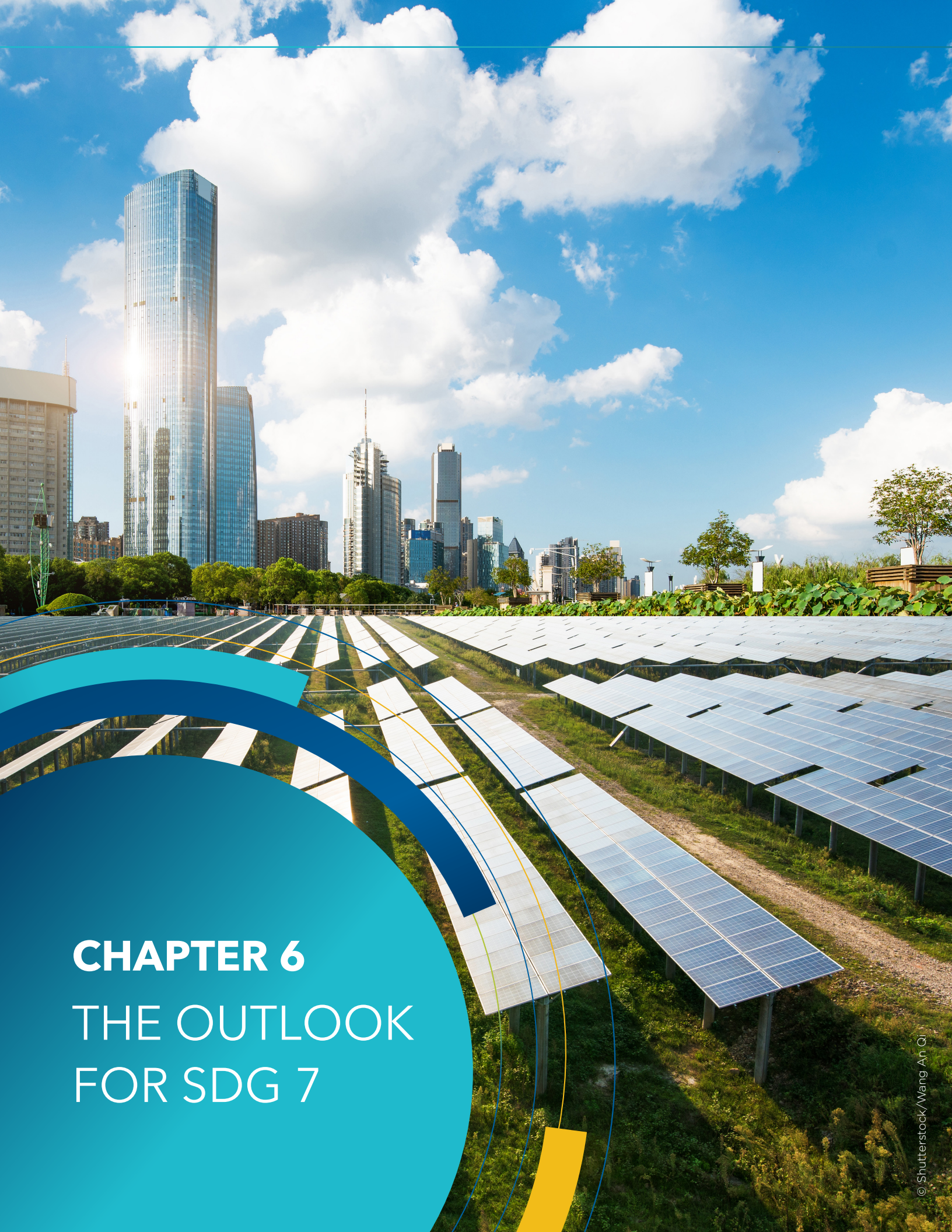

CHAPTER 6
THE OUTLOOK FOR SDG 7

MAIN MESSAGES

- **Outlook for progress toward 2030 goals:** The COVID-19 pandemic has continued to slow global progress on SDG 7. Efforts to reach universal access to clean cooking and electricity slowed during the pandemic, as did progress in energy efficiency, with renewables being the only area in which progress was consistently made throughout the pandemic. In response to the pandemic, however, many governments advanced new policies in support of energy-related Sustainable Development Goals (SDGs), particularly in advanced economies. Together with new concrete commitments coming out of the 26th Conference of Parties (COP26), adoption of these policies improved the outlook for progress toward achieving SDG 7.2 (on energy efficiency) and SDG 7.3 (on renewable energy). However, access setbacks associated with COVID-19 outweighed new policies advancing access, which slowed as developing economies directed their limited fiscal leeway toward maintaining the affordability of food and fuel amidst the crisis. This diversion of resources, along with delays incurred by lockdowns and global supply chain disruptions, has slowed global progress on universal access during the pandemic (2020–21). These trends and new policies are captured in the Stated Policies Scenario (STEPS) of the International Energy Agency (IEA) and the Planned Energy Scenario of the International Renewable Energy Agency (IRENA), both of which depict a trajectory that is off track for achieving the targets set forth in SDG 7. IEA's Net Zero Emissions by 2050 Scenario (NZE) and IRENA's 1.5°C Scenario lay out pathways to bridge the gap and put the world's energy system on track to achieve or surpass the SDG targets most closely related to energy (those in SDG 3.9, SDG 7, and SDG 13) and then achieve emissions levels in the energy sector that would have a 50 percent chance of limiting global temperature rise to 1.5°C in 2100.[1]
- **Outlook for access to electricity:** IEA's Stated Policies Scenario projects that 670 million people would still lack access to electricity in 2030—10 million more than last year's projection. The COVID-19 crisis continues to slow global progress on reaching universal access to electricity, reversing years of steady progress, particularly in Sub-Saharan Africa. The pandemic has slowed the rate of new access, particularly for stand-alone systems. In contrast, grid and mini-grid connections remained resilient during the pandemic in some regions. As a result, the number of people without access to electricity is likely to have increased by 2 percent in 2021, almost entirely in Sub-Saharan Africa, where more than four in five people without access now live. Swift actions by governments to provide lifeline tariffs during the pandemic helped improve outcomes in 2020 compared with projections. However, governments without strong access policy frameworks in place had little ability to quickly mobilize supports. Many of these supports are set to expire as the immediate pandemic situation comes under control, but the impact on household income will linger, especially for people on the lowest rungs of the economic ladder. The outlook for countries without institutions in place to address access thus appears unpromising. The outlook is better in countries that have strong access policy supports in place, such as Ethiopia, Senegal, and Kenya in Sub-Saharan Africa and countries in Developing Asia, which are still set to reach near universal access by 2030. Between 2020 and 2030, the connection rate needs to reach an average of 100 million a year, including 80 million in Africa, where the rate of new connections needs to triple. Urgent action is needed in the Democratic Republic of Congo, Ethiopia, Myanmar, Nigeria, Pakistan, Sudan, Tanzania, and Uganda, eight countries in which over half of the world's population without access lives.

