Secure, Sustainable and Affordable Power Systems in Emerging Economies

Abstract

The global power sector will change significantly in the coming years, as variable renewable resources are deployed on a large scale and new flexibility options appear, such as energy storage devices. In this context, thermal plants that use fossil fuels will experience a reduction in their share of power sector output, particularly in advanced economies, as efforts to achieve climate goals are increased. In developing economies, overall electricity demand will increase as power demand is pushed up by economic growth, urbanisation and increasing energy access. This report clarifies the role that thermal plants will play in the power systems of emerging economies in different IEA scenarios, including the Stated Policies Scenario and Sustainable Development Scenario of the 2019 *World Energy Outlook*. International co-operation and knowledge sharing can play significant roles in helping emerging economies carry out an affordable energy transition.

Preface

The power sector's vital importance for modern society will only increase as electrification allows the decarbonisation of other sectors, like transport. However, the power sector accounts for 40% of greenhouse gas emissions, most of which is emitted from thermal plants, and in particular from those using fossil fuels. What roles will thermal plants play in enabling decarbonisation, satisfying energy needs and providing electricity security? To what extent will emerging economies need to rely in these sources in coming years?

To answer these questions, this report builds on the scenarios in *World Energy Outlook 2019*. IEA scenarios are internally consistent visions of the world that can be compared with each other to understand what global energy supply and demand could look like depending on the paths that are taken.

The Stated Policies Scenario (STEPS) describes what would happen if countries successfully implement the plans and ambitions they have announced. The Sustainable Development Scenario (SDS) charts a global path to meet Paris Agreement climate objectives and Sustainable Development Goals on energy access and air quality.

This report uses STEPS and SDS to describe two different pathways to meeting electricity demand in emerging economies without compromising security of supply. It includes regional reviews of Africa and Southeast Asia. Each region presents unique challenges in terms of projected electricity demand growth, current resource mix and resource potential.

The first chapter examines how recent announcements and current policies are expected to change the global power sector under STEPS assumptions, comparing advanced economies with developing economies. The chapter then focuses on Africa and Southeast Asia, and shows how taking a fast development path could increase possibilities in Africa. This scenario, the Africa Case, highlights how the continent that will experience the largest population growth can boost social and economic development while keeping emissions to a level similar to that in STEPS.

The second chapter explains the transformation that the global power sector would experience under the SDS at a global level, emphasising the implications of a fast decarbonisation path for power systems in Southeast Asia and Africa. By 2040, coal-fired electricity generation will be 90% lower in developing economies under the SDS. In particular, the chapter details the need for dramatic increases in investments in the SDS rather than in STEPS. Reaching SDS goals requires drastically reducing coal-fired electricity generation by lowering operating rates of coal plants, shifting from less efficient coal plants in emerging market power systems to more efficient plants and plants equipped with carbon capture, utilisation and storage (CCUS), and decreasing overall capacity of coal plants.

The final chapter discusses the role of dispatchable thermal capacity in providing electricity security in STEPS and SDS. To ensure secure, sustainable and affordable power systems while meeting development goals, the chapter shows, international cooperation in technical and financial support is crucial, as well as sharing of best practices. It is also vital that advanced economies engage in the development and power system transitions in developing countries.

Table of contents

The global power sector in the Stated Policies Scenario

Large changes are expected in the global electricity supply

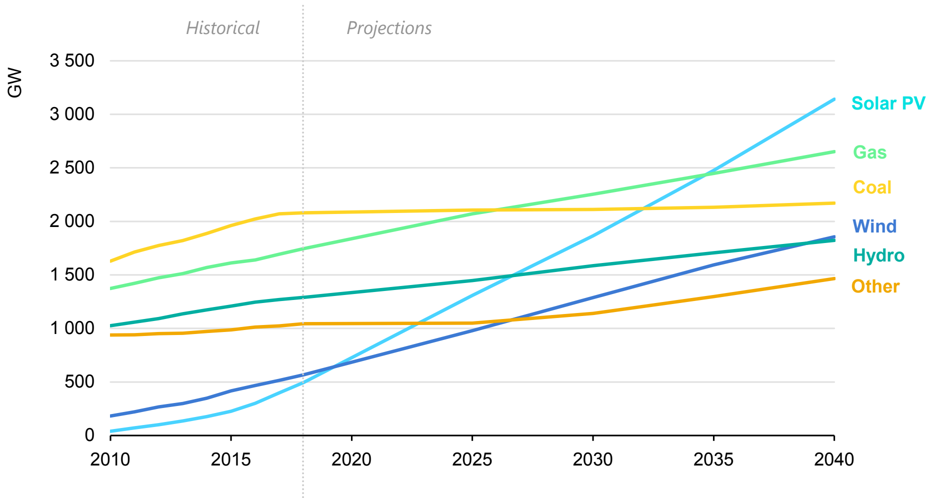
Under the Stated Policies Scenario (STEPS), the world will witness a significant shift in the type of technologies that will satisfy our electricity needs. Natural gas-fired power plants are expected to become the most important dispatchable technology for generation, surpassing coal in the mid-2020s. The global coal fleet is likely to have reached already the level at which it will stay stable in coming decades, although the efficiency of the fleet could keep changing.

The most relevant change for the power sector is the uptake of variable renewables, boosted by their low cost and modularity. Solar PV is expected to become the technology with the largest fleet, in capacity terms, in the mid-2030s. Wind capacity is on track to equal hydro capacity in 2040. With the exception of the Middle East, at least half of the capacity additions will come from renewable sources.

New flexibility sources, such as batteries, will also be deployed, modifying significantly the way power systems are operated.

Most of the electricity demand growth will come from emerging economies, which will attract 60% of the investments in the power sector to 2040. Unless their policies consider the cost of carbon to the global economy, emerging economies will be the recipients of coal-related investments in the power sector.

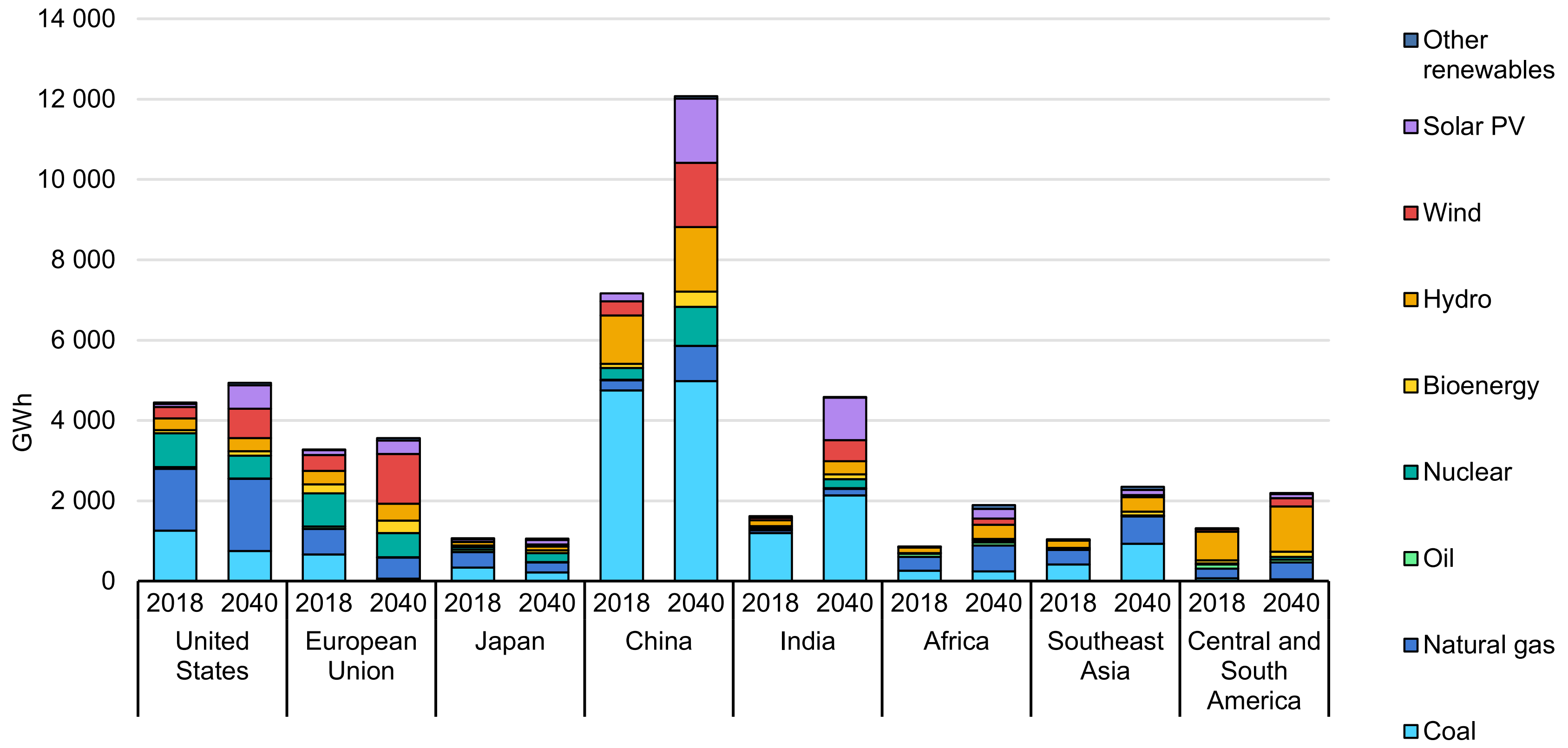
Global power capacity by source in STEPS



Source: IEA (2019), *World Energy Outlook 2019*.

Generation mix will vary greatly by region: Coal rises in Asia but falls in the United States and European Union

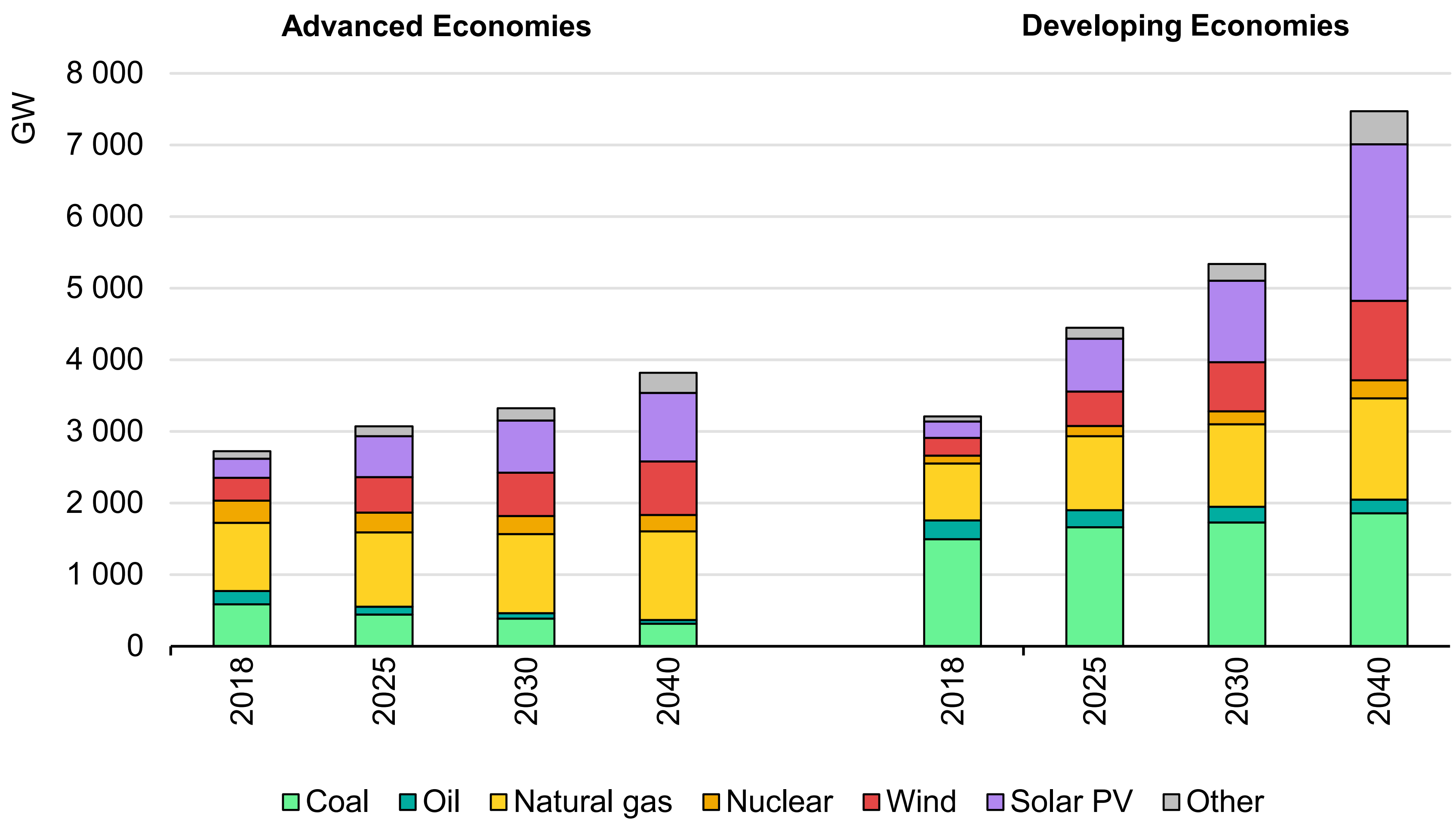
Electricity production by type and region in STEPS, 2018-40



Source: IEA (2019), *World Energy Outlook 2019*.

All sources of generation in developing economies increase to 2040 to meet growing demand

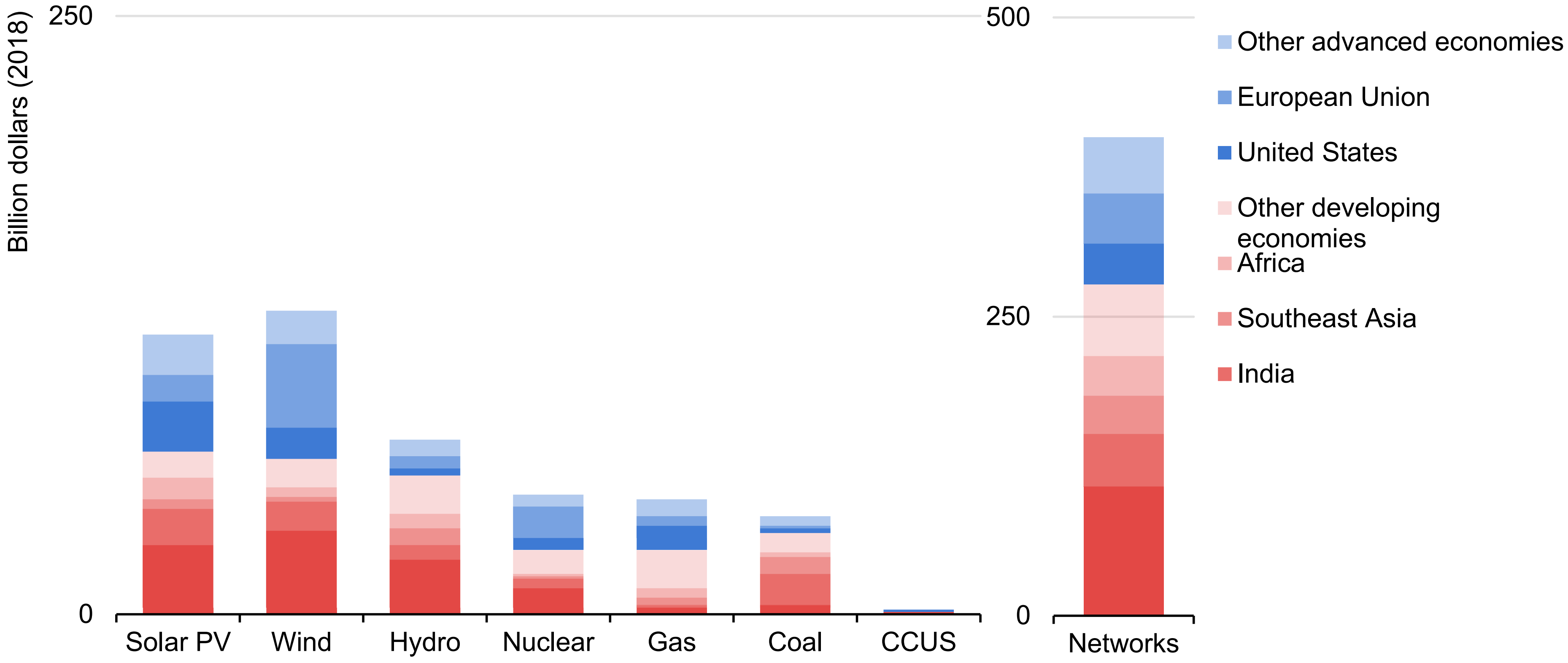
Installed capacity in advanced and developing economies in STEPS



Source: IEA (2019), *World Energy Outlook 2019*.

