorate of Sustainability, Technology and Outlooks (STO) of the International Energy Agency (IEA), in co-operation with other directorates and offices of the Agency. The study was designed and directed by Tim Gould, Head of the WEO Energy Supply and Investment Outlooks Division. Wataru Matsumura co-ordinated the work and was one of the principal authors of the sections on Energy in Southeast Asia and Southeast Asia's Energy Prospects to 2040, together with Livia Gallarati and Yoko Nobuoka.

Melanie Slade, Maxine Jordan and Luis Lopez were the principal authors of the section on the Future of Cooling. Zoe Hungerford, Randi Kristiansen, Yugo Tanaka, Peerapat Vithayasrichareon and Matt Wittenstein were the principal authors of the section on Regional Power Trading. Michael Waldron and Lucila Arboleya Sarazola were the principal authors of the section on Investment in Reliable, Sustainable and Affordable Power.

The study relied on support from across the entire *WEO* team, in particular from Zakia Adam, Stephanie Bouckaert, Michela Cappannelli, Arthur Contejean, Timothy Goodson,

Tae-Yoon Kim, Paweł Olejarnik, Claudia Pavarini, Glenn Sondak, Brent Wanner and Peter Zeniewski, as well as valuable guidance from Laura Cozzi, Chief Energy Modeller and Head of Division for Energy Demand Outlooks.

Debra Justus carried editorial responsibility.

The report also benefited from valuable inputs, comments and feedback from other experts within the IEA, including Keisuke Sadamori, Carlos Fernandez Alvarez, Kieran Clarke, Craig Hart, Kevin Lane, Raimund Malischek, Emily McQualter, Brian Motherway, Jacob Teter, Maki Yamaguchi and Shuang Zhang. Kieran Clarke, the IEA's programme manager for Southeast Asia provided support and advice throughout.

Thanks go to the IEA's Communication and Digitalisation Office for their help in producing the report and website materials, particularly to Jad Mouawad, Jethro Mullen, Astrid Dumond, Katie Lazaro, Jon Custer, Christopher Gully, Martin Tav, Rob Stone and Sabrina Tan. Eleni Tsoukala provided essential support to the peer review process.

Acknowledgments

The IEA would like to thank ASEAN member countries and the ASEAN Secretariat for their co-operation and support with numerous aspects of this analysis, in particular Singapore, which held the Chairmanship of ASEAN in 2018, Thailand, Chair in 2019, and Viet Nam, Chair in 2020.

Valuable input to the analysis on Regional Power Trading was provided by the ASEAN Centre for Energy and Nord Pool Consulting. The IEA would also like to thank the ASEAN Secretariat Energy & Minerals division, HAPUA, AERN and APGCC for their valuable support.

The work could not have been undertaken without the support and co-operation provided by many government bodies, organisations and companies worldwide, in particular the Ministry of Economy, Trade and Industry of Japan, the Electricity Generating Authority of Thailand (EGAT) and Temasek from Singapore. The ASEAN-Australia Development Cooperation Program Phase II provided support for the work on Regional Electricity Cooperation. Activities within the IEA Clean Energy Transitions Programme (CETP) provided valuable support to this analysis on investment: the CETP is funded by Canada, Denmark, the European Commission, Finland, Germany, Italy, Japan, New Zealand, Sweden, Switzerland and the United Kingdom.

Many high-level government representatives and experts have contributed to the process, from consultations and contributions to the workshop, to reviewing the draft report. Their insights and comments were of great value. They include:

Saleh Abdurrahman	Natural Resources Economics, ESDC
Venkatachalam Anbumozhi	Economic Research Institute for ASEAN and East Asia (ERIA)
Christopher Beaton	International Institute for Sustainable Development (IISD)
Tuan Ab Rashid bin Tuan Abdullah	Universiti Tenaga Nasional (UNITEN), Malaysia
Hans-Arild Bredesen	CEO Nordpool consulting
Mick Buffier	Glencore
Weerawat Chantanakome	Ministry of Energy, Thailand
Rebecca Collyer	European Climate Foundation

Acknowledgments

David C. Elzinga
Bert Fabian
Faith Gan

Masazumi Hirono
Ken Koyama
Kira Lamont
Bert Metz
Michelle Murphy Rogers
Nicholas Ong
Nguyen Phuong Mai

Eric Puik
Hans-Wilhelm Schiffer
Shigeru Suehiro
Beni Suryadi
Cecilia Tam
Jesus Tamang
Xiaodong Wang
Adam Ward
Kelvin Wong
Akira Yabumoto
Yongping Zhai