1 Most of this chapter is based on results from IEA's World Energy Model and analysis in the World Energy Outlook (IEA 2021). Unlike some other chapters, this chapter uses some geographical groupings used in the *World Energy Outlook*. "Developing Asia" refers to non-OECD Asia.

- **Outlook for access to clean cooking solutions:** If clean cooking fails to find a lasting place on the global political agenda, over 2.1 billion people would continue to rely on traditional uses of biomass, kerosene, or coal for cooking in 2030, according to IEA's Stated Policies Scenario. This reliance on polluting fuels will have dramatic consequences for the environment, economic development, and health, particularly of women and children. The number of people without access to clean cooking increased by 30 million between 2019 and 2021, a rise of 1 percent. The increase reflected the marked slowdown in progress in Developing Asia, where many people who had recently gained access to clean cooking fuels reverted to traditional fuels during the pandemic, especially as global fuel prices spiked during the recovery period. Many governments—including in Ethiopia, India, Indonesia, and Nigeria—intervened to maintain affordability for consumers who used liquefied petroleum gas (LPG) and provided financial support to energy providers during the pandemic. However, mounting subsidy burdens from before the pandemic are driving many countries, including Kenya, Zambia, and India, to phase out LPG fuel subsidies, implement fuel taxes, or announce plans to do so to shore up accounts. Reaching universal access to clean cooking by 2030 faces both administrative and cultural barriers, but technologies to help achieve the goal are available. Only a third of countries facing lack of access to clean cooking have dedicated programs and policies in place. They need to be established in the coming years to keep universal access to clean cooking within reach.
- **Outlook for renewable energy:** Although the COVID-19 pandemic stalled many energy projects in 2020, the use of renewables continued to grow, accounting for more than 80 percent of all new electricity capacity added in 2020. Supportive policies in all major regions and falling technology costs made this growth possible. In the power sector, both the IEA and IRENA scenarios conclude that solar photovoltaic (PV) and wind would account for most growth in renewables-based electricity generation by 2030 under stated policies. Although the renewable energy target under SDG 7 is not quantified, stated policies remain insufficient to stay on track to meet the goals agreed to under the Paris Agreement and are even farther from what is required to be achieve net-zero emissions in energy by 2050, in line with global agreement on what is needed to limit end-of-century warming to 1.5°C. IEA's Net Zero Emissions by 2050 Scenario shows that intensified policy support and cost reductions could push the share of modern renewables in total final energy consumption (TFEC) to 32 percent by 2030, in which case renewables would account for 60 percent of electricity generation. In IRENA's 1.5°C Scenario, the rise in renewables by 2030 would reach 38 percent of TFEC and 65 percent of electricity generation. Greater efforts are also needed to increase renewable penetration in transport and heating, both directly, through the use of biofuels and biogas, and indirectly, through electrification. Despite its large share of final energy consumption, heat receives limited policy attention globally compared with other end-use sectors.[2] The number of countries with national targets for renewable heat is less than one-third those with targets for renewable electricity. Policy support is also critical for transport, particularly in a lower oil and gas price environment.
- **Outlook for energy efficiency:** The rate of global energy intensity—the percentage decrease in the ratio of global total energy supply per unit of GDP—has slowed from the 2010–15 highs in recent years, as programs in China to replace the most inefficient industrial facilities have reached completion. In addition, the pandemic reduced household and business spending on energy efficiency. Government programs incentivizing retrofits and upgrades and strengthening appliance and building codes are set to overcome the previously projected near-term slump in energy efficiency, as seen in IEA's Stated Policies scenario, under which the annual rate of global energy intensity increases from 1.9 percent in 2010–19 to 2.3 percent in 2020–30. The annual rate of improvement would need to reach over 3.2 percent to achieve SDG 7 by 2030. Under IEA's Net Zero Emissions by 2050 Scenario, the rate would rise to 4.2 percent a year, reflecting the widespread implementation of minimum energy performance standards, building codes, incentives for retrofits of industrial facilities and housing, and bans on the sale of the most inefficient equipment in the coming decade. In IRENA's 1.5°C Scenario the rate of energy intensity improvement in 2020–30 would need to be 40 percent faster than it was in 2010–19.

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2 "Heat" in this chapter refers to the amount of energy consumed to produce heat for industry, buildings, and other sectors. Heat as a final energy service refers to the energy available to end users to satisfy their needs, after considering transformation losses.

- **Investment needs:** Under IEA's Stated Policies scenario, investment in clean energy—which includes renewable power, renewable fuels, efficiency, end-use electrification, and grids and networks—would increase to USD 1.7 trillion a year by 2030, roughly 80 percent higher than in 2020. IEA's Net Zero Emissions Scenario projects that annual clean energy investment worldwide would need to more than triple by 2030 to USD 4 trillion. Much of this investment is directed to renewables and efficiency. However, reaching universal energy access by 2030 would require annual investment of USD 35 billion in electricity and USD 6 billion in clean cooking, according to IEA's Net Zero by 2050 Scenario. This level is only 15 percent of the levels tracked today by Sustainable Energy for All (SEforAll). Under IRENA's 1.5°C Scenario, investment in clean energy amounts to almost USD 5 trillion a year through 2030, a 60 percent increase over current plans and policies.