Developing countries account for over 60% of power sector investment to 2040

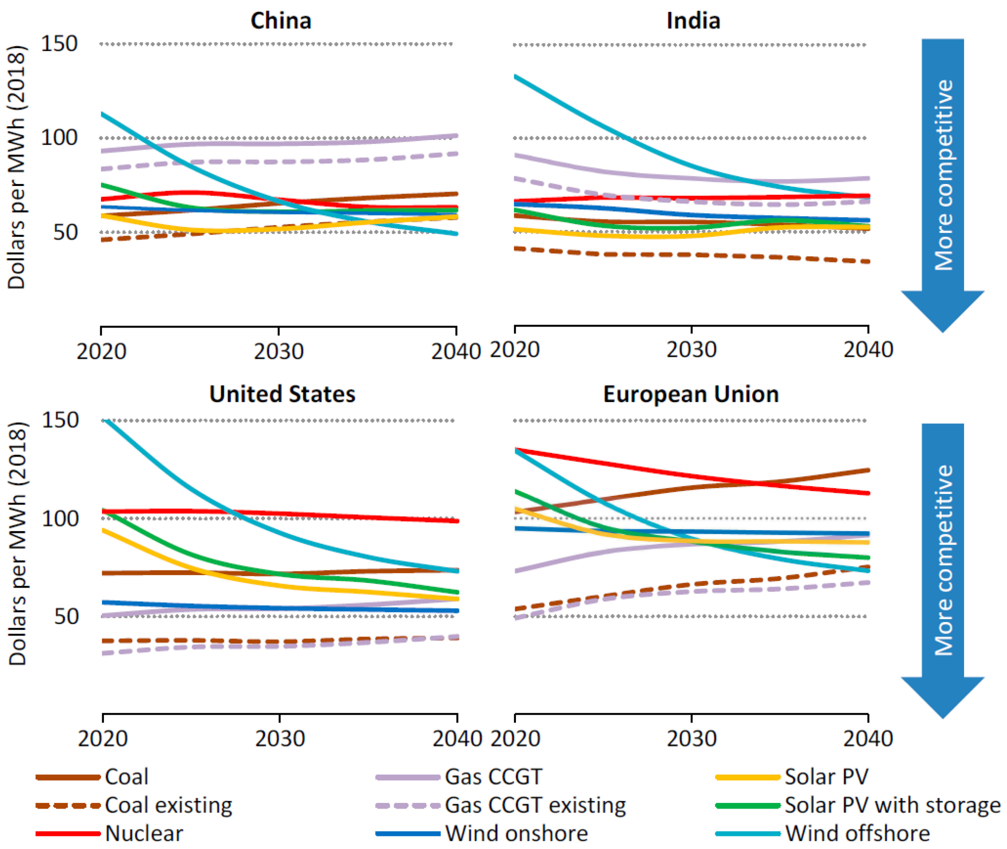
Average annual power sector investment by region in STEPS, 2019-40



Source: IEA (2019), *World Energy Outlook 2019*.

Low carbon sources become cheaper than coal, even when considering peak capacity and flexibility value

Value-adjusted levelised cost of electricity by technology in selected regions in STEPS, 2020-40



Note: CCGT = combined-cycle gas turbine.
Source: IEA (2019), *World Energy Outlook 2019*.

Regional focus: The Africa Case

Africa could have a bright energy future. Modern energy sources such as renewables and natural gas are already accelerating economic development in many countries. But there is a large disconnect between the potential and today's energy reality.

Three key factors will shape Africa's energy future: its rapidly rising population, the largest urbanisation ever seen, and industrialisation. These factors will increase Africa's influence on global energy trends, as the continent emerges as a prominent consumer and supplier of energy.

For now, however, low access to electricity and unreliable electricity supply are holding back Africa's economic development, limiting progress in improving health and well-being.

Investment in power infrastructure is among the lowest in the world, despite the immense need to expand and upgrade power systems, including generation and grid networks.

As part of *World Energy Outlook 2019*, the IEA produced a special report on Africa. It outlined a new scenario, the Africa Case, describing how the continent could achieve its own vision for accelerated economic and industrial development, Agenda 2063. This agenda was officially adopted in 2015 by the heads of state and government of the African Union and implemented in the national planning frameworks of over 30 countries.

Africa's energy context

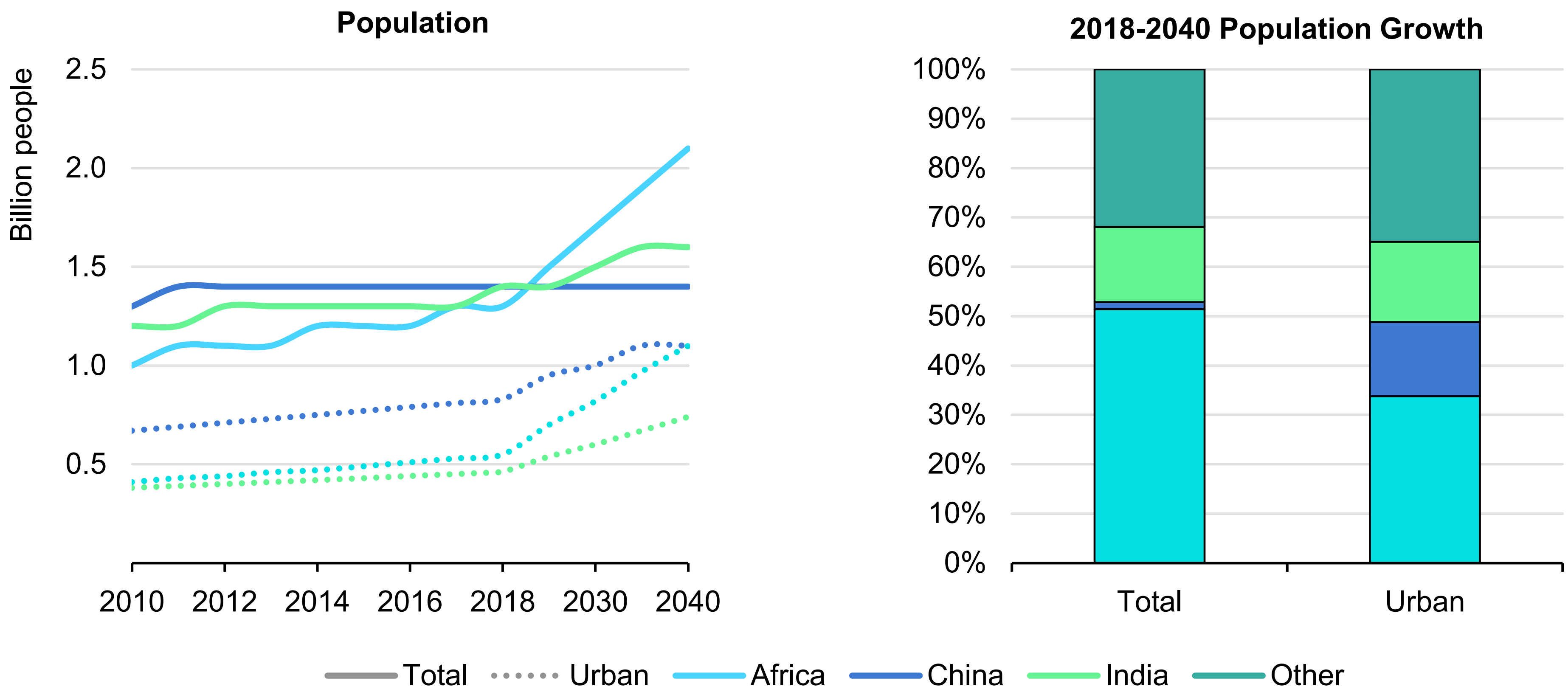
Africa's population is among the fastest-growing and youngest in the world, with a median age of 20 years, compared with a global average of 30 years.

By 2040, three African countries will be among world's 10 largest nations. Nigeria will become the most populous country in Africa, with 330 million people, and the fourth most populous country in the world, just behind the United States. Ethiopia and the Democratic Republic of Congo will both join the top 10. The next most populous countries in Africa will be Egypt and Tanzania, each with a population above 100 million.

The African population is also rapidly urbanising, on a scale never seen before in human history. The urban population is set to grow by more than half a billion, much higher than the growth in the People's Republic of China's ("China" hereafter) urban population during the country's two-decade economic and energy boom. The large increase in population, and especially in urban population, will be a major force driving Africa's energy demand growth.

Africa will account for half of population growth and one-third of urban population growth to 2040

Total and urban population in Africa, China and India, and share of global growth, 2018-40



Source: IEA (2019), *World Energy Outlook 2019*.

Africa's energy demand

Africa's future electricity demand will be driven by the desire to provide universal access to its people. Our detailed country-by-country data analysis indicates that progress in electricity access has accelerated since 2013. Nonetheless, 600 million people remained without access in 2018 and under STEPS 530 million people would still lack electricity by 2030. Almost 90% of the global population without access to electricity will be concentrated in Africa by then.

Some countries achieve good progress in STEPS, showing potential exemplary ways forward. Ethiopia, Ghana, Kenya, Rwanda and Senegal reach full access before 2030. Kenya, in particular, achieves universal access by 2022, after having managed to increase its access rate from 25% in 2013 to 75% in 2018. In most other countries, however, today's policy and investment plans do not yet have enough momentum to meet the energy needs of the population.

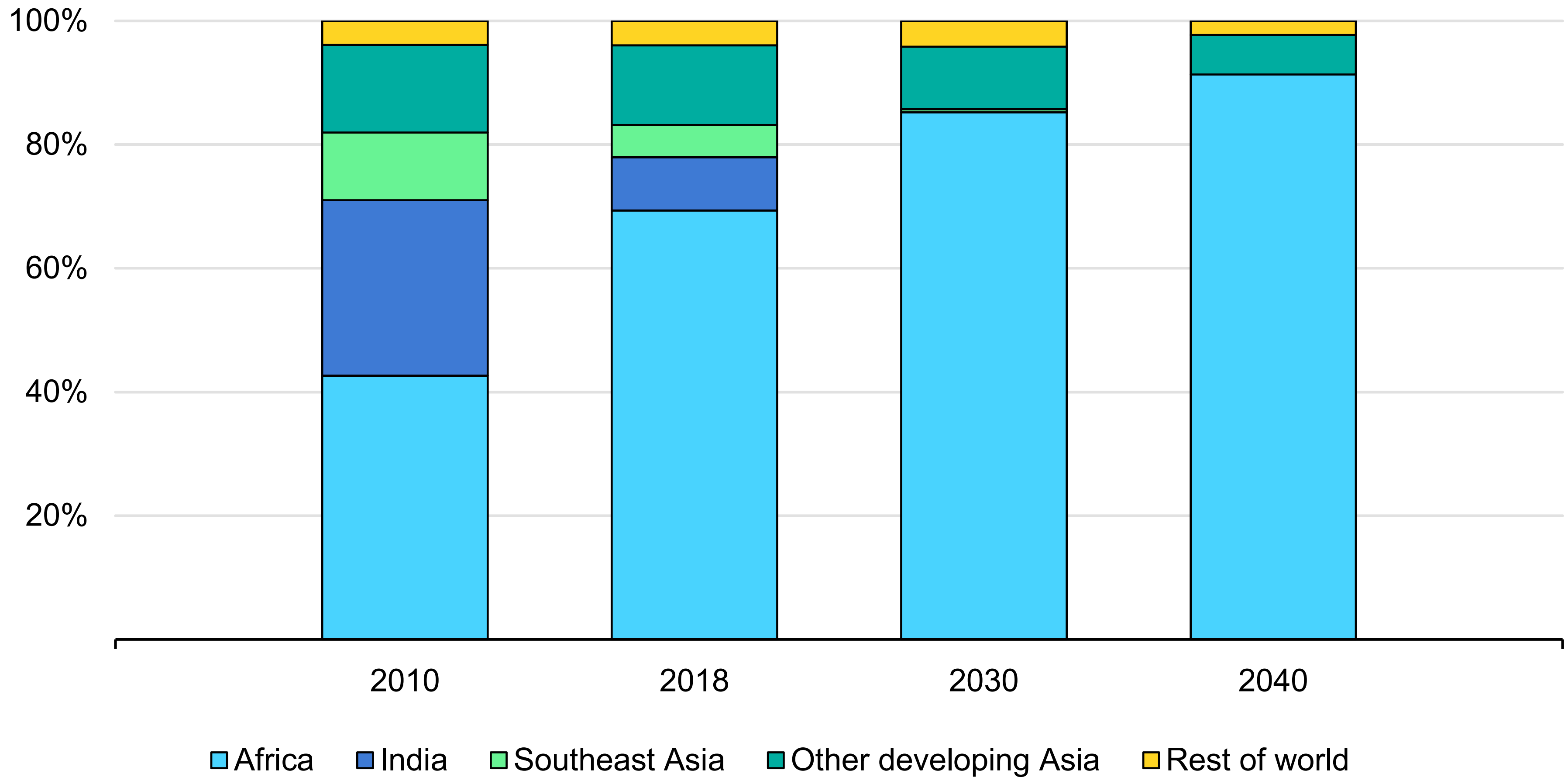
In the Africa Case, by contrast, efficiency improvements across all sectors limit the increase in energy demand to only 50%, even though the size of the economy quadruples and universal access to electricity is achieved.

Meeting demand for cooling is a particular challenge, as cooling needs are an order of magnitude higher in Africa than in countries such as France and Italy. Cooling needs across Africa also dwarf the major cooling demand centres of China and the United States.

Almost 600 million Africans today live in areas where the average daily temperature exceeds 25ºC. Average temperatures are often 1-2ºC higher in cities and as Africa's population urbanises, cooling needs will further increase. By 2040, the number of Africans living in hot areas will approach 1.2 billion, as populations expand, especially in cities. In addition, average temperatures will increase with climate change.

Lack of access to electricity is increasingly concentrated in Africa

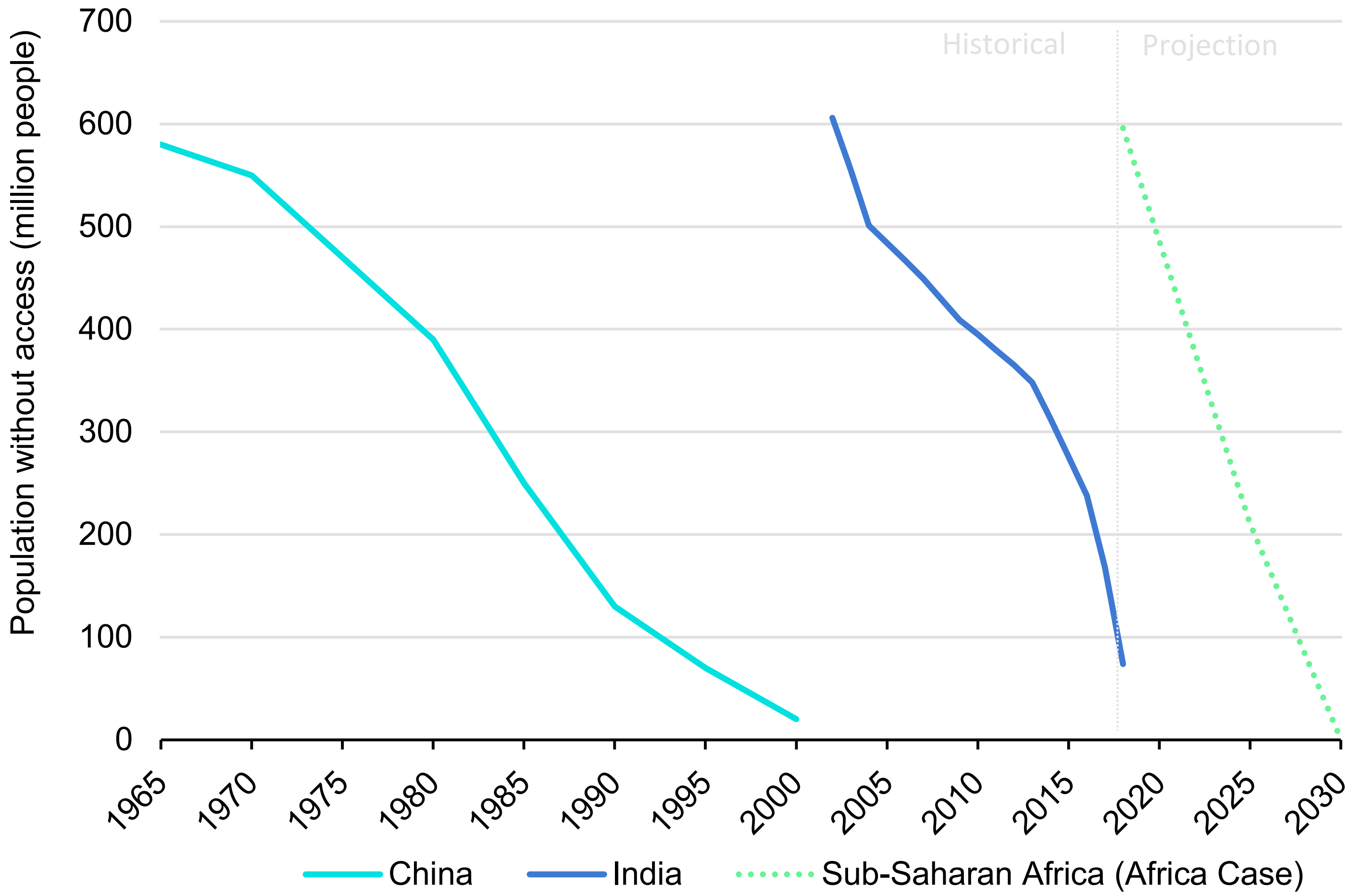
Share of population without access to electricity by region in STEPS



Source: IEA (2019), *World Energy Outlook 2019*.