Asian Development Bank (ADB)
United Nations, Environment Programme
Energy Market Authority - External Relations Department - International
Cooperation
Tokyo Gas
Institute of Energy Economics, Japan
United Nations ESCAP
European Climate Foundation
Allotrope Partners
Temasek
Electricity and Renewable energy Authority Ministry of Industry and Trade of
Vietnam
Shell
World Energy Council
The Institute of Energy and Economics, Japan
Asean Centre for Energy (ACE)
OECD Environment Directorate
Energy Policy and Planning Bureau, Philippines
World Bank
Global Green Growth Institute - Green Growth Planning and Implementation
Project Finance, DBS Bank
J-power
Asian Development Bank (ADB)

References

ACE (ASEAN Centre for Energy) (2017a), *ASEAN Power Cooperation Report*, www.aseanenergy.org/resources/reports/asean-power-cooperation-report/, accessed 5 September 2019.

- (2017b), *ASEAN ESCO Report*, <http://www.aseanenergy.org/resources/esco-report/>, accessed 15 June 2019.

Bieri (2019), *Case study presentation on business models and financing for distributed solar PV*, Singapore-IEA Clean Energy Investment and Financing Training, Singapore.

Bloomberg (2019), Bloomberg terminal, accessed 15 June 2019.

CBI (Climate Bonds Initiative) (2018), *ASEAN Green Finance – State of the Market 2018*, https://www.climatebonds.net/files/reports/asean_sotm_18_final_03_web.pdf, accessed 15 June 2019.

Damodaran Online (2019), (data base), <http://pages.stern.nyu.edu/~adamodar/>, accessed 15 June 2019.

DEDE (Department of Alternative Energy Development and Efficiency, MINISTRY OF ENERGY, Thailand), *Thailand Alternative Energy Situation 2017*, www.dede.go.th/ewt_news.php?nid=47340, accessed 5 September 2019.

ERIA (Economic Research Institute for ASEAN and East Asia) (2018), *Lao PDR Energy Statistics 2018*, <http://www.eria.org>, accessed 28 June 2019.

European Union Road Federation (2017), *Road Statistics Yearbook 2017*, <http://www.erf.be>, accessed 3 July 2019.

References

IEA (International Energy Agency) (2019a), *The Future of Rail*, IEA, Paris.

- (2019b), *World Energy Investment 2019*, IEA, Paris.

- (2019c), *World Energy Prices Data*, IEA, Paris

- (2018a), *Energy Service Companies*, IEA, Paris, <https://www.iea.org/topics/energyefficiency/escos/>, accessed 15 June 2019.

- (2018b), *World Energy Outlook-2018*, IEA, Paris.

- (2017), *The Future of Cooling*, IEA, Paris.

IEA and Singapore Energy Market Authority (2019), *Clean Energy Investment and Financing Capacity Building Roadmap for ASEAN*, IEA, Paris.

IMF (International Monetary Fund) (2019), *World Economic Outlook 2019* (database), IMF, Washington, D.C.

McCoy Power Reports (2019), (database), Richmond, <https://www.mccoypower.net/>

MEM (Ministry of Energy and Mines, Lao PDR) (2018), *Lao PDR Energy Statistics 2018*, www.eria.org/uploads/media/0_Lao_PDR_Energy_Statistics_2018_complete_book.pdf, accessed 5 September 2019.

Nexus for Development (2019), *Finance Solutions Map*, <https://nexusfordevelopment.org/lift/finance-solutions-map/>, accessed 30 August 2019.

The ASEAN Secretariat (2018), *ASEAN Statistical Year Book 2018*, <https://www.aseanstats.org>, accessed 3 July 2019.

References

United Nations Statistics Division (2019), *National Accounts Official Country Data*, <http://data.un.org/>, accessed 10 September 2019.

UNEP (UN Environment Programme) and DBS (2017), *Green finance Opportunities in ASEAN*, https://www.dbs.com/iwov-resources/images/sustainability/img/Green_Finance_Opportunities_in_ASEAN.pdf, accessed 10 October 2019.

World Bank (2019a), *Private Participation in Infrastructure* (database), World Bank, <https://ppi.worldbank.org/en/ppi>, accessed 15 June 2019.

- (2019b), <https://data.worldbank.org/indicator/>, accessed 15 June 2019.

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“Revised version, October, 2019.
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Design in France by IEA – October 2019