PRESENTATION OF SCENARIOS

This chapter describes the results of global modelling exercises undertaken to determine whether current policy ambitions are sufficient to meet the SDG 7 targets and to identify what additional actions might be needed. It also examines what investments are required to achieve the goals. Scenarios for the targets are taken from IEA's flagship publication World Energy Outlook (IEA 2021) and IRENA's World Energy Transitions Outlook: 1.5°C pathway (IRENA 2021). Both explore two types of scenarios: one in which energy trends evolve under today's policies and another that explores a pathway that delivers on all energy-related SDGs, including substantially reducing the air pollution that causes deaths and illness (SDG 3.9) and taking effective action to combat climate change (SDG 13).

IEA's Stated Policies Scenario explores how energy trends would evolve under today's policies, assuming that no additional policies are put in place. It holds a mirror up to policy makers' current plans, in order to evaluate whether they are sufficient to reach their long-term targets and goals. This scenario does not take countries' decarbonization pledges, Nationally Determined Contributions (NDCs), or access targets as givens but rather conducts bottom-up modelling that considers how policies, pricing policies, efficiency standards and schemes, electrification programs, and specific infrastructure projects would influence energy trends.

IEA's Net Zero Emissions by 2050 Scenario takes the SDG targets in 2030 and net-zero emissions in the energy sector by 2050 as its targets and works backward to determine what would be needed to achieve those outcomes in a cost-effective and plausible way.[3] Under this scenario, by 2030, universal access to both electricity and clean cooking is achieved, modern renewables reach 32 percent of TFEC, and energy efficiency gains exceed the SDG 7 targets, with average annual improvements in global energy intensity reaching 4.2 percent a year between 2020 and 2030. After this critical near-term period, the scenario emphasizes efficiency, renewables, and clean fuels, bringing energy sector emissions to net zero by 2050 and limiting the end-of-century global temperature increase over pre-industrial levels to 1.5°C.

IRENA's Planned Energy Scenario provides a perspective on energy system developments based on governments' energy plans and other planned targets and policies, including NDCs under the Paris Agreement. It also provides the reference case for IRENA's 1.5° Scenario, which describes an energy transition pathway aligned to limit global average temperature increase to 1.5°C by the end of the 21st century relative to pre-industrial levels. It is underpinned by six technological avenues and measures that would achieve major emission reductions between today and 2050, paving the way toward a net-zero carbon world by mid-century. The scenario also provides insights into the socioeconomic footprint of the global energy transition (box 6.1).

3 More information on the IEA Net Zero Emissions by 2050 Scenario can be found at https://www.iea.org/reports/world-energy-model/net-zero-emissions-by-2050-scenario-nze.

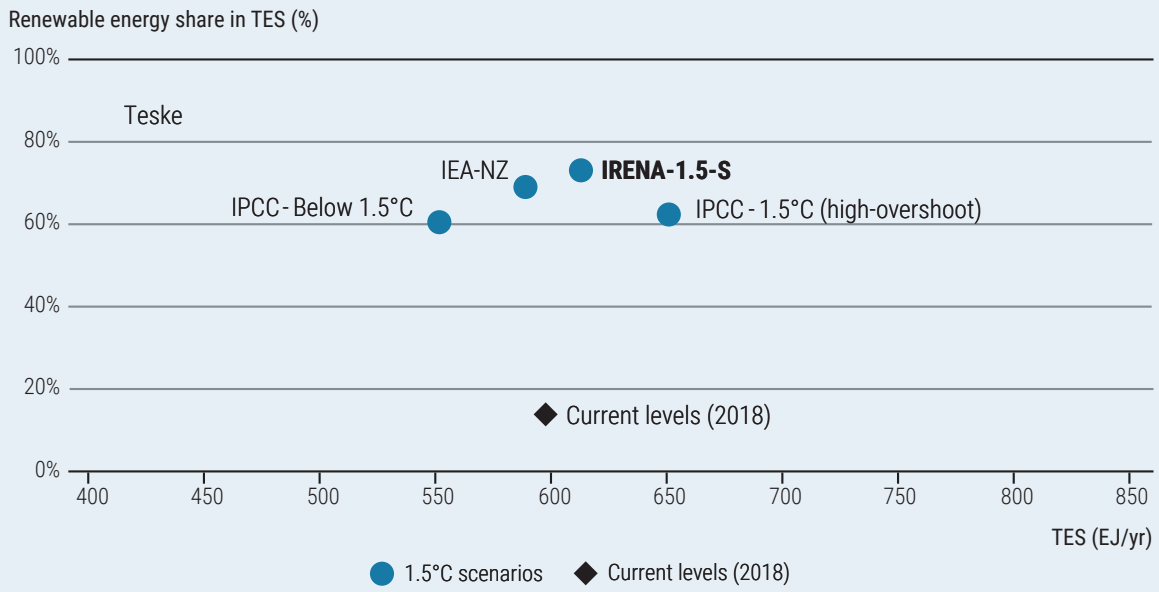
Box 6.1 • How do the IEA and IRENA scenarios compare with the 1.5°C scenarios of the Intergovernmental Panel on Climate Change?

Countries that together produce more than 70 percent of today's emissions have committed to reach net-zero emissions in the energy sector. If met in full and on time, these pledges would limit the median rise in global temperatures to 1.8oC by 2100. However, this target is still far from the target expressed in the Paris Agreement to make best efforts to limit global warming to 1.5°C by the end of the century. This gap has prompted both IEA and IRENA to design new scenarios to look at what would be needed in the energy sector to achieve the Paris goal, which focuses on reaching net-zero emissions in the energy sector by 2050.

There is no singular pathway to 1.5°C, but the direction of travel is clear: The energy sector must be one of the first to drive decarbonization, especially between now and 2030, the focus for achieving the current energy-related SDG targets. In the near term, the IEA and IRENA scenarios focus on efficiency, electrification, and power sector renewables; after 2030, they continue to advance these goals, bringing power sector renewables to 90 percent of the electricity mix by 2050. Both scenarios rely on clean fuels and carbon capture to help reduce emissions in hard-to-abate sectors, but they limit the reliance on negative emissions and non–energy sector offsets to contain global temperature rise through 2050.