Achieving access for all in sub-Saharan Africa in only 12 years will require an unprecedented effort

Reaching universal access to electricity in sub-Saharan Africa compared with achievements in China and India



Source: IEA (2019), *World Energy Outlook 2019*.

How can African countries satisfy soaring electricity demand?

In the Africa Case, gas-fired generation will continue to expand and remain the largest source of electricity, helping to satisfy the growing appetite for baseload electricity. Beyond North Africa and traditional gas producers such as Nigeria, growth will also be driven by the newly developed domestic gas resources of countries such as Mozambique, Senegal and Tanzania.

Renewables are the main growth story, making up three-quarters of additional needs across the continent and contributing to over half of electricity supply in 2040 in the Africa Case.

Africa, the continent with the world's richest solar resources, to date has installed only 5 GW of solar PV, less than 1% of the global total. In the Africa case, however, Africa's vast renewables resources and falling technology costs drive double-digit growth in deployment of solar PV and other renewables. Solar PV deployment will average almost 15 GW a year to reach 320 GW in 2040, overtaking hydropower and natural gas to become the largest electricity source in Africa in terms of installed capacity, and the second-largest in terms of generation. Alongside utility-scale projects, distributed solar PV will be key in helping deliver affordable electricity access to millions.

Hydropower will remain a cornerstone of Africa's power system. Better regional co-operation and integration of power networks will be instrumental in unlocking a larger share of hydropower's huge potential. With the completion of large projects that would not be justified based only on domestic power demand levels, DR Congo, Ethiopia and Mozambique will become sizeable exporters to neighbouring countries and regions.

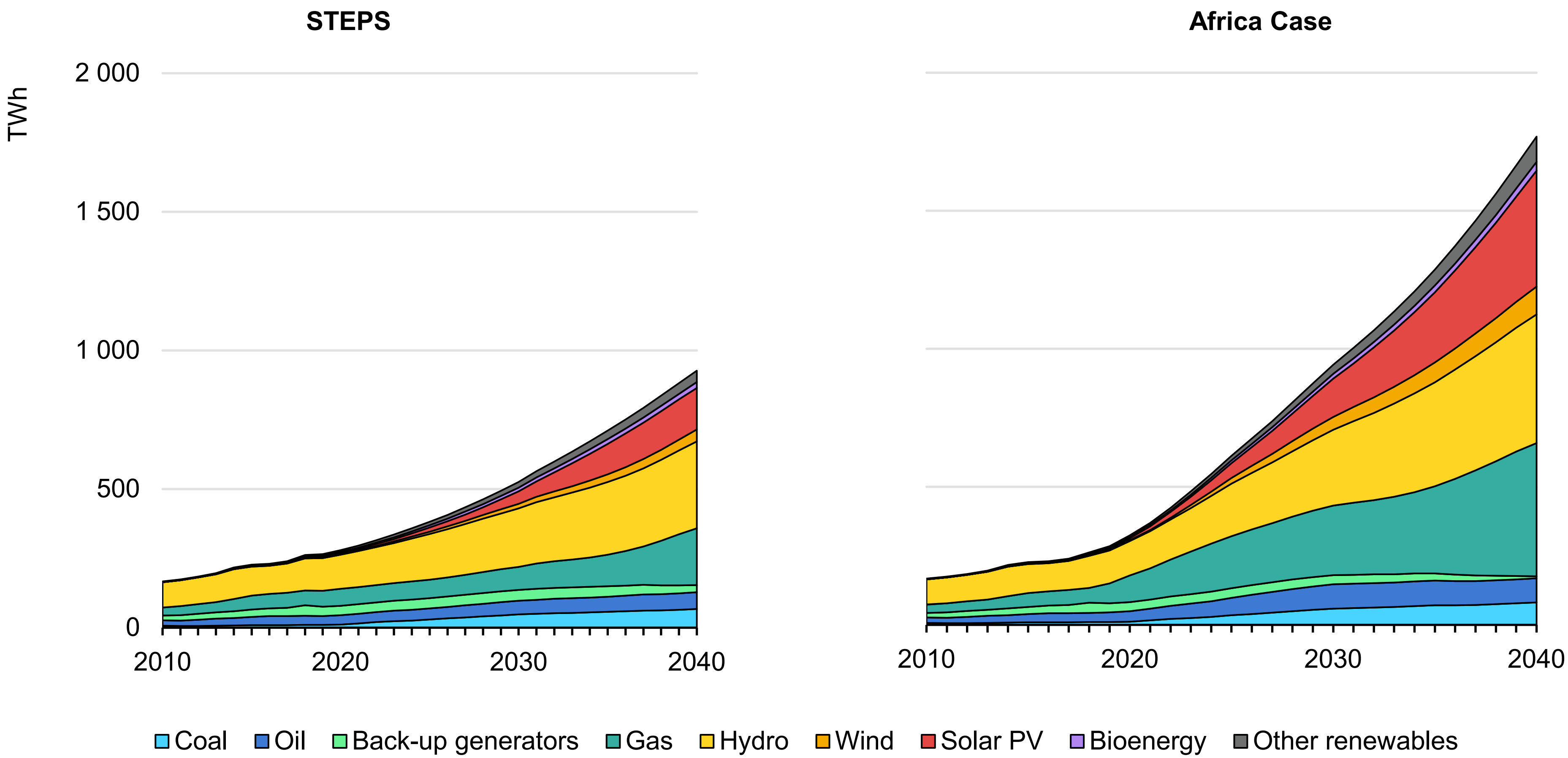
Wind power also expands rapidly in several countries with high quality wind resources, most notably Ethiopia, Kenya, Senegal and South Africa. Kenya is also at the forefront of geothermal deployment.

The Africa Case requires building a more reliable power system and paying more attention to transmission and distribution assets. A key priority is targeted investment and maintenance to reduce power outages, which are a major obstacle to enterprise, with the aim of lowering losses from 16% today to a level approaching that of advanced economies (less than 10%). There is also a need to build up the necessary regulation and capacity to support Africa's power pools and strengthen regional electricity markets.

To serve growing electricity demand, Africa needs to expand its energy infrastructure, especially in the power sector. Despite being home to 17% of the world's population, Africa accounts for just 4% of global power supply investment. On a per capita basis, power supply investment in Africa ranks among the lowest in the world. In sub-Saharan Africa, power generation capacity per capita has shown little growth since 1990, while that of India and Southeast Asia has grown fourfold.

The Africa Case calls for an enormous increase in generation from all technologies to 2040

Electricity generation by technology in sub-Saharan Africa



Source: IEA (2019), *World Energy Outlook 2019*.

The role of gas in Africa's power sector

Natural gas is facing a turning point in Africa. Gas already meets around half of North Africa's energy needs, but in sub-Saharan Africa the share of gas in the energy mix is around 5%, among the lowest in the world. Today Africa accounts for 4% of global gas demand and 6% of global production.

In recent years, however, major gas discoveries have been made in every part of the continent, notably in Egypt (the Zohr and adjacent fields), East Africa (Mozambique and Tanzania), West Africa (Mauritania and Senegal) and South Africa. Between 2011 and 2018, Africa accounted for more than 40% of global gas discoveries. Together with LNG technology innovation, these developments could enable Africa's push for industrial growth and meet its need for reliable electricity supply.

In the power sector, the rapid deployment of renewables leaves room for gas to grow as a flexible and dispatchable source of electricity. Outside the power sector, successful industrialisation depends on stable energy supplies, including for energy uses that are hard to electrify. Gas could be well suited to these roles, displacing the more polluting fossil fuels, oil and coal.

To achieve this vision, however, some hurdles need to be overcome. Much will depend on the price at which gas becomes available, the development of distribution networks (including small-scale LNG distribution), whether financing is available for infrastructure and the strength of policy efforts to displace polluting fuels.

Today, Africa as a whole exports a similar volume of gas to Australia, and the continent's gas demand is similar to the combined demand of Japan and Korea. In our projections, Africa becomes a major player in natural gas as a producer, consumer and exporter.

The region becomes the third-largest for gas production growth after the United States and the Middle East. With production growth higher than the rise in demand, Africa emerges as a major supplier of LNG to global markets.

Rapid production growth also underpins a doubling in gas demand, primarily in power and industry. Africa becomes the third-largest source of gas demand growth after China and the Middle East.

Africa's power sector emissions

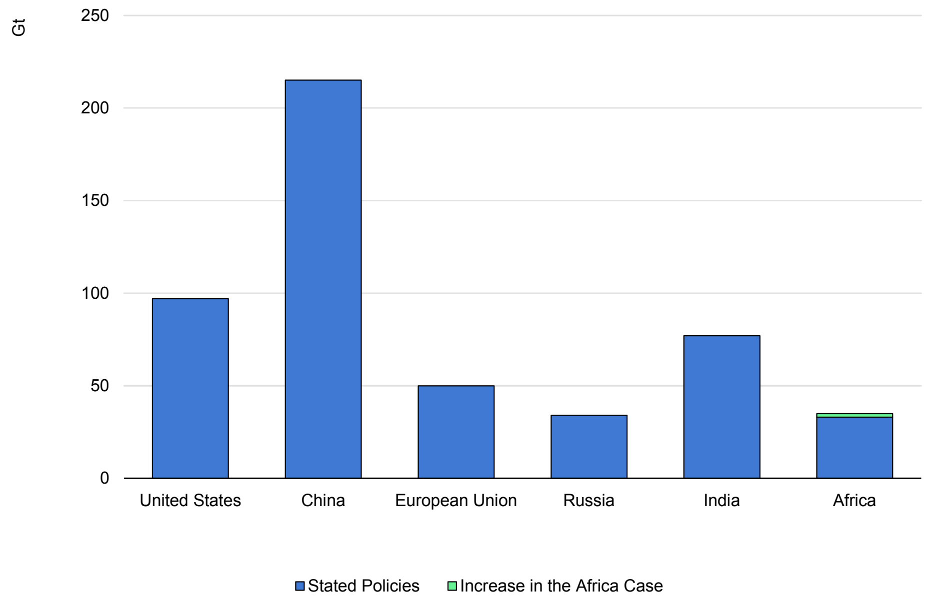
Africa has contributed little to global greenhouse gas emissions during the age of industrialisation. Energy-related CO_2 emissions in Africa account for only 2% of global cumulative emissions from 1890 to today. Although Africa's economy and energy demand grow significantly in STEPS, its contribution to global energy-related CO_2 emissions increases to just 3% of total cumulative emissions by 2040, accounting for only 4% of global CO_2 emissions between today and 2040.

In the Africa Case, by contrast, African economies grow much faster, and universal access to electricity and clean cooking is achieved. Despite the much higher level of energy service demand in this case, the continent's share of cumulative global emissions since 1890 rises by just 0.1 percentage points to 2040. The increased role of energy efficiency and renewables in this case play a major role in reducing the potential increase in CO_2 emissions.

Total greenhouse gas emissions in the Africa Case are at the same level as in STEPS, despite the higher level of economic development and access to energy, because the slight increase in CO_2 emissions is offset by reductions in methane and nitrous oxide emissions as the continent moves away from the inefficient combustion of biomass for cooking.

While Africa contributes little to the causes of climate change, it is on the front line when it comes to the effects of a changing climate on the energy sector. As well as pushing up cooling needs, climate change will lead to increasing variability in generation output, notably hydropower. Planning and investment decisions for energy infrastructure need to be climate-resilient.

Cumulative energy-related CO_2 emissions by region and scenario, 2018-40



Source: IEA (2019), *World Energy Outlook 2019*.

Africa's annual power sector investment will need to double (STEPS) or quadruple (Africa Case)

Bridging Africa's power infrastructure gaps will require a significant increase in spending. Investments in power supply need to double through to 2040 in STEPS.

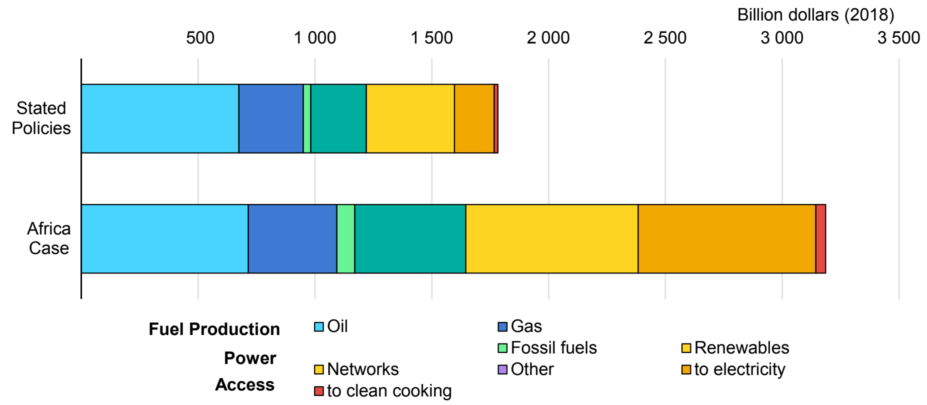
The Africa Case requires a further doubling to around USD 120 billion per year to ensure reliable and affordable power for all and to serve an economy growing at over 6% a year.

Half of the investment is needed to expand and upgrade electricity networks – including mini-grids – and most of the rest is needed to increase low-carbon generation capacity, with solar PV playing an important role.

The cumulative power sector investment needed between today and 2040 is equal to 1.6% of Africa's GDP in STEPS (USD 1.4 trillion) and 2.4% of GDP in the Africa Case (USD 2.6 trillion). These levels of investment are high, but they can be mobilised if African governments and the global community make concerted efforts.

There are some precedents. Since 2000, India has invested the equivalent of 2.6% of GDP in the power sector and China has invested 1.9% of GDP, though there is a need to take account of what has and has not worked well with power sector investment in these countries.

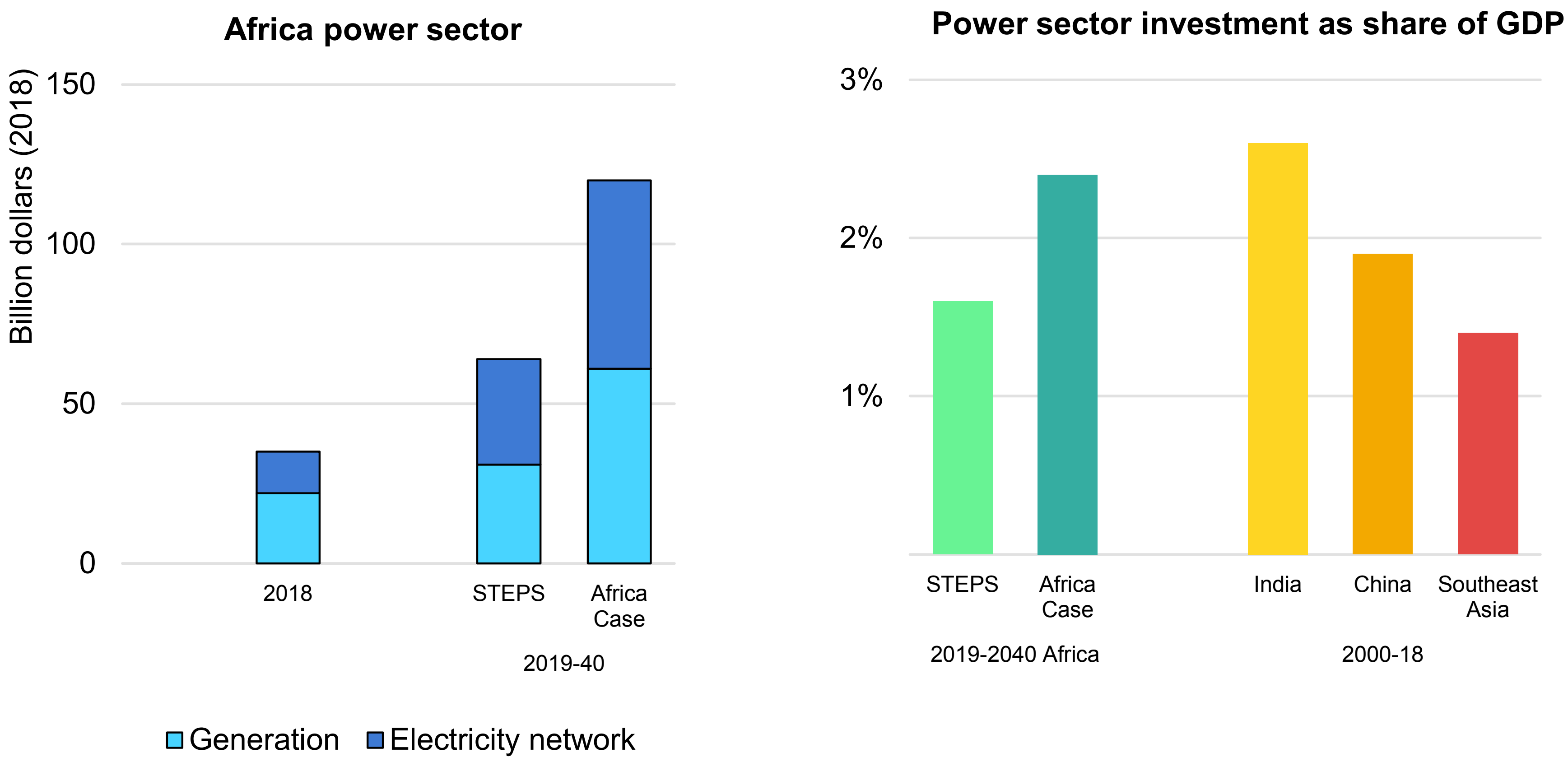
Africa's cumulative investment needs, 2018-40



Source: IEA (2019), *World Energy Outlook 2019*.

Power sector investment in Africa lags behind other developing economies – a more favourable investment climate is needed

Average annual power supply investment in Africa by scenario and historical power sector investment in selected regions



Source: IEA (2019), *World Energy Outlook 2019*.

Regional focus: The electricity mix in Southeast Asia

Southeast Asia's electricity sector is in a very dynamic phase of development, for both supply and demand. Low generation costs and indigenous supply have traditionally given coal a prominent place in power sector planning. This is maintained in STEPS, where 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, will also 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.

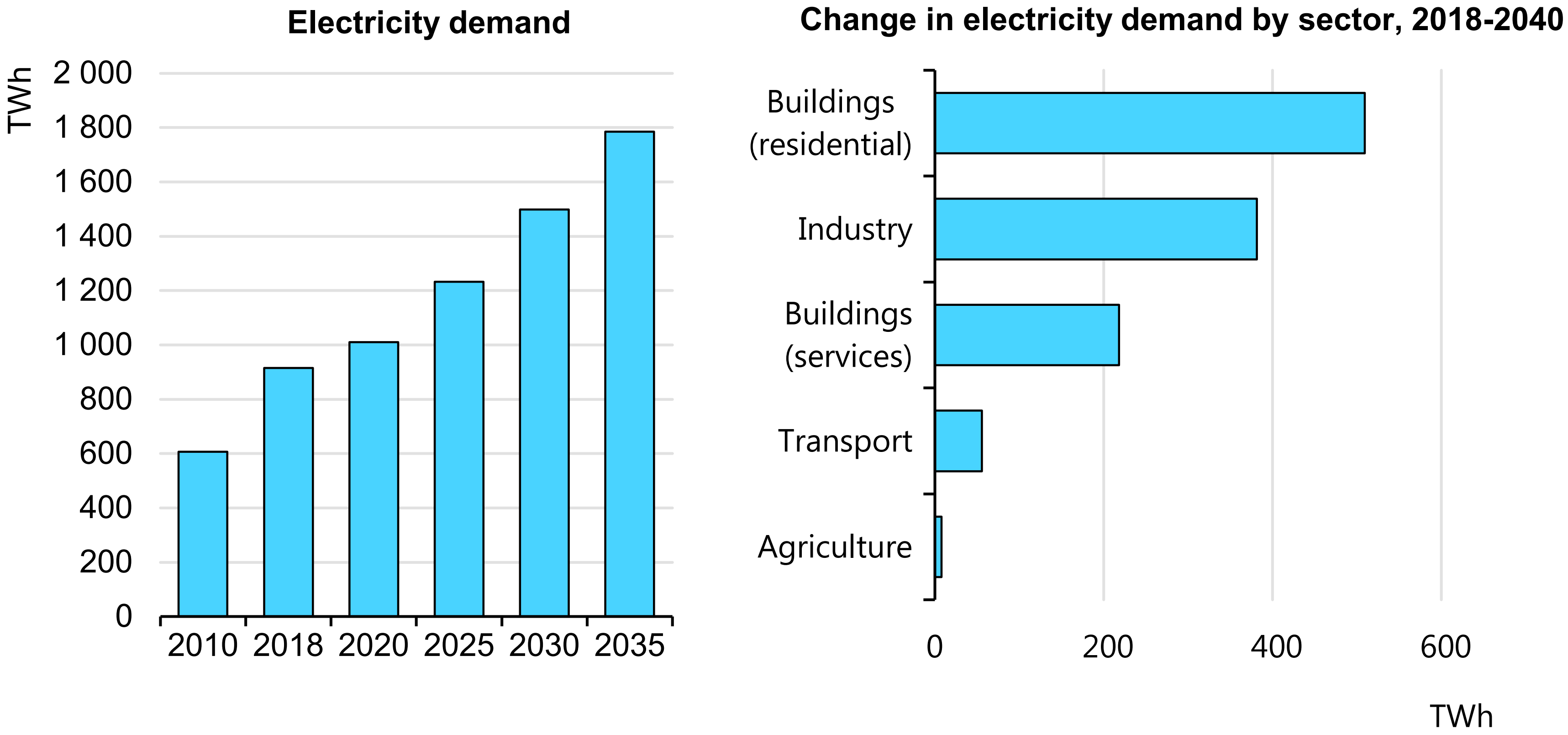
Recent revisions to policy planning documents have tended to boost the long-term share of renewables, typically at the expense of coal. Moreover, a switch is visible in near-term project developments, with a significant slowdown in decisions to move ahead with new coal-fired capacity and a rise in additions of solar and wind. In the first half of 2019, approvals of capacity additions of solar PV exceeded new coal-fired capacity for the first time.

On the demand side, electricity consumption in Southeast Asia is set to 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 will rise rapidly to 26% in 2040 and reaches the global average.

Space cooling is one of the fastest-growing uses of electricity to 2040, pushed up by rising incomes and high cooling needs. For the moment, less than 20% of households across the region have air conditioning; in Indonesia, the region's most populous 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%.

Electricity demand more than doubles in Southeast Asia to 2040

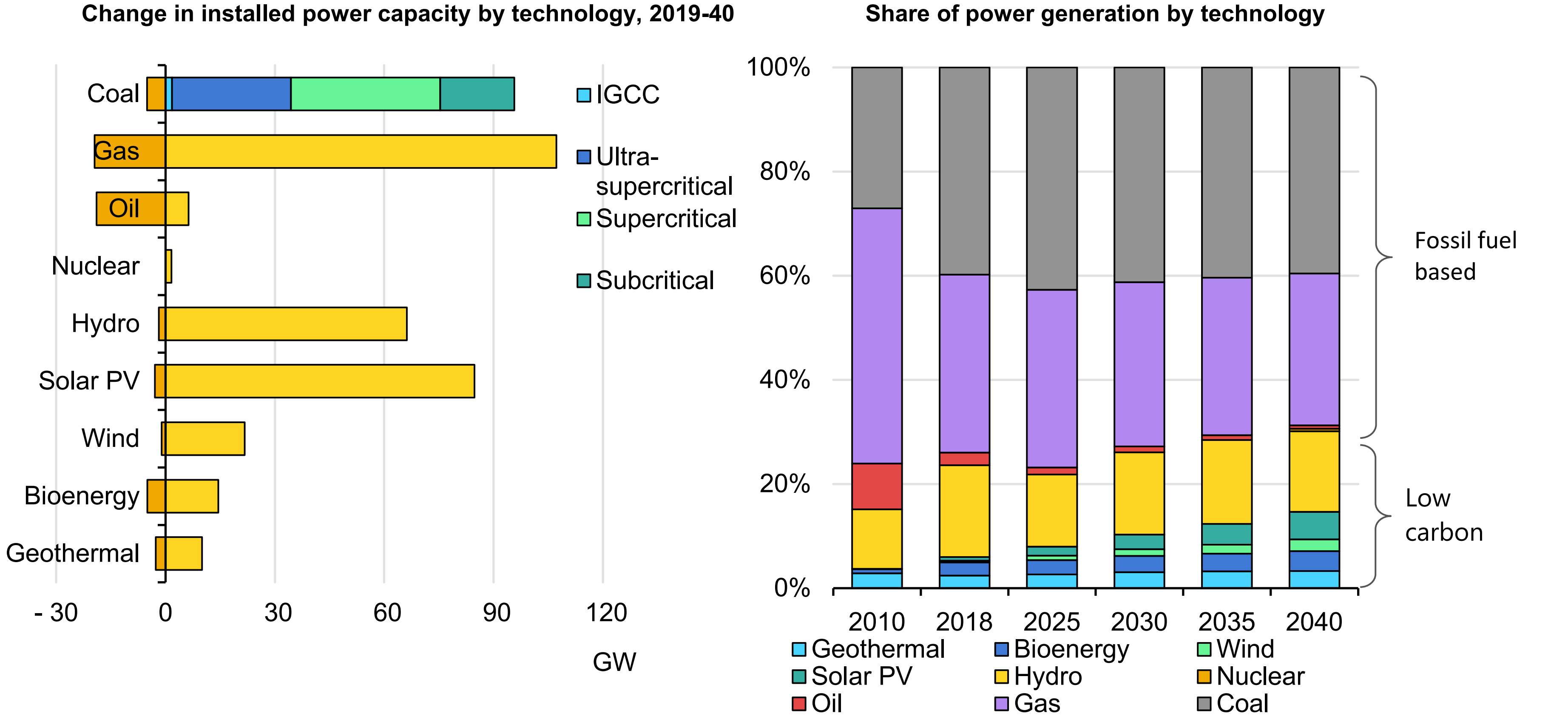
Electricity demand in Southeast Asia in STEPS



Source: IEA (2019), *Southeast Asia Energy Outlook 2019*.

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

Change in installed power capacity and share of power generation by technology in Southeast Asia in STEPS, 2019-40



Note: IGCC = integrated gasification combined-cycle.
Source: IEA (2019), *Southeast Asia Energy Outlook 2019*.

Changing course – The Sustainable Development Scenario

A large shift is required to put the global energy system and power systems on a sustainable path

The IEA Sustainable Development Scenario (SDS) provides a strategic pathway to meet global climate, air quality and energy access goals. Comparing STEPS with the SDS provides a clear idea of the large shifts in policy and investment trends that are required between now and 2040 to reach those goals.

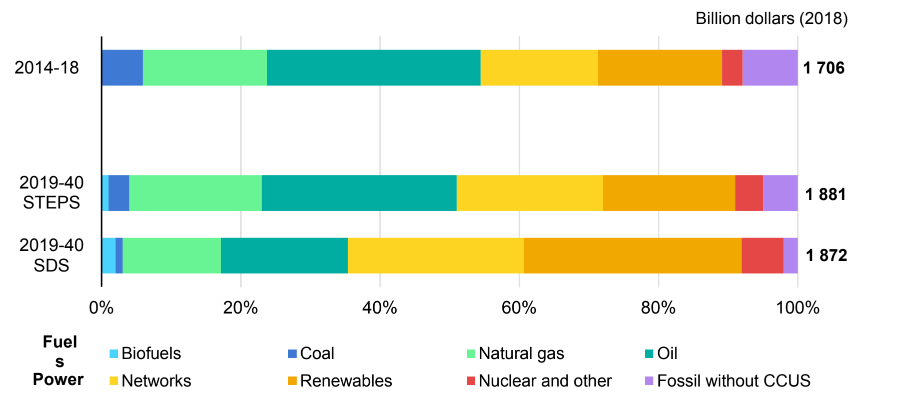
The annual average investment required in the next two decades to put global energy supply on a sustainable path is similar in both scenarios, and only 10% larger than annual average between 2014 and 2018.

The big difference is the destination of these investments. Under SDS, more investment is directed to the power sector in general and less to oil, gas and coal. Within the power sector, every low-carbon technology, including nuclear, CCUS and renewable energy, would receive more investment in the SDS than in STEPS, while average annual investments in coal would become marginal and completely concentrated in emerging economies.

At a global level, average annual investment in unmitigated fossil fuel-fired power plants are 28% lower in SDS than in STEPS, and most go towards technologies based on natural gas.

The largest change in investment trends in SDS is in end-use, including energy efficiency in transport, buildings and industry. These investments explain to a large extent why SDS can achieve deep decarbonisation while keeping supply side investments at current levels.

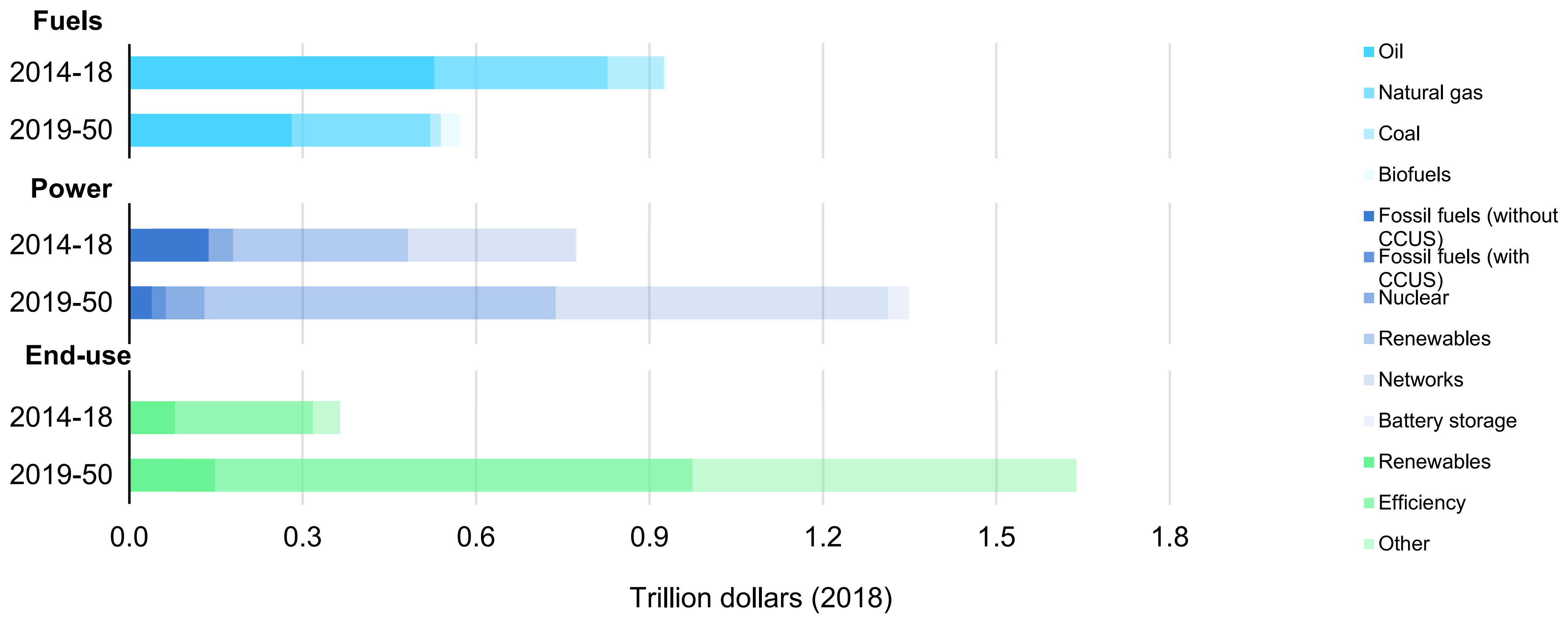
Global average annual investment in energy supply, by type and scenario



Source: IEA (2019), *World Energy Outlook 2019*.

Shift in investments – less oil and more power

Average annual energy investment in SDS, 2014-18 and 2019-50

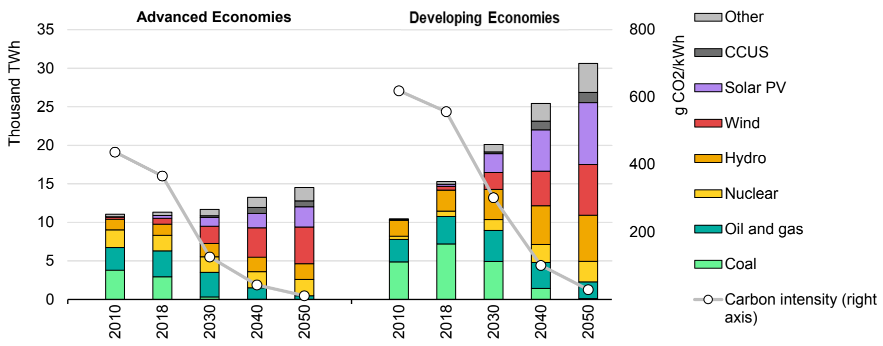


Source: IEA (2019), *World Energy Outlook 2019*.