The range of scenarios reflects the complexity and uncertainties of the speed and scale of the energy transition (figure B6.1.1). There is, however, broad consensus on the central role that renewables would play in electricity generation, especially in light of the growing recognition of the imperatives to tackle climate change.

Figure B6.1.1 • Share of renewables in total energy supply in 2018 and 2050 under various energy scenarios



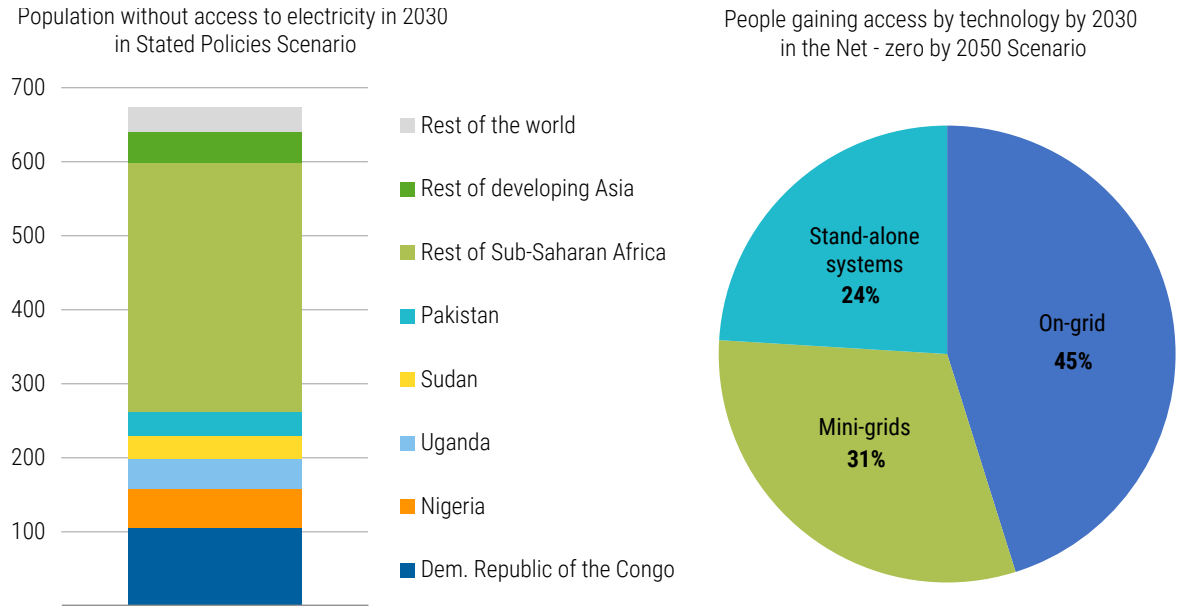
Sources: IEA's Net Zero Emissions by 2050 (IEA 2021), IRENA'S 1.5°C Scenario (IRENA 2021), the "Below 1.5°C" and "Above 1.5°C" scenario from the Intergovernmental Panel on Climate Change (IPCC 2018).

THE OUTLOOK FOR ACCESS TO ELECTRICITY

The economic downturn caused by COVID-19 is compounding the difficulties governments face as they try to reduce energy poverty and expand access. The pandemic has reversed progress on energy access in many parts of Africa, where the number of people without access to electricity is set to increase in 2021 and basic electricity services have become unaffordable for up to 10 million people who had recently gained electricity access. Many regions have implemented emergency financial relief to reduce these impacts, but as African countries and utilities face mounting debt levels, many of these programs are set to end before the need for them has been addressed.

After the setbacks from the pandemic fade, access to electricity is projected to increase through 2030. These trends vary significantly across regions, however, and remain far from sufficient to reach universal access by 2030. In the Stated Policies Scenario, 670 million people—roughly 8 percent of the global population—would remain without access by 2030, including 565 million (85 percent of the total) in Sub-Saharan Africa. SDG target 7.1 remains within reach in many countries in which adequate policies have been implemented for centralized and decentralized solutions; countries in which electrification plans and enabling frameworks are lacking are not on target (figure 6.1).

Figure 6.1 • Population without access to electricity in 2030 and delivery of electricity connections under the IEA Net Zero Emissions by 2050 Scenario, by technology



Source: IEA 2021.

Developing (non–OECD) Asia remains on track to reach access of 98 percent by 2030, close to a 20 percentage point improvement since 2010, and the highly populated countries of Bangladesh, India, Indonesia, and the Philippines are on a pathway to reach full access before 2030. Efforts need to be stepped up in other Asian countries, such as Afghanistan and Mongolia, if the region is to achieve 100 percent access in 2030. Central and South America are projected to continue to make steady progress, moving to 98 percent access in 2030, with only the most rural populations remaining without access. Haiti remains the only major country in the region in which a substantial share of the population is projected to lack access.

In much of Sub-Saharan Africa, the prospects for progress to 2030 remains bleak, with little evidence of effective policy making on the ground set to change the current trajectory. As of 2020, more than 40 percent of countries in Sub-Saharan Africa had not set electricity access targets or developed solid national plans and policies. Some 225 million people without electricity access live in these countries. If nothing changes, the number of people without access in these countries will increase by 20 percent by 2030.

There is also a possibility that the countries with the greatest need to improve access to electricity will face even greater challenges for accessing finance, impeding their capacity to increase access. This situation could further deteriorate as global inflation and price spikes exacerbate importing country indebtedness. The financial resources available for funding expansion and upgrades of electricity access have been much lower than needed to achieve SDG 7. On average, between 2013 and 2019, USD 12 billion a year was spent to improve electricity access in 20 countries representing 80 percent of the world's population without access to electricity. Most of this financing came in the form of debt from international institutions. Recent trends reveal an important increase in domestic public financing, which is helping mobilize more private finance participation (SEforAll 2021). The impact of the COVID-19 pandemic is likely to reduce the level of finance available, however, as evidenced by the downgrading of sovereign credit ratings across many low-income countries (box 6.2). Some countries are facing rising costs of capital, including some countries in Africa that are now financing costs that are seven times higher than they are in Europe and North America. SDG target 7.1 can remain within reach only if governments and donors put access at the heart of recovery plans and programs.