The shift towards low-carbon power systems follows different paths in emerging and advanced economies

The in SDS presents significantly different power sector decarbonisation paths for different regions – and hence for emerging and advanced economies – depending on their demand growth, their resources and the composition of their existing fleets. Between now and 2040, electricity demand is expected to grow by two-thirds in emerging economies and by about a quarter in advanced economies, mostly after 2030. Lower demand growth rates, large investments in low-carbon sources and phasing out of older coal fleets allow advanced economies in this scenario to eliminate un-mitigated coal by 2030 while reducing average carbon intensity by two-thirds.

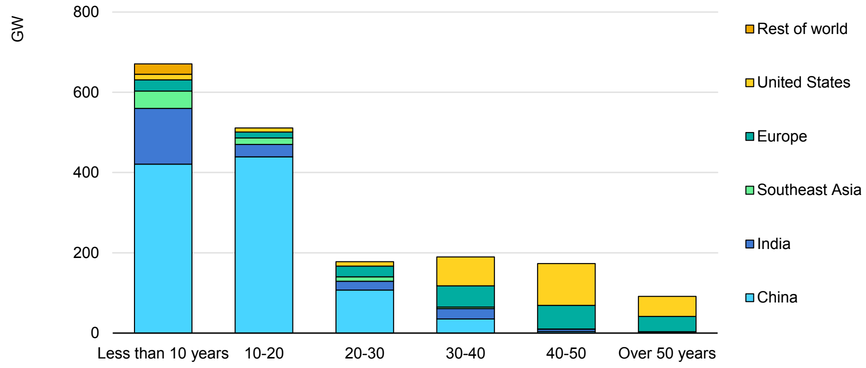
Electricity generation by source and carbon intensity of electricity in SDS



Source: IEA (2019), *World Energy Outlook 2019.*

By contrast, emerging economies would keep using unmitigated coal beyond 2040 but at a much reduced level and in high efficiency plants. Given that the emerging economies' fleets are mostly 20 years old or less, SDS would require a significant amount of retrofitting with CCUS or biomass co-fire equipment, as well as repurposing from baseload to peak-only operation and, to a lesser degree, the earlier retirement of the most inefficient plants that are not required to cover peak demand.

Global coal-fired power capacity by plant age, 2018

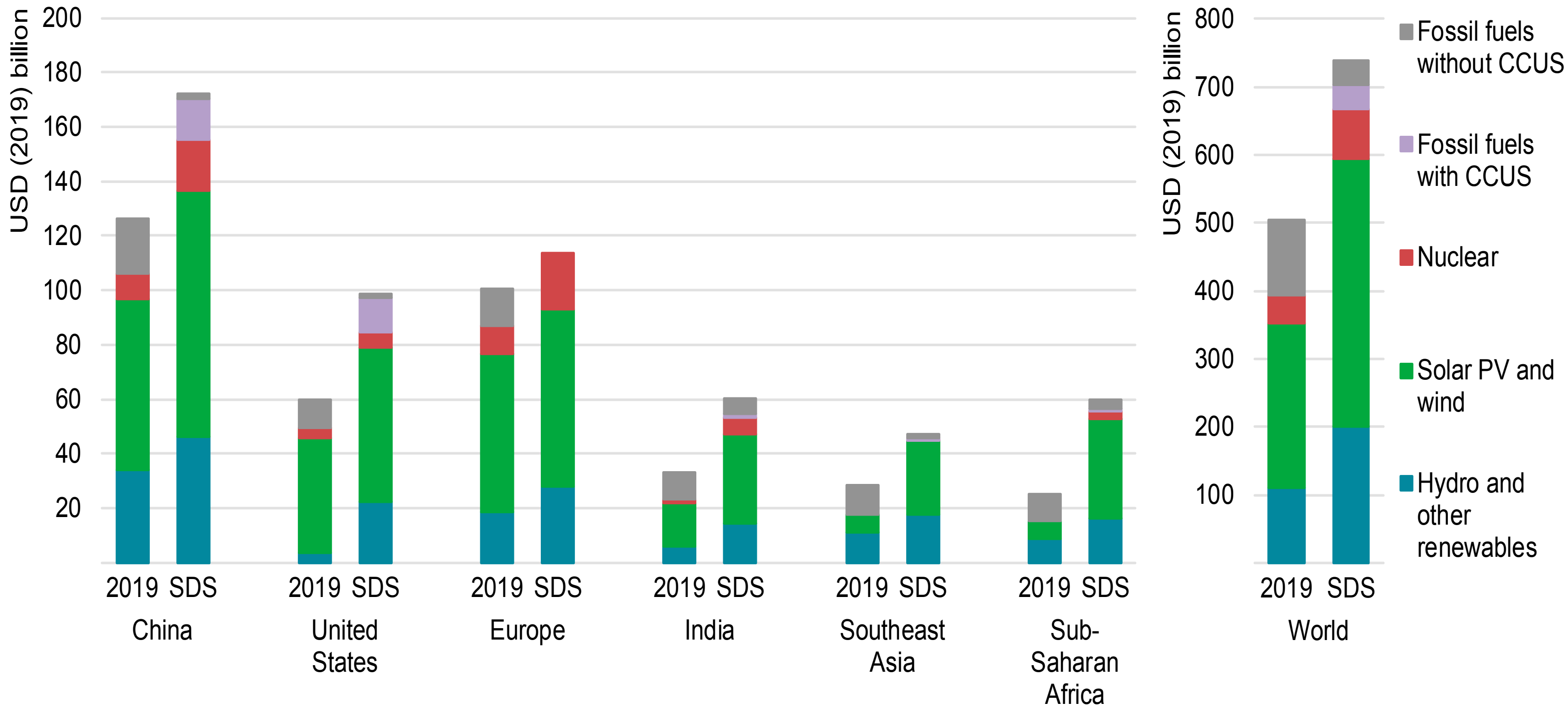


Source: IEA (2019), World Energy Outlook 2019.

This would mean that in 2040, under the SDS, no plant in operation should be a subcritical plant, while supercritical and ultra- supercritical coal plants will be the only unmitigated coal-fired generation technology. The rest of the coal fleet would be retrofitted with CCUS or equipped to use biomass.

Investment and resource allocation will need to rise dramatically under the SDS, particularly in developing economies

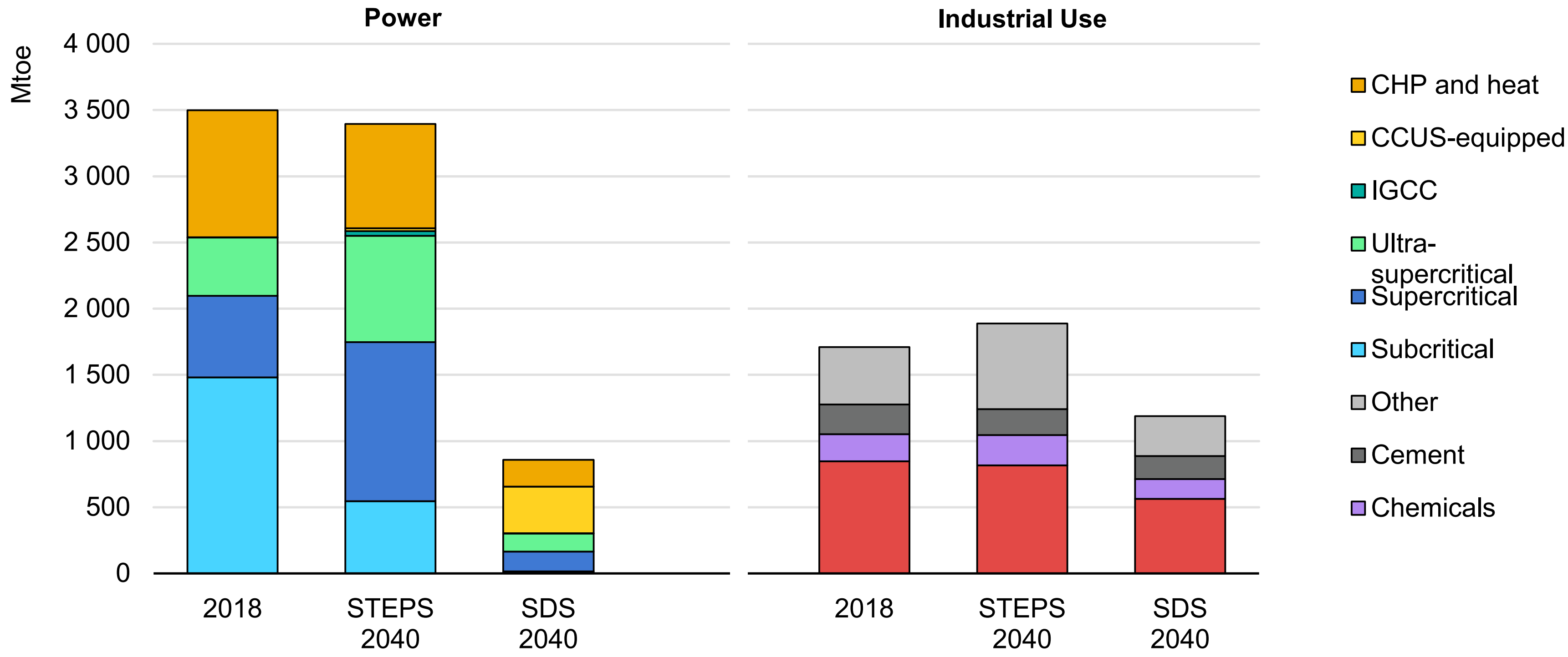
Average annual power sector investment in SDS, 2019-40



Source: IEA (2019), *World Energy Outlook 2019*.

SDS requires that only highly efficient coal technologies are used in 2040

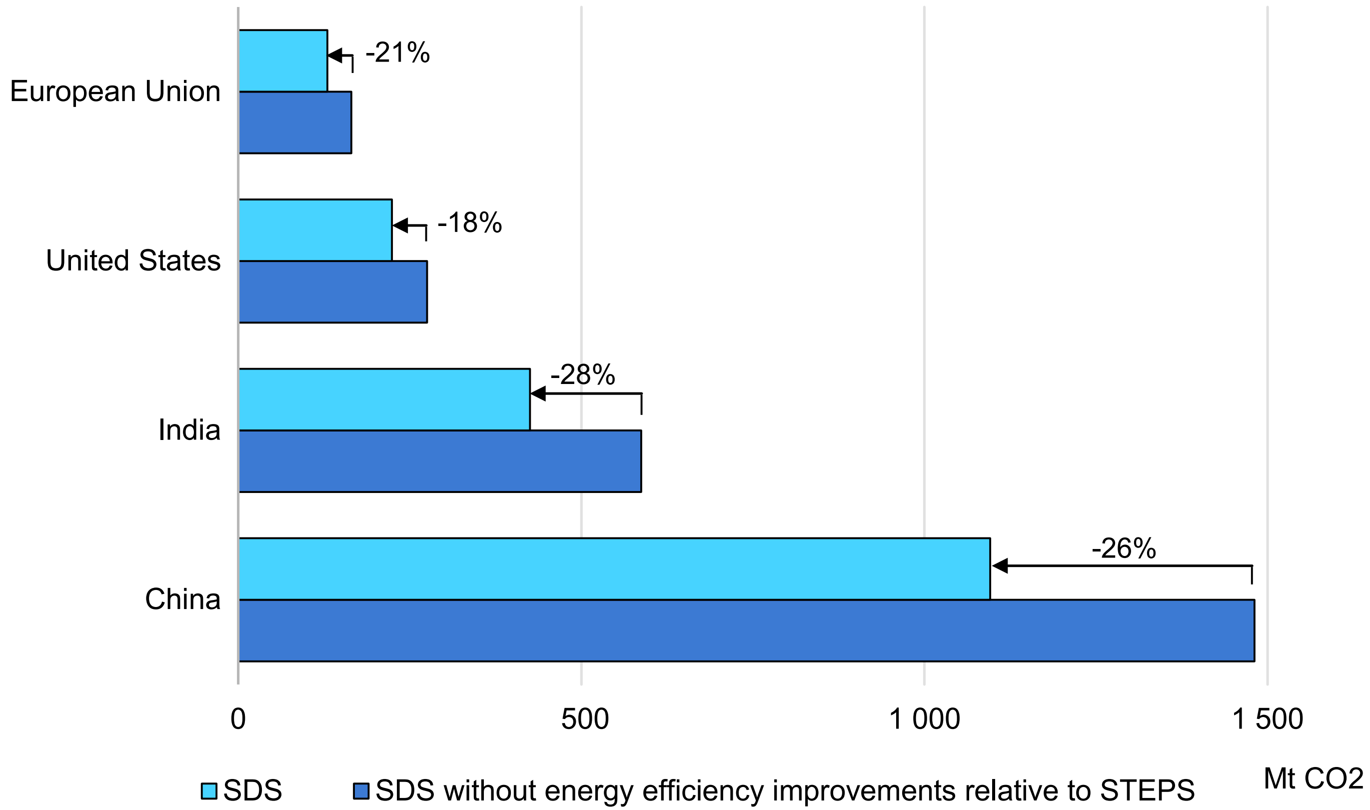
Global coal demand by key sector and scenario



Note: CHP = combined heat and power; CCUS = carbon capture, utilisation and storage; IGCC = integrated gasification combined-cycle.
Source: IEA (2019), *World Energy Outlook 2019*.

SDS requires significant improvements in energy efficiency compared with STEPS

Impact of energy efficiency on CO_2 emissions from electricity supply in SDS, 2040



Source: IEA (2019), *World Energy Outlook 2019*.

Regional focus: Africa in SDS

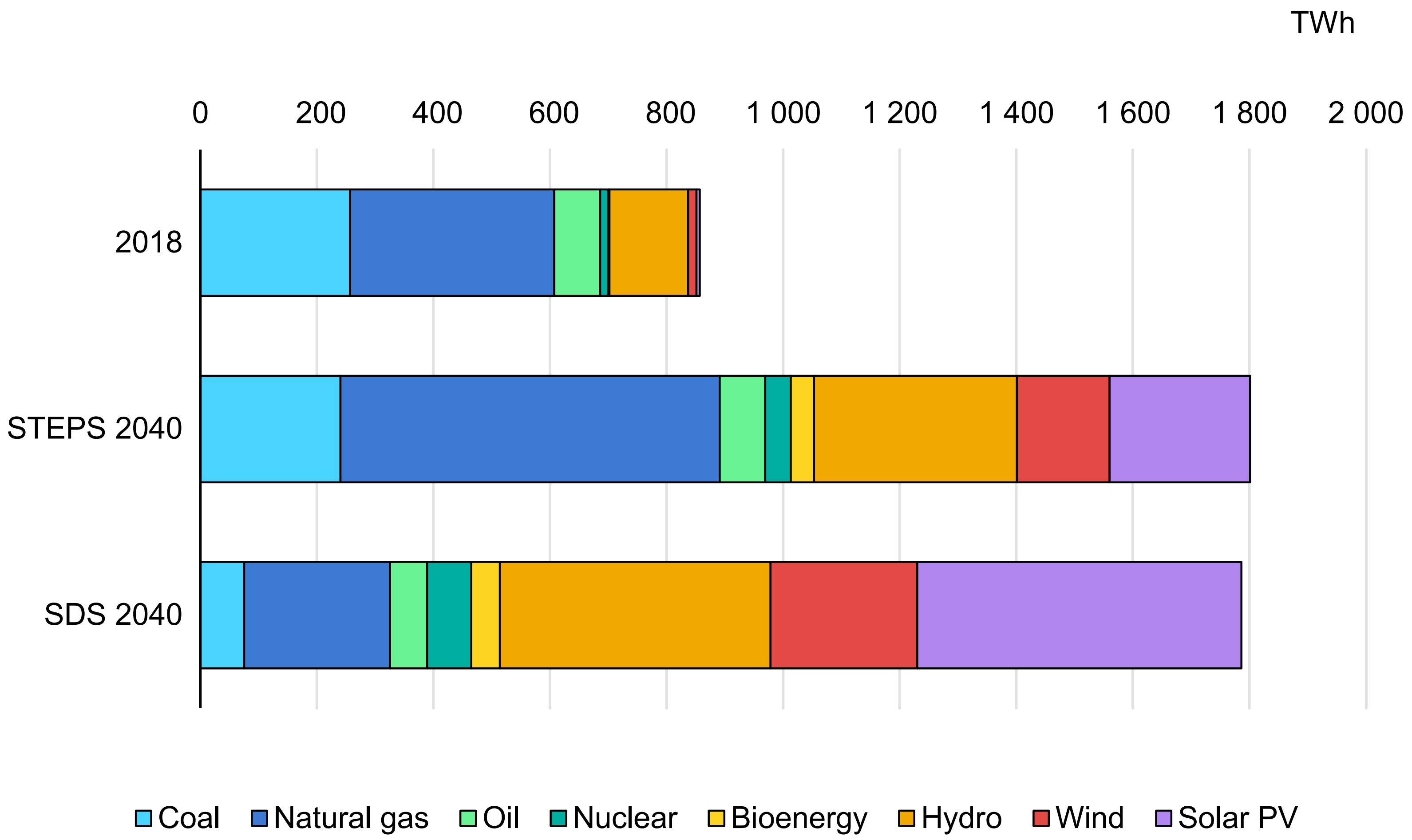
A low-carbon future under SDS will require reorienting efforts toward renewables and energy efficiency.

The Africa Case mentioned above projects a development path that includes strong growth and meets sustainable development targets, including universal access to electricity and clean cooking.

But overall emissions of CO_2 track closely to STEPS, not SDS. To meet their SDS targets, African economies need to further reorient their investments towards renewables and energy efficiency. Fossil fuels' share of the power mix will need to fall from 50% in STEPS to 20% in SDS. Annual investments in solar and wind in SDS are twice those in STEPS and investment in networks will need to increase by almost 30%.

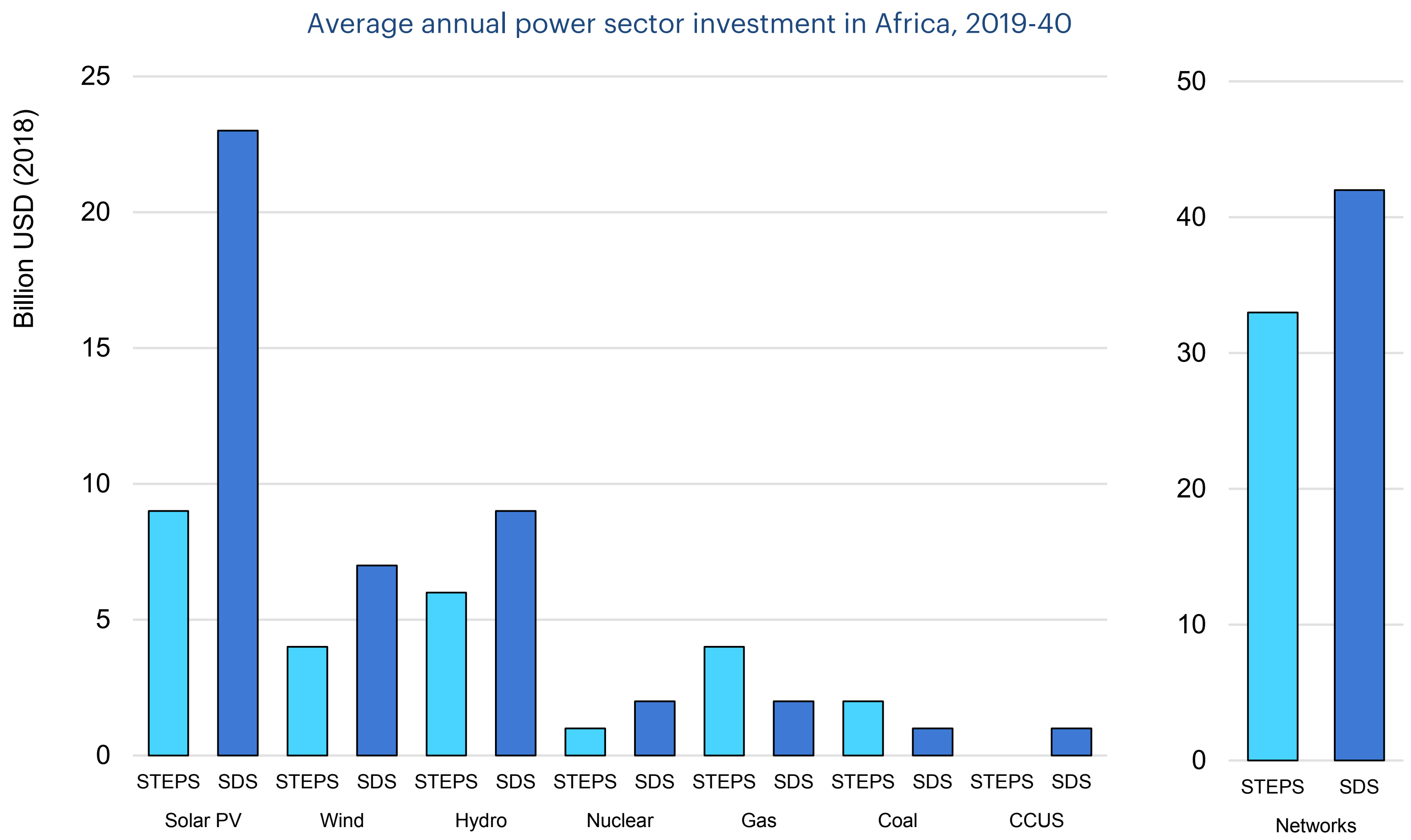
To move from STEPS to SDS, Africa's power generation mix needs to change dramatically

Electricity generation in STEPS and SDS



Source: IEA (2019), *World Energy Outlook 2019*.

Investments by generation type and in networks vary greatly between STEPS and SDS in Africa



Source: IEA (2019), *World Energy Outlook 2019*.

Regional focus: Southeast Asia in SDS

A low-carbon future under SDS will require reorientation of efforts toward renewables and energy efficiency.

STEPS shows that Southeast Asia is on track to meet some key energy policy goals, such as achieving universal electricity access. However, 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.

The transition of Southeast Asia's energy system towards a low-carbon pathway based on SDS would yield many benefits, including reversing the rising trend in CO_2 emissions, improving energy security and bringing down import bills. But achieving these results would require significantly stronger policy efforts. Transmission needs wide expansion to integrate more renewables and stringent energy efficiency policy is necessary to push energy intensity levels 27% higher than those in STEPS.

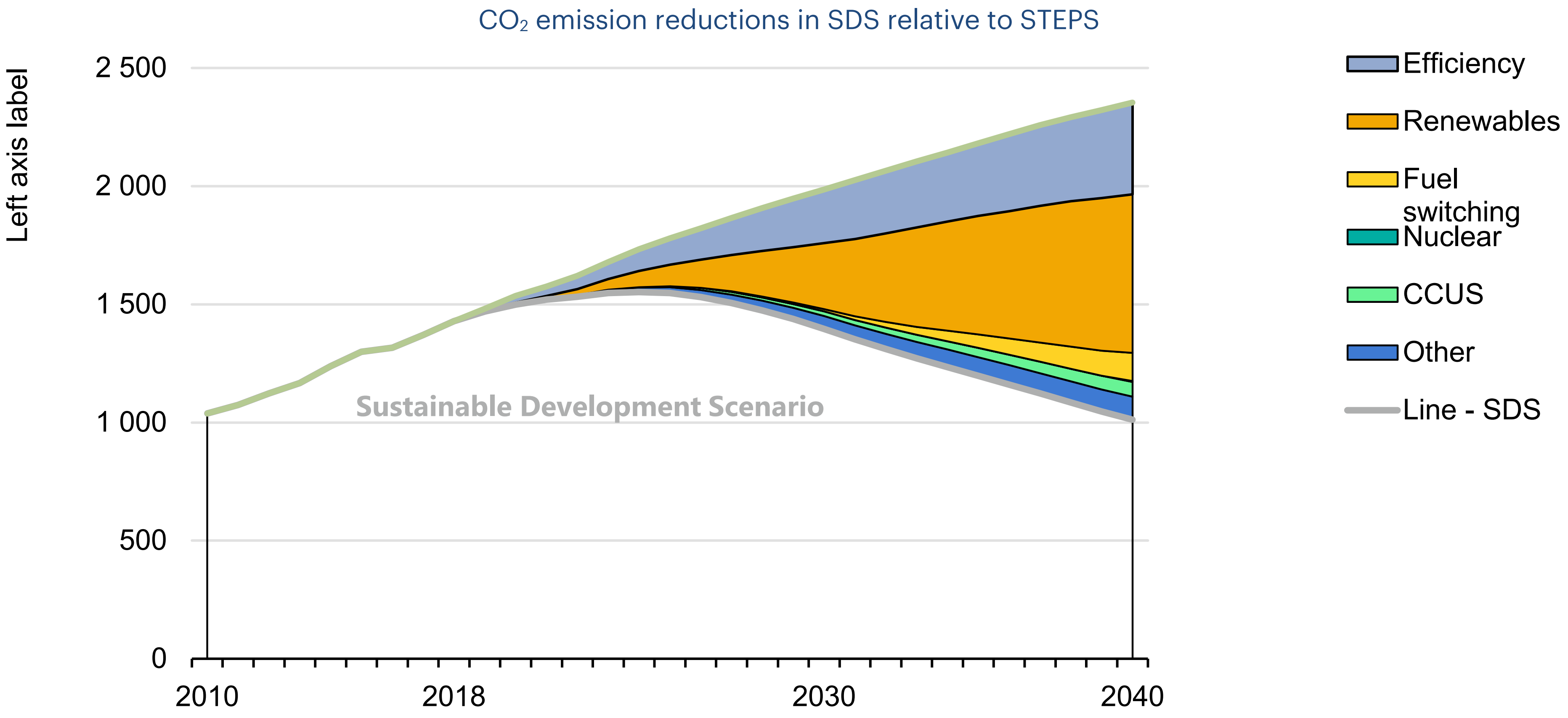
All parts of the energy sector have important roles to play in achieving Southeast Asia's energy transition. Increasing the role of renewables and improving the efficiency of energy end-uses – particularly in rapid growing sectors such as cooling – are key elements in the transition, but a host of other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

Other priorities to bridge the gap between STEPS and SDS include switching fuels from coal to gas; retiring or repurposing today's inefficient coal power plants and the deploying CCUS in both power and industry. In SDS, only highly efficient coal plants are invested in and used.

Investment needs to be significantly reoriented towards renewable deployment, including investment in network and energy efficiency measures.

Energy efficiency measures will reduce demand growth and by extension investments in generation resources. Demand will be met primarily by investment in renewables and gas generation.

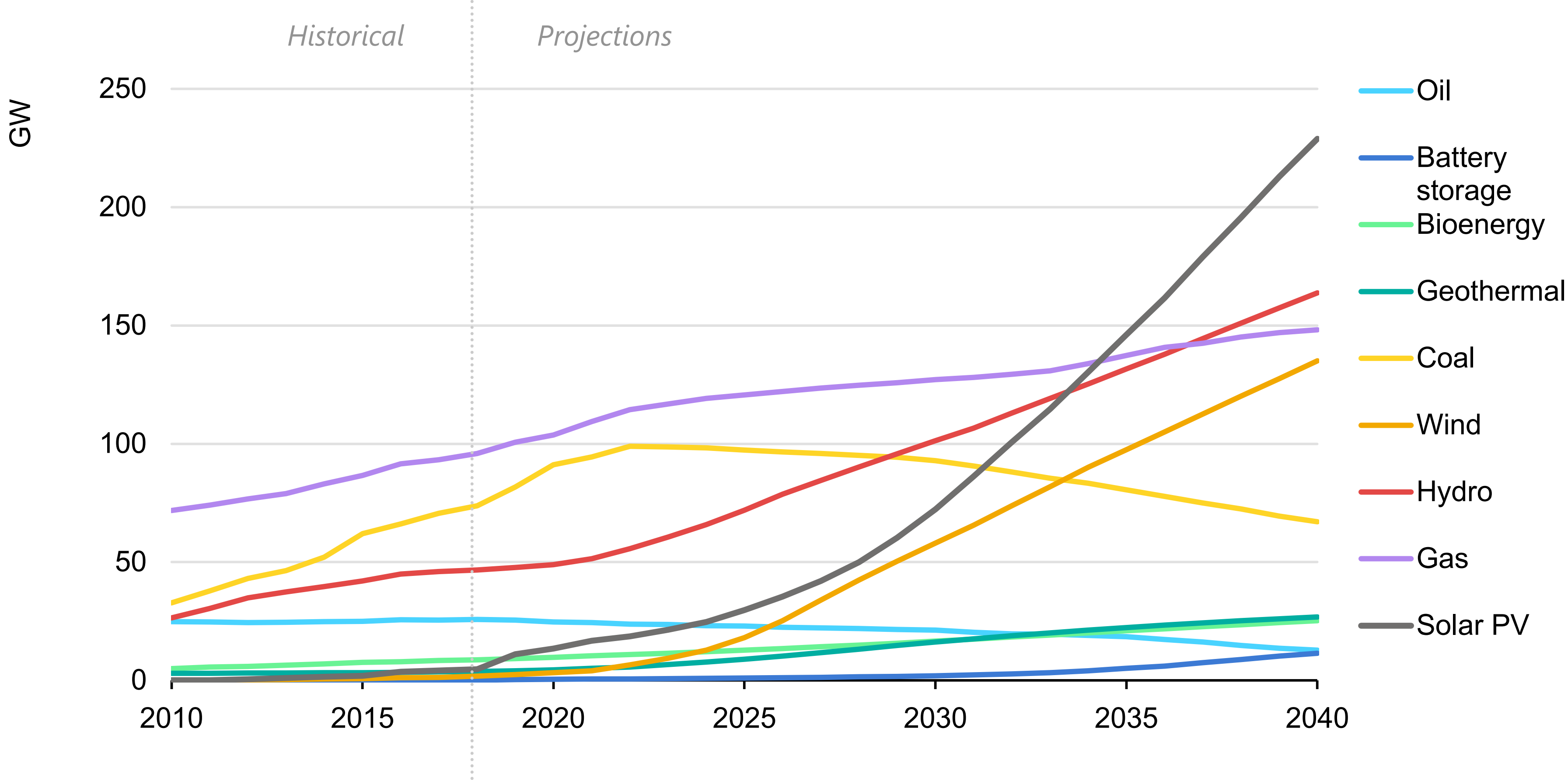
There is no silver bullet for Southeast Asia's energy transition: many technologies and approaches are required



Note: IGCC = integrated gasification combined-cycle.
Source: IEA (2019), *Southeast Asia Energy Outlook 2019*.

In SDS, solar PV and hydro lead in installed power capacity after 2035 and renewables comprise almost three-quarters of capacity by 2040

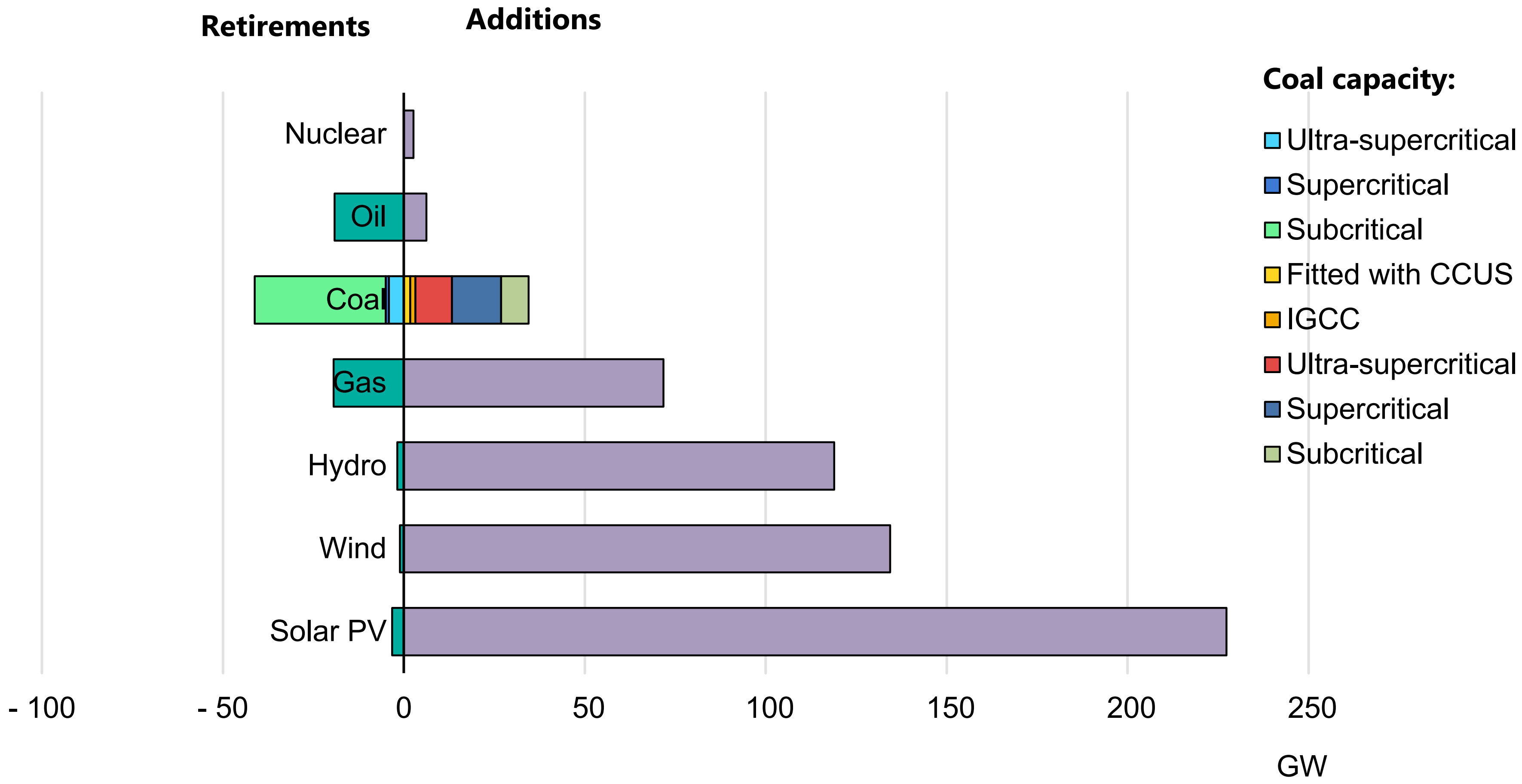
Installed generation capacity by technology in Southeast Asia in SDS



Source: IEA (2019), *Southeast Asia Energy Outlook 2019*.