Box 6.2 • Tracking sustainable recovery measures in COVID-19 fiscal packages

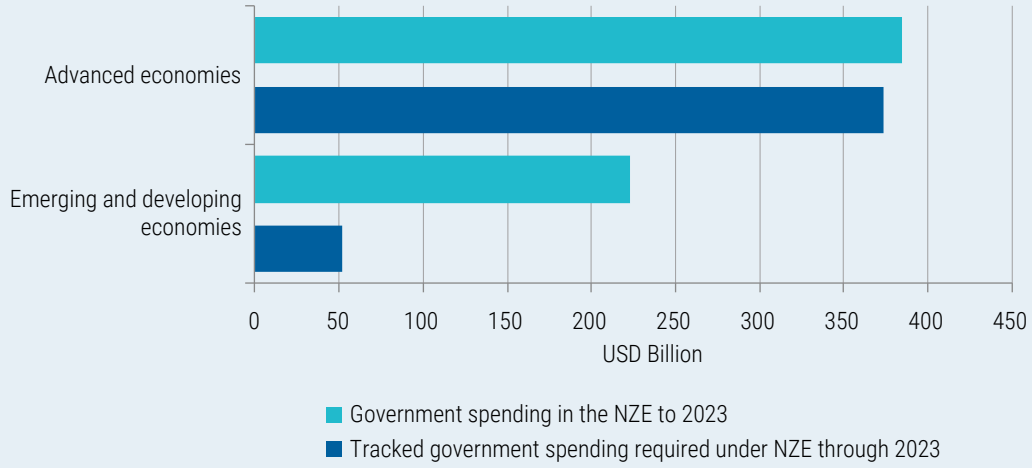
Governments worldwide have mobilized an unprecedented amount of fiscal support—over USD 18.2 trillion by March 2022—to manage the impacts of the pandemic on households, workers, and businesses. The vast majority of the spending (more than 80 percent of the total) has been for short-term emergency responses, such as supporting health systems and vulnerable segments of the economy and society, but some has taken a longer-term perspective, focusing on building back better and ensuring a sustainable recovery, including through investments crucial to achieving the energy-related SDGs.

Enabling the acceleration of energy transitions through recovery measures will enable countries to achieve multiple objectives. The IEA's detailed Sustainable Recovery Plan (IEA 2020), developed in cooperation with the International Monetary Fund, shows how increasing annual investments in clean energy by USD 1 trillion in 2021–23 would keep the globe on track with the SDGs and the Paris Agreement while boosting economic growth. The Sustainable Recovery Plan and IRENA's post-COVID recovery plan (IRENA 2020) are detailed in chapter 6 of last year's Tracking SDG 7 Report (IEA, IRENA, UNSD, World Bank, and WHO 2021).

To date, governments have directly earmarked more than USD 710 billion for sustainable recovery measures (IEA 2022). Of this amount, 60 percent is to be spent in the crucial recovery period to 2023, thus mobilizing an additional USD 1.6 trillion in investment. The latter figure is in line with government short-term public spending needs outlined in IEA's Net Zero Emissions by 2050 Scenario.

These encouraging global figures must not be allowed to obscure a severe geographical imbalance. Nearly 90 percent of the sustainable recovery spending intended by 2023 is concentrated in advanced economies (figure B6.2.1). In emerging and developing economies (EMDEs) it has been not only limited but also relatively short-lived, most having been withdrawn in 2021. This is due to EMDE governments' narrow fiscal leeway, constrained borrowing capacity, and mounting debt levels, which have led them to focus what fiscal latitude they have on short term emergency measures meant to support health systems and cushion the most vulnerable households and businesses from the shock caused by the pandemic. As a result, EMDE governments are spending less than a quarter of what would be needed in the short term to stay on track with IEA's Net Zero Emissions by 2050 Scenario. That level of spending contrasts starkly with the clean energy investments that EMDEs must take in this decade to stay on track with Paris Agreement goals and SDG 7.

Figure B6.2.1 • Sustainable recovery earmarks through 2023, by region, and government spending required by IEA's Net Zero Emissions by 2050 Scenario through 2023



Source: IEA 2022.
NZE = IEA Net Zero Emissions by 2050 Scenario

A small number of recovery plans actually targeted electricity and clean cooking access challenges. Nigeria included new spending to help finance solar home systems and liquefied petroleum gas cook stoves; it also provided monetary incentives for off-grid solar businesses to connect 25 million people. As part of its COVID-19 recovery response, Indonesia committed to provide poor households with 1 gigawatt of solar panels a year. The Brazilian government financed electrification in remote areas of the Amazon through recovery measures.

Fossil fuel price spikes in late 2021, reinforced by the Russian invasion of Ukraine are now pressuring many cash-strapped EMDE governments to reinstate affordability measures, mostly by freezing or cutting automobile fuel taxes (South Africa), raising consumer subsidies (Nigeria), or subsiding some categories of fuel-dependent activities (Morocco). But because fiscal reserves are widely depleted, very few countries can afford even short-term interventions. Development banks and other international financial institutions have provided some short-term relief to African countries through extended lending facilities, debt relief, or reimbursement alleviation instruments. But international catalysts such as development assistance will become even more essential to increasing clean energy investment during this decade.

Source: IEA 2022.

To bridge the gap and connect the remaining 670 million people without access by 2030, the connection rate would have to accelerate in most regions to 100 million a year between 2020 and 2030. Under IEA's Stated Policies Scenario, most of the acceleration would have to occur in Sub-Saharan Africa, where on average, efforts need to reach three times historical levels. Action needs to be stepped up in the Democratic Republic of Congo, Niger, Nigeria, Sudan, Tanzania, and Uganda, which together are home to half of the region's population projected to lack access in 2030.

The delivery technology varies by region under IEA's Net Zero Emissions by 2050 Scenario. In Sub-Saharan Africa, 43 percent of connections by 2030 would be directly to the grid, 31 percent would be mini-grid stand-alone systems, and the remainder would be stand-alone systems. In Developing Asia, just over half of connections would be directly to the grid, a third would be through mini-grids, and the remainder would be to stand-alone systems.

Under the Net Zero Emissions by 2050 Scenario, governments and donors put access at the heart of recovery plans and programs in order to achieve universal access by 2030. Doing so involves, for example, measures to support the emerging private sector, extend financial support to off-grid solutions, enhance access planning through stronger monitoring and the use of geospatial data and models, and build up dedicated programs to help coordinate implementation. In a world in which finance is constrained, access projects will need to be smart (linked with livelihood and public sectors like health and agriculture to unlock related benefits, for example); effective; and capable of being implemented quickly. Decentralized energy solutions will play an important role, particularly in reaching households, enterprises, farms, and public institutions that are far from a grid.

Some countries are already moving ahead. Integrated national electricity access plans using both centralized and decentralized solutions adapted to the local context are already showing benefits in Ethiopia, Ghana, Nigeria, Rwanda, and Senegal (IEA 2019). Many of these plans aim to maximize the benefits of energy access by considering the needs of health facilities, schools, agricultural enterprises, and similar organizations alongside those of households. Under the Net Zero Emissions Scenario, achieving universal access to electricity by 2030 requires annual investment of USD 35 billion through 2030 on generation, electricity networks, and decentralized solutions through smart and efficient integrated delivery programs. Current global spending is at only 15 percent of those spending levels.

Ultimately, energy access must look beyond basic access to electricity and clean cooking and facilitate the rising use of energy services sufficient to underpin socioeconomic prosperity and well-being.

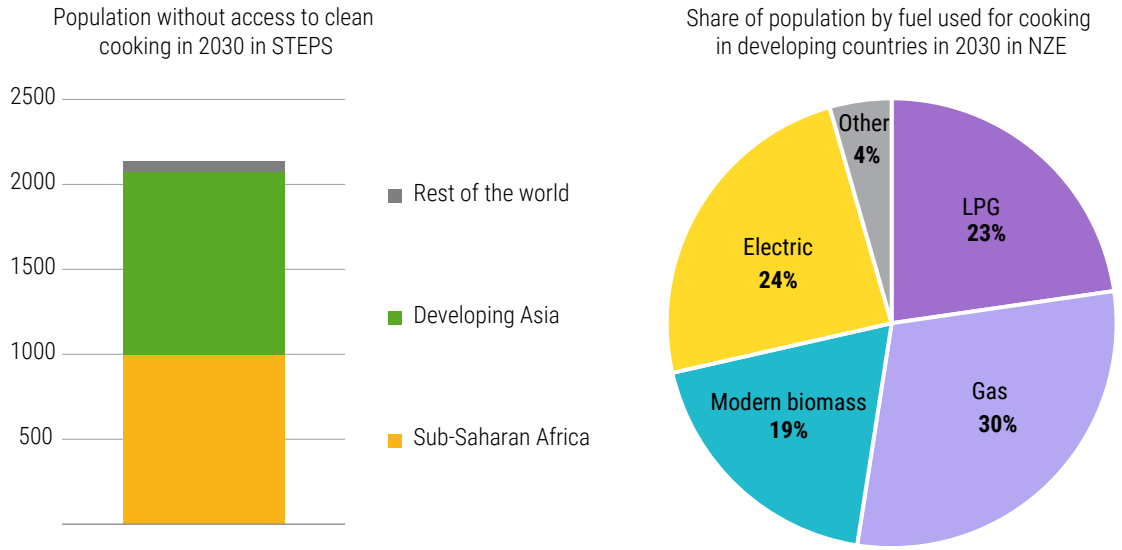
THE OUTLOOK FOR ACCESS TO CLEAN COOKING FUELS AND TECHNOLOGIES

Globally, the number of people without access to clean cooking fell in recent decades. This decline reflects efforts to reduce the reliance of vulnerable populations on biomass, with the aim of improving indoor air quality, reducing the amount of time spent gathering fuel, and curbing deforestation and emissions from the incomplete combustion of biomass.

Progress has been uneven, however, and the number of people without access to clean cooking has continued to increase in Sub-Saharan Africa. The COVID-19 pandemic has set back modest advances, as consumers face the dual threats of reduced income and higher LPG and clean cooking fuel prices, which may remain elevated as a result of the Russian invasion of Ukraine. Some countries have implemented policies to counter this trend, but millions of people are reverting to traditional uses of biomass, especially in Sub-Saharan Africa.

The outlook for clean cooking remains of serious concern: Under today's policies, the world will be far from achieving universal access to clean cooking solutions by 2030 (figure 6.2). Progress slowed in 2020 and 2021. Although it is expected to return to pre-COVID levels of progress in certain regions, 2.1 billion people are projected to be without access to clean cooking in 2030. Forest degradation, sometimes leading to outright deforestation, is yet another grave consequence of the unsustainable harvesting of fuelwood, chiefly for the production of charcoal to be used in cities.

Figure 6.2 • Population without modern cooking solutions in 2030 and use of clean cooking technologies required



Source: IEA 2021.

In 2030, the population without access to clean cooking solutions is projected to be split almost equally between Developing Asia and Sub-Saharan Africa. In Developing Asia, the projected access rate in 2030 is 75 percent, leaving some 1.1 billion people without access. Significant progress is projected in India, which is expected to reduce the number of people without access from 490 million in 2020 to 282 million in 2030, achieving an access rate of 81 percent.

To satisfy the objective of the Net Zero Emissions by 2050 Scenario in line with SDG 7, every household in the world would have access to clean cooking by 2030, an achievement that would require providing access to over 280 million people each year.

To achieve the Net Zero Emissions by 2050 Scenario, access programs would need to be quickly ramped up. These programs need to help reduce the upfront cost of stoves; train people to use new cooking equipment safely and effectively; and provide cultural programming, such as cooking classes or recipes that help adapt culinary practices to improved cookstoves. Supporting infrastructure—such as fuel delivery and storage systems, a stable supply chain of cooking equipment in-country, and workers to help administer these programs—also need to be ramped up (IEA 2020). Scalable LPG solutions are already available in many regions, but fuel distribution services may not be consistently available, and LPG remains exposed to market prices, leaving users vulnerable to unaffordable price spikes without government intervention. Alternative fuels for cooking, such as biogas, could also play a role in rural areas, but biodigesters to produce biogas require support to cover the high upfront cost, sufficient feedstock, and training on their use. Electric pressure cookers powered by the grid or solar PV and a battery represent an increasingly popular mode of clean cooking, particularly in urban areas. In some countries, utilities and off-grid solution providers offer all-electric cooking bundles and programs, as increasing electric cooking can increase the profitability of providing electricity access. Improved biomass stoves (ISO Tier ≥ 1) can also be useful, especially in rural areas, and fuels such as ethanol can help cover gaps in certain regions. Reaching universal access to clean cooking by 2030 requires an all-solutions approach to meet the diverse needs in different countries and rural and urban environments.

THE OUTLOOK FOR RENEWABLE ENERGY

SDG target 7.2 calls for a substantial increase in the share of renewable energy in the energy mix. Although it does not specify a quantitative objective, long-term scenarios charting various paths for the energy sector to reach net zero by 2050 find that renewables' share of TFEC would need to reach well above 30 percent by 2030 to be on track.

Despite the impact of the COVID-19 pandemic, the outlook for renewables under IEA's Stated Policies Scenario and IRENA's Planned Energy Scenario remains positive in all regions helped by supportive policies and falling technology costs. Under IEA's Stated Policies Scenario, the share of all renewables (including traditional uses of biomass) is projected to rise from 17.7 percent of TFEC in 2019 to 22.0 percent in 2030, and the share of modern renewables is projected to increase from 11.5 percent in 2019 to 17.0 percent in 2030. These projections are substantially higher than in previous outlooks, as some of the world's largest economies—including the European Union, the United States, China, and India—incorporated renewable energy provisions in their recovery plans. In contrast, IRENA's Planned Energy Scenario sees the share of renewables in TFEC decreasing from 17.7 percent in 2019 to 16.0 percent in 2030, because of a more rapid phase-out of traditional uses of bioenergy, but the share of modern renewables would increase, from 11.5 percent in 2019 to 15.5 percent in 2030.

Power sector renewables remain the fastest-growing source of energy globally. Renewable sources of electricity have been resilient during the COVID-19 crisis, experiencing only minor setbacks. They are poised for strong growth, with annual capacity additions in 2020–30 rising by over 60 percent compared with 2015–19 trends, with solar PV and wind acting driving growth. Over the decade, renewables overtake coal as the primary means of producing electricity. Of the renewable sources of electricity, solar PV is the strongest performer, meeting almost one-third of electricity demand growth over the period, thanks to widely available resources, declining costs, and policy support in over 130 countries. Hydropower remains the largest low-emissions source of electricity globally through 2030. It also provide flexibility and other power system services.

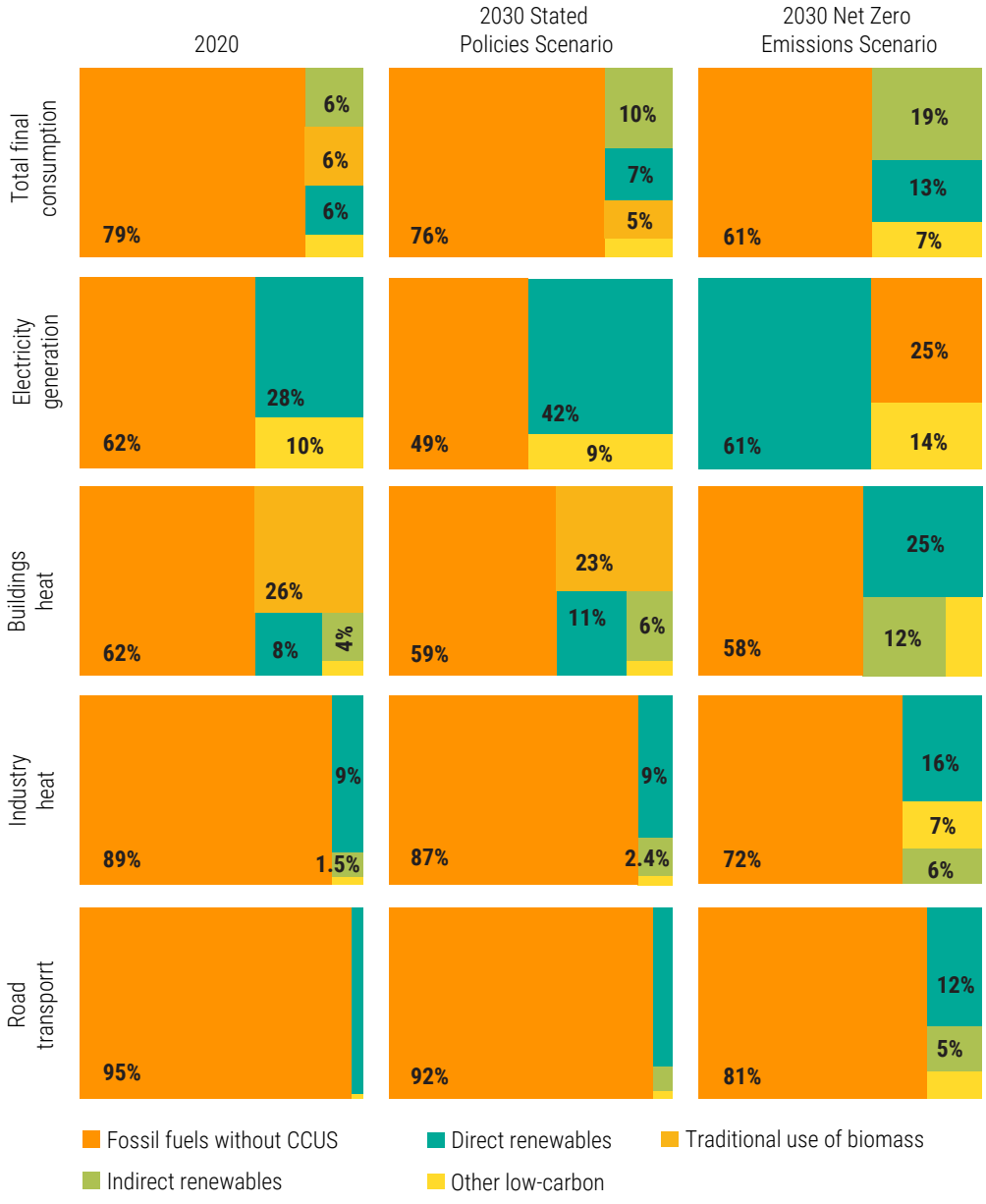
Expansion of the direct use of renewables in end-use sectors has been steady but slower. Modern bioenergy accounts for the lion's share of growth in end-use renewables through 2030. In the transport sector, biofuels see strong growth, although their use will be limited if new blending requirements are not adopted in places where they do not currently exist. Renewables for heat grow, with modern bioenergy accounting for the largest share of the growth, driven by renewable requirements in Europe and some pilots in China. Demand for biogas and modern biomass for heating also increases, driven by growth in industry (IEA 2021).

The outlook for growth for end-use renewables depends to a large extent on further policy action at a time of economic difficulty and competing budgetary pressures. There is a risk that some targets may not be enforced or that implementation dates may be delayed as a result of pressures arising from the COVID-19 pandemic. Supportive policies may play a big role in recovery packages, especially for transport biofuels, which would support agricultural production as well as emissions reductions.

INSIGHTS ON BRIDGING THE GAP FROM IEA'S NET ZERO EMISSIONS BY 2050 SCENARIO

The projected increases in the use of renewable energy that are likely to occur under stated policies fall short of what is required to achieve global goals for climate protection and sustainable development. Under IEA's Net Zero Emissions by 2050 Scenario, use of renewables increases twice as rapidly as under stated policies. Under this more ambitious scenario, modern renewables would reach just under 32 percent of TFEC in 2030 (figure 6.3).

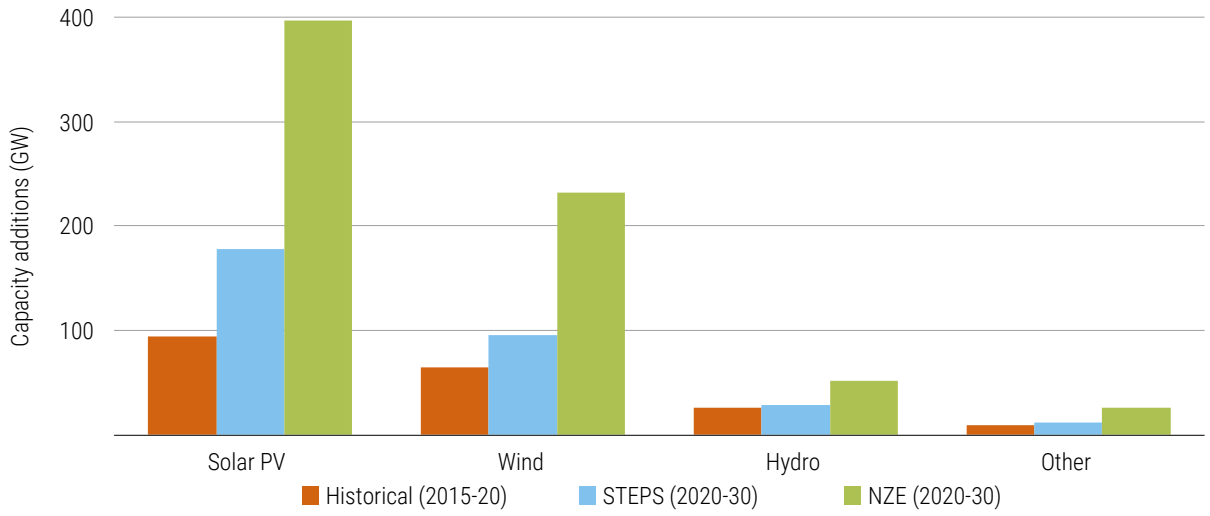
Figure 6.3 • Share of renewables in total final energy consumption under the IEA Net Zero Emissions by 2050 Scenario, 2010–30



Source: IEA 2021.

The share of renewables-based electricity generation increases most rapidly, increasing its current share to just over 50 percent by 2030, or almost 14 percentage points higher than in the Stated Policies Scenario. At the global level, electricity generation from renewables-based electricity generation increases by 8 percent a year to almost 16,200 terawatt-hours (TWh) by 2030, or more than five times the amount of electricity generated in the United States today from all sources (figure 6.4). Investment in renewables-based power doubles to over USD 600 billion a year, supported by additional spending on expanding and modernizing electricity networks and battery storage and enhancing the operational flexibility of existing assets to better integrate renewables.

Figure 6.4 • Annual additions to average renewable power generation capacity under the IEA Net Zero Emissions by 2050 compared with the Stated Policies Scenario and historical additions, by technology



Source: IEA 2021.

Under IEA's Net Zero Emissions by 2050 Scenario, increased electrification of energy end uses is a primary means to increase renewables' share of TFEC. The share of electricity in final energy demand rises to 26 percent by 2030, compared with about 23 percent under the Stated Policies Scenario. The electrification of transport and heat are the primary drivers of this electrification. Direct renewables, principally biofuels, make up 15 percent of road transport fuel, on average; combined with growing electrification, the share of renewables in transport rises to nearly 12 percent (IEA 2021).

The use of renewables for heat applies to space and water heating, cooking, industrial processes, and other uses. It can be provided directly by bioenergy, solar thermal, or geothermal or indirectly through electricity and district heat produced from renewable sources. Switching to the direct use of renewables—through the use of solar thermal water heating, biomass, and low-carbon gases, for example—can also reduce the use of fossil