In SDS, coal capacity remains stable as new highly efficient plants replace older units

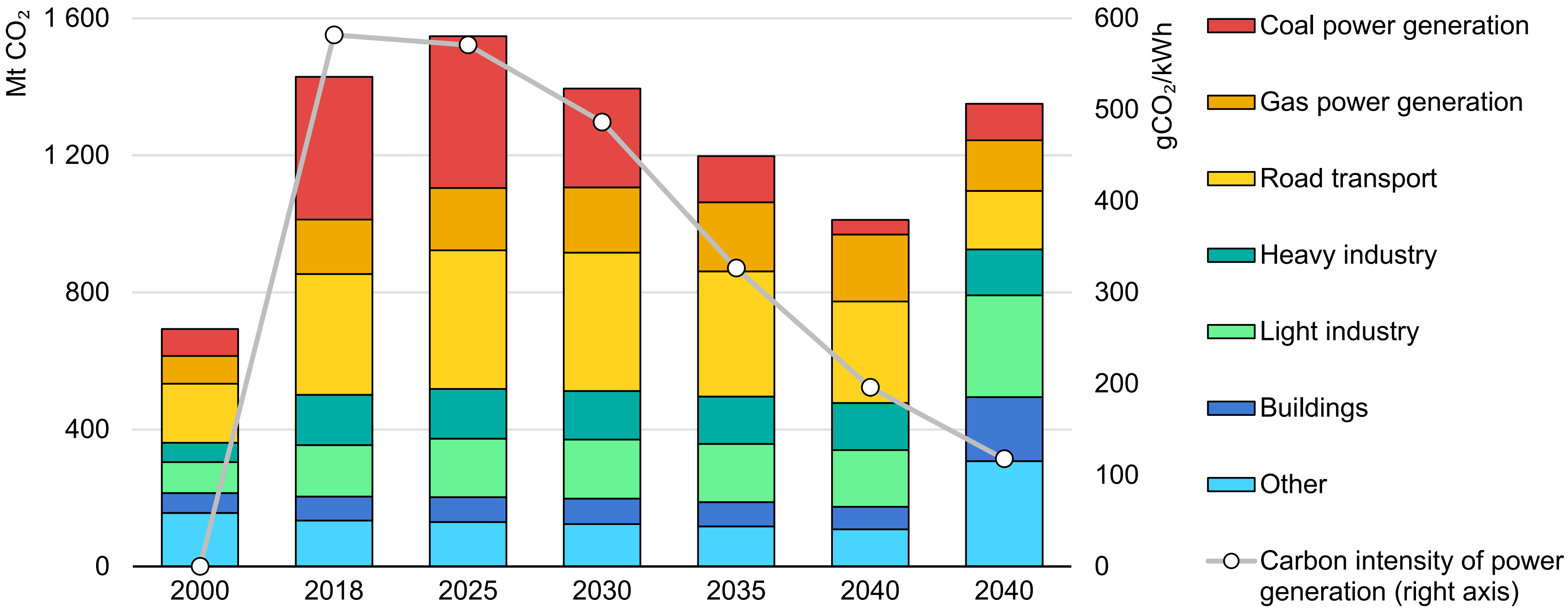
Total power capacity additions and retirements in Southeast Asia in SDS, 2019-40



Note: IGCC = integrated gasification combined-cycle.
Source: IEA (2019), *Southeast Asia Energy Outlook 2019*.

In SDS, CO_2 emissions peak before 2025 and carbon intensity of electricity generation decreases nearly 80% by 2040

CO_2 emissions from selected sectors and carbon intensity of power generation in SDS in Southeast Asia



Notes: Mt CO_2 = million tonnes of carbon dioxide; g CO_2/kWh = grams of CO_2 per kilowatt-hour. Light industry includes manufacturing. Heavy industry includes iron and steel, chemicals, cement, paper and aluminium.

Source: IEA (2019), *Southeast Asia Energy Outlook 2019*.

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

Whichever way Southeast Asia's energy sector develops, 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 STEPS, cumulative investment needs between 2019 and 2040 total over USD 2.5 trillion; in SDS they rise to nearly USD 3.2 trillion.

Investment in oil supply, which has been falling since 2014, needs to taper further to be consistent with SDS and therefore with the Paris Agreement. Current investment levels are more aligned with a pathway of continued strong demand growth, as in STEPS. For both scenarios, current investment levels fall shortof necessary spending on natural gas and exceed the limits for coal. Inefficient (subcritial) coal plants will decrease or even will be eliminated by 2040 in both scenarios.

In the power sector, today's investment falls short of the projected needs in STEPS and is more than 50% lower than required in SDS. Both scenarios would require a sizeable reallocation of capital. This need is particularly visible in SDS, which would require renewable-based power spending to quadruple and a significant boost to spending on electricity networks.

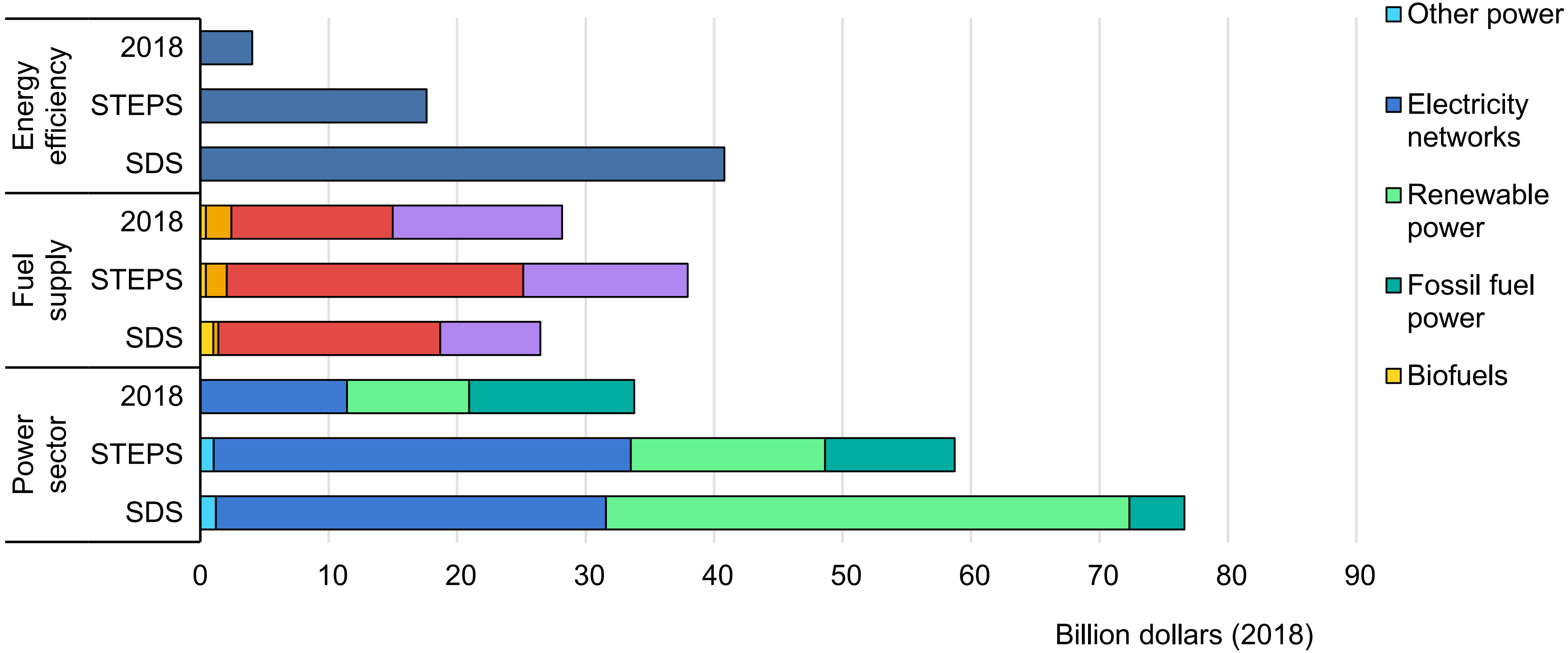
Although a quadrupling of investment in renewable electricity supply appears challenging, annual investment in energy efficiency needs to increase by ten times in the SDS, to USD 40 billion, much of it to reduce the growth in demand for electricity. Moreover, while purchases of more efficient air conditioners, 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). These efforts make it possible to lower the necessary capacity of thermal power plants, including coal plants. Thus, while this much higher level of investment in energy efficiency is feasible, if daunting, any shortfall will increase energy demand and the need for investment in supply.

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

The higher investment needs of SDS are compensated for by savings elsewhere, notably in fuel supply. For example, while average annual capital spending in SDS is over USD 140 billion over 2019-40 (compared with around USD 110 billion in STEPS), Southeast Asian economies save nearly USD 200 billion annually on fossil fuel imports by 2040.

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 STEPS and SDS, 2019-40



Notes: Projected investment is expressed as the annual average over the 2019-40 period. Other power includes investment in battery storage and nuclear. Fossil fuel power includes plants with and without CCUS.
Source: IEA (2019), *Southeast Asia Energy Outlook 2019*.

Investment in coal in the SDS decreases and focuses on only highly efficient and advanced plants, while the role of gas increases

By 2040, coal-fired electricity generation is 90% lower in SDS than in STEPS. This drastic reduction is achieved by lowering the operation rate of coal plants, shifting from less efficient coal plants to more efficient and CCUS-equipped plants, and decreasing the overall capacity of coal plants.

The coal technologies that remain in SDS are considerably more efficient than those in STEPS. 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.

While coal capacity declines slightly, coal demand peaks after 2020 and is cut by 80% relative to STEPS; an average annual decline in coal use of 4.3% over the projection period brings demand down towards 50 Mtoe in 2040.

Of the decline in coal use by 2040, 90% occurs in the power sector, where the share of coal in electricity generation falls from 40% today to 4% in 2040. As a consequence, the main role of coal plants by 2040 is to provide flexibility and security of supply, rather than baseload operation, especially when electricity generation derived by other energy sources is disrupted or unexpectedly low.

Natural gas is the only fossil fuel that does not experience a pronounced peak and decline in SDS. Its use increases by around 50% by 2040 from today's levels. The fleet of gas generation capacity increases steadily to 2040 and is part of the solution to meet demand growth in line with sustainability targets in a least-cost manner.

Enhanced regional power trade and policy frameworks that encourage investment in a low-carbon mix of renewables, dispatchable generation and storage (notably batteries) are also key tools for achieving the SDS goals.

Electricity security in a high renewables system

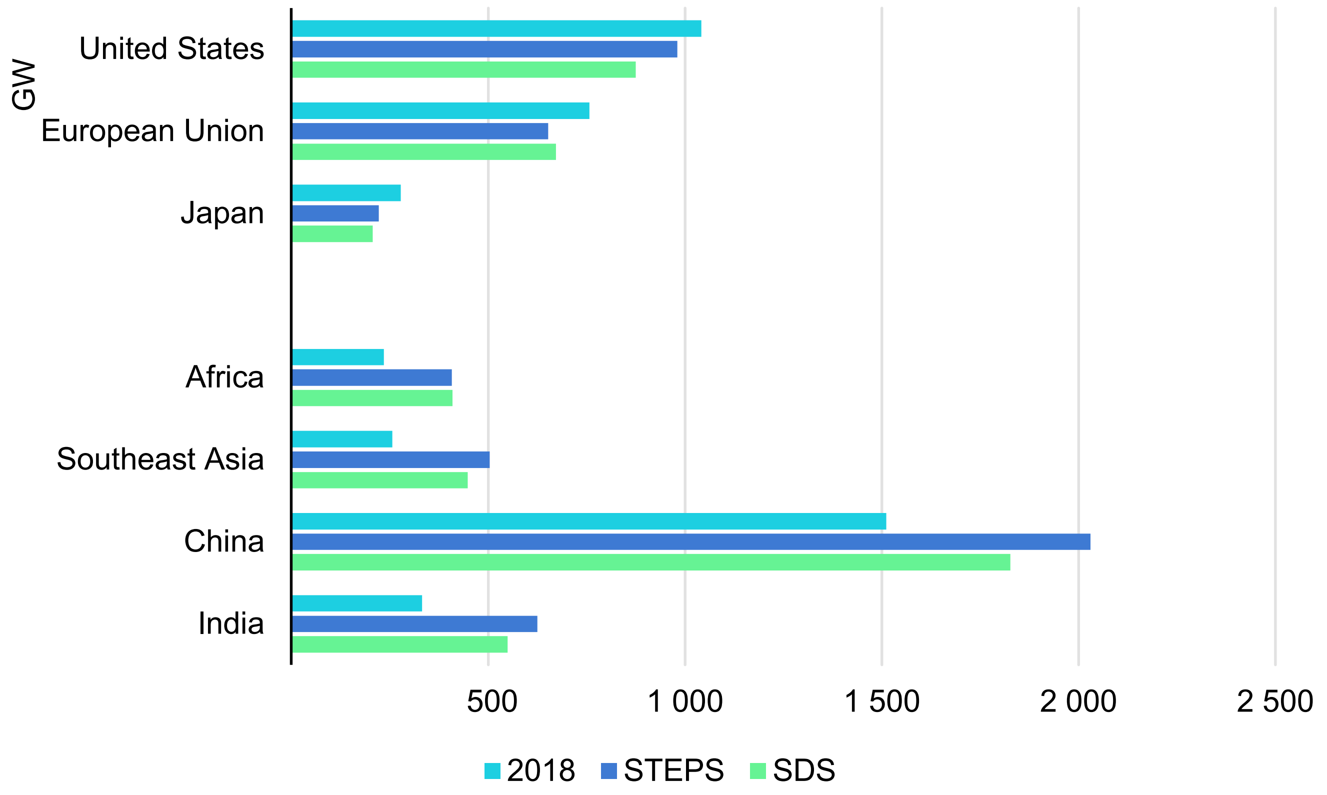
Electricity systems in emerging economies need substantial numbers of conventional power plants to ensure security of supply

Even though wind and solar power will grow rapidly, integrating variable renewables requires dispatchable capacity to maintain stable power supply. New technologies like battery storage and demand response can provide flexibility to the grid. It would be difficult or unaffordable, however, to fufill all electricity needs with a power system that relies only on renewables, storage and demand response. Considering the current cost of batteries and of providing demand side response, there are still substantial technological and cost-related risks to going down this path. In addition, we cannot be sure if large-scale power systems can depend on non-synchronous generation sources like wind and solar for balancing, as they do not provide system inertia.

Therefore, it is likely that electricity systems in emerging economies will have to maintain substantial numbers of conventional power plants to ensure power supply security, even when power generation from such conventional power plants will decrease, especially in SDS. In countries like the China and India, coal and gas plants will provide 40% of the flexibility needs in 2040 in STEPS. These plants will run less often at full capacity, however, particularly in SDS. This will create opportunities to use these resources to provide flexibility services.

Dispatchable capacity will increase in STEPS and SDS in developing economies but decline in advanced economies

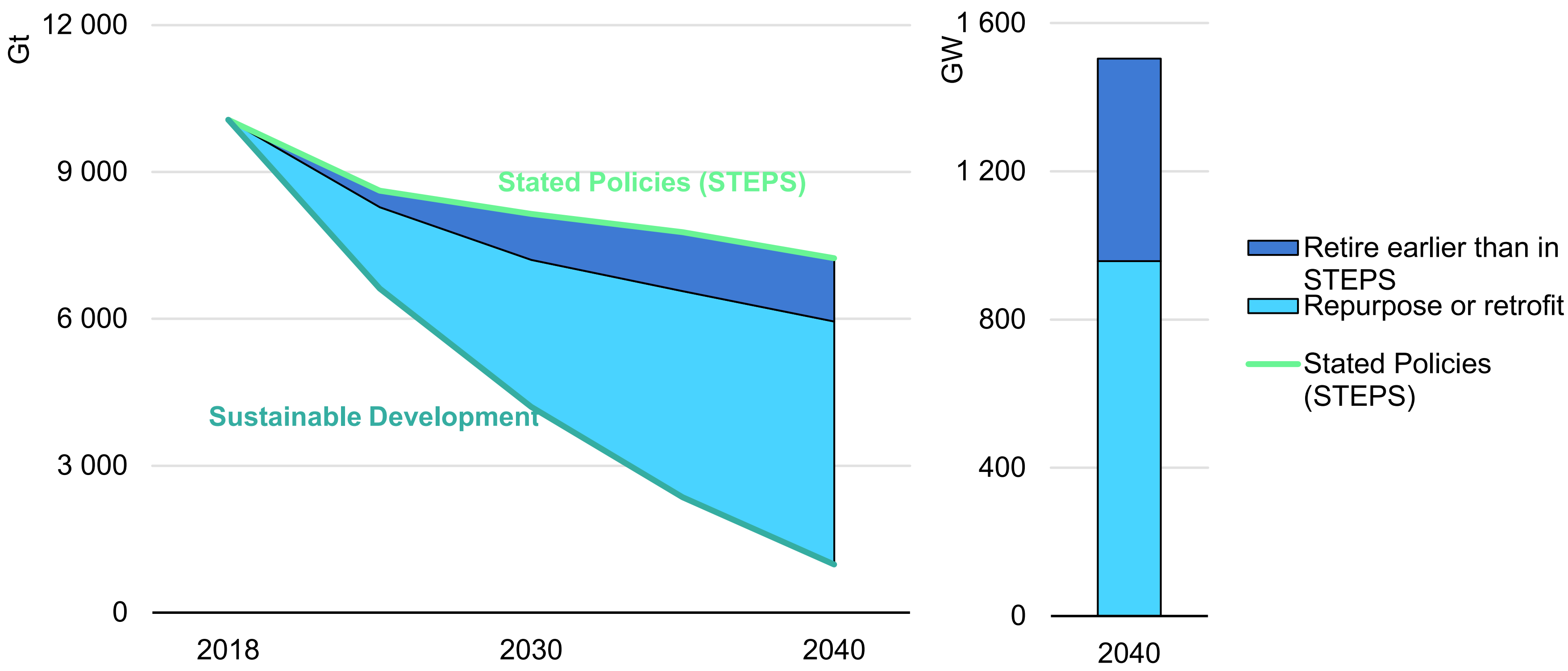
Amount of dispatchable capacity* by country and scenario, 2018 and 2040



*Note: Includes coal, natural gas, CCUS, oil, nuclear, hydro, bioenergy, geothermal, concentrating solar power and marine.
Source: IEA (2019), *World Energy Outlook 2019*.

CO_2 emissions from coal-fired power plants must be curbed by retrofitting with CCUS, repurposing or retiring the existing fleet in order to meet SDS targets

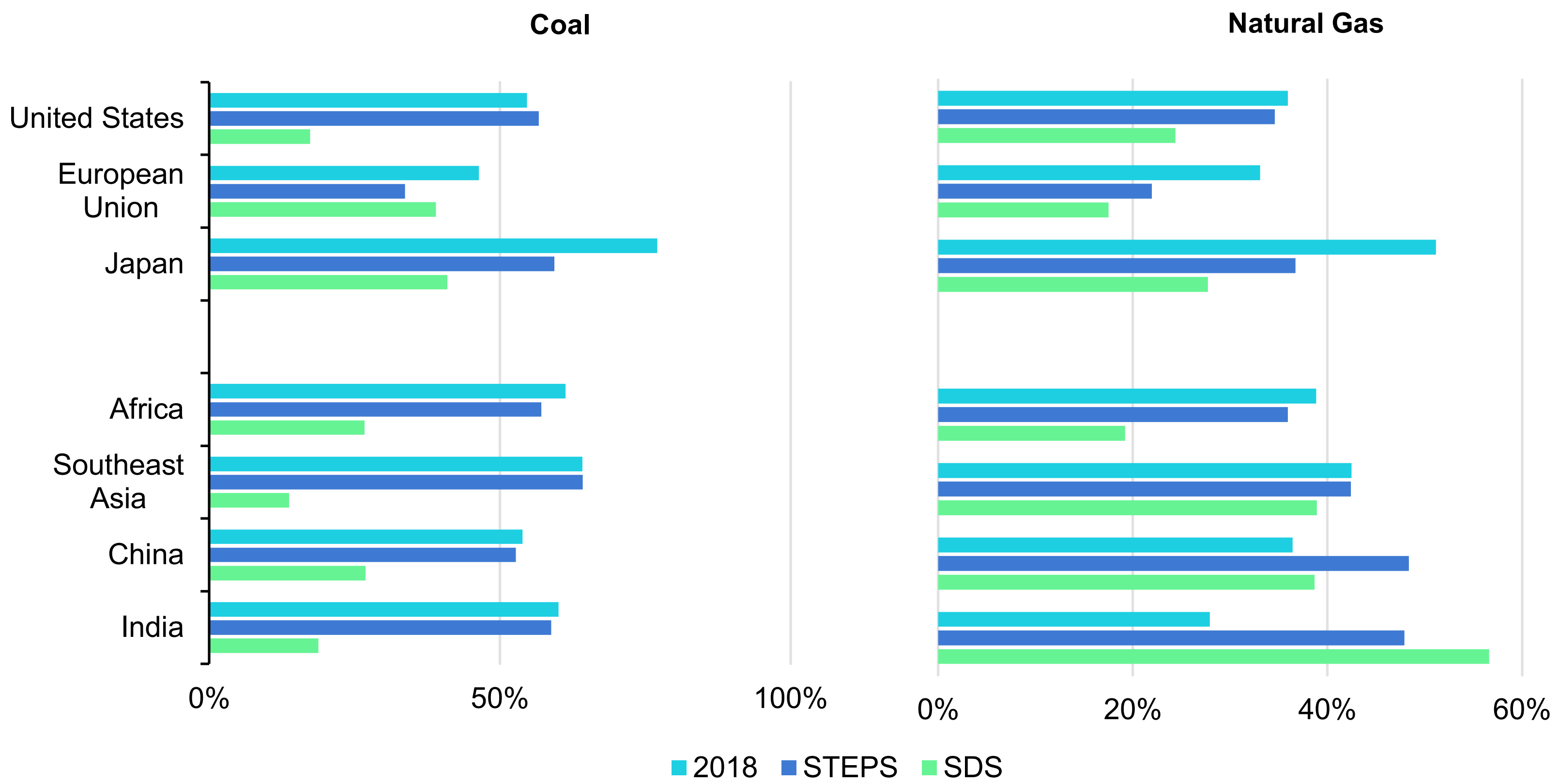
Reducing CO_2 emissions from existing coal-fired power capacity, by measure



Source: IEA (2019), *World Energy Outlook 2019*.

In SDS, coal and gas-fired generation will be repurposed to run less frequently, but will be needed to meet peak demand and to provide system flexibility

Capacity factors* of coal and natural gas-fired generation by scenario, 2018 and 2040

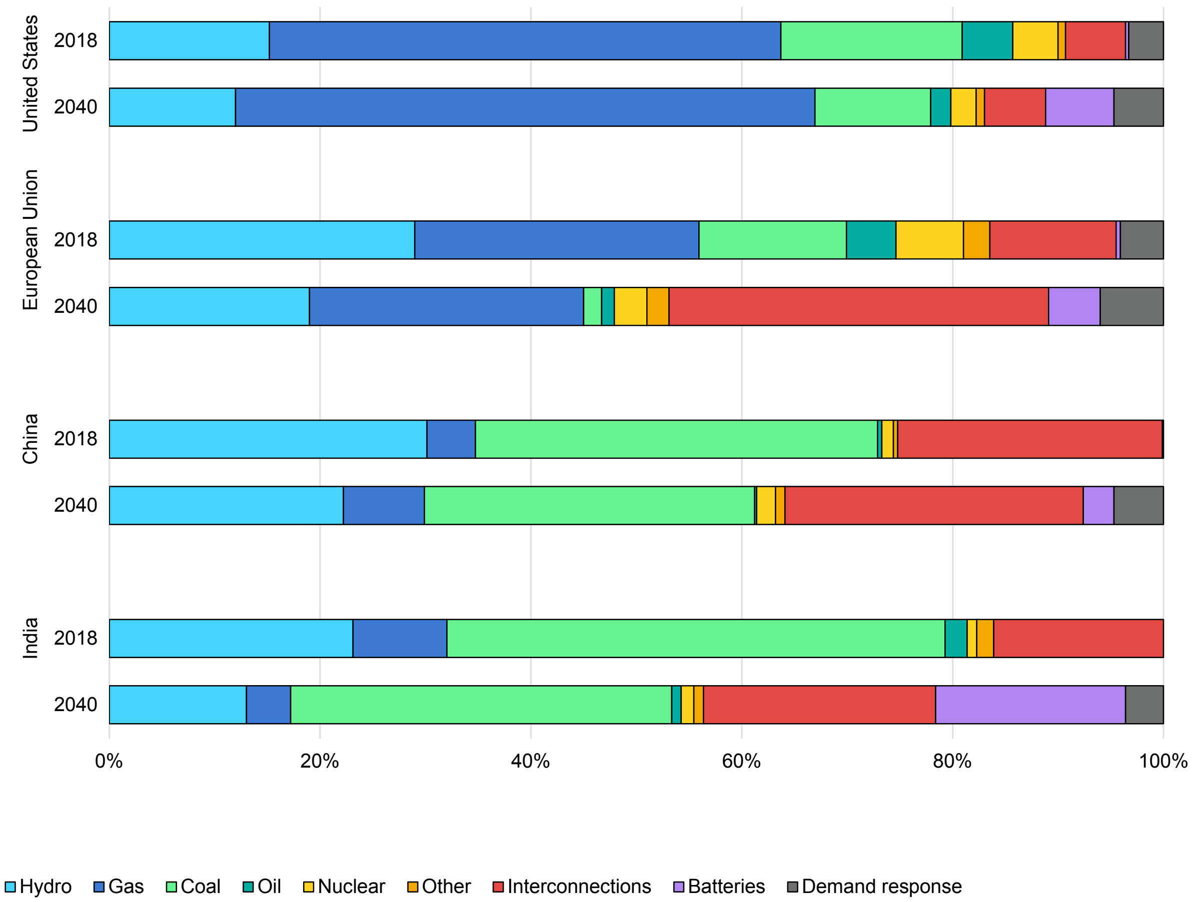


*Note: Capacity factors are the number of full load hours of a plant in a year. In SDS and STEPS, some coal and gas-fired capacity is retrofitted with CCUS or biomass co-firing equipment.

Source: IEA (2019), *World Energy Outlook 2019*.

Thermal power plants continue to provide the bulk of flexibility needs, along with interconnections, but use of batteries and demand-side response is rising fast

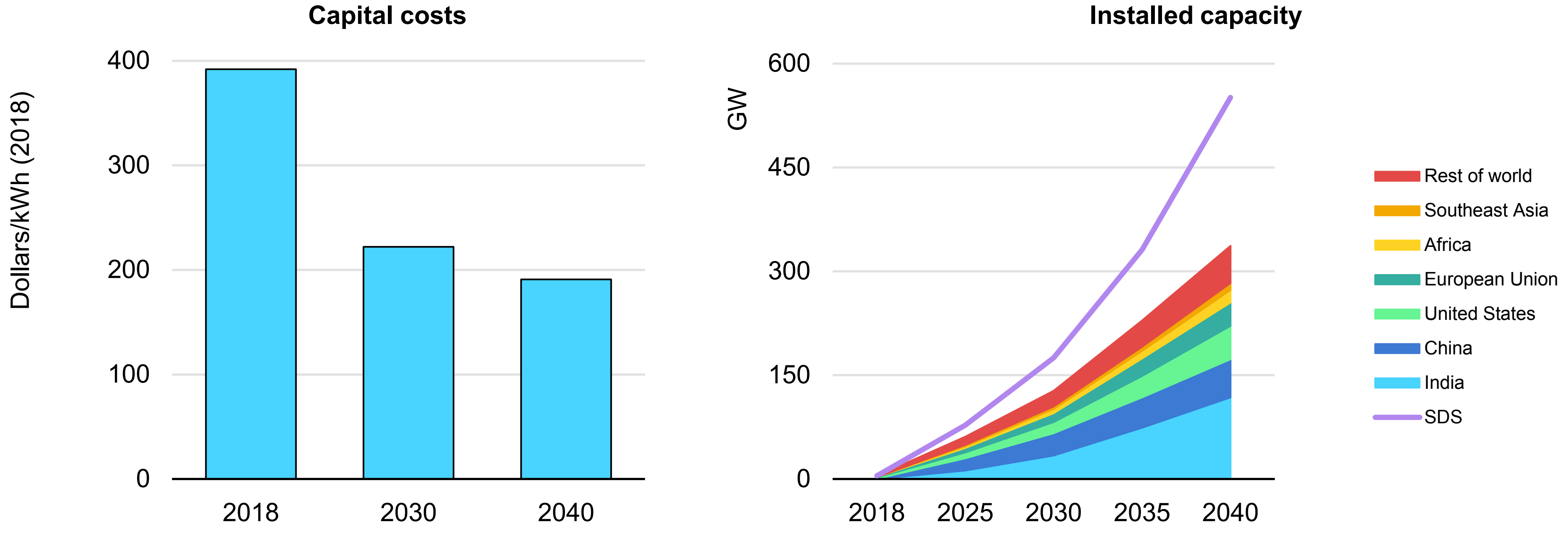
Sources of flexibility by region in STEPS



Source: IEA (2019), *World Energy Outlook 2019*.

The emergence of advanced technologies like batteries will expand the portfolio of dispatchable resources – and provide a good complement to variable renewables

Battery storage capital costs and installed capacity by scenario



Source: IEA (2019), *World Energy Outlook 2019*.

International co-operation and knowledge sharing can play a significant role in supporting emerging economies' efforts towards an affordable energy transition

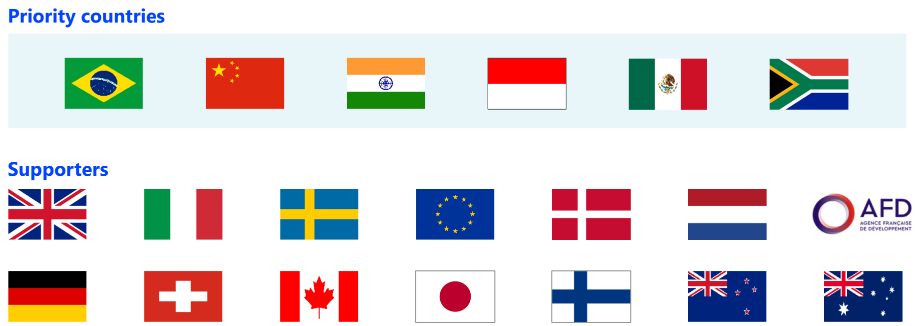
In emerging economies, electricity demand will grow rapidly in the coming years. In this context, it will require spectacular efforts to fulfil their populations' needs while meeting our shared climate and energy goals and safeguarding energy security.

The IEA is convinced that international co-operation is vital to change the current path. Building secure and sustainable power grids calls for efforts in all areas, from boosting energy efficiency to integrating more renewables, and operating more efficient and more flexible thermal power plants with CCUS. Advanced economies have a key role to play in the development and transitions of power systems in emerging economies.

The IEA promotes numerous initiatives to facilitate international co-operation on energy policy and technologies, including the Clean Energy Transitions Programme (CETP), the Clean Energy Ministerial (CEM) and the Technology Collaboration Programme (TCP).

CETP is centred on Latin America, Africa and Southeast Asia, with Brazil, China, India, Indonesia, Mexico and South Africa as focus countries. CETP provides support in seven key areas: energy efficiency, electricity, policy advice and modelling, sectoral work, innovation, digitalisation, and data and statistics.

CETP priority countries and supporters



CETP is funded by countries and organisations looking to support ambitious policies undertaken by emerging economies, and whose impact could be fostered by knowledge sharing and technical support.

CEM is a high-level global forum to promote policies and programmes that advance clean energy technology, to share lessons learned and best practices, and to encourage the transition to a global clean energy economy. Initiatives are based on areas of common interest among participating governments and other stakeholders. The CEM Secretariat has been hosted by the IEA since 2018.

CEM has 15 initiatives that focus on empowering energy decision makers around the world with the up-to-date information and tools they need to improve the policy environment for clean energy. Additionally, CEM currently organises 15 campaigns, which are short-term efforts to raise ambition, increase visibility, and target resources to initiate work and topic areas that have particular potential for impact. CEM campaigns seek to catalyze public and private action towards ambitious but realistic targets.

TCP is a multilateral mechanism established by the IEA 45 years ago with the belief that the future of energy security and sustainability starts with global collaboration. The programme is made up of thousands of experts across government, academia and industry in 55 countries, who are dedicated to advancing common research and specific energy technologies.

Currently there are 38 technology collaborations working across several technology or sector categories: energy efficiency end-use technologies (buildings, transport, industry and electricity), renewable energy and hydrogen, fossil energies, fusion power, and cross-cutting issues. These technology collaborations are a critical, member-driven part of the IEA family but are functionally and legally autonomous from the IEA Secretariat. The breadth of the analytical expertise in TCP is a unique asset in the global transition to a cleaner energy future

INTERNATIONAL ENERGY AGENCY

The IEA examines the full spectrum of energy issues including oil, gas and coal supply and demand, renewable energy technologies, electricity markets, energy efficiency, access to energy, demand side management and much more. Through its work, the IEA advocates policies that will enhance the reliability, affordability and sustainability of energy in its 30 member countries, 8 association countries and beyond.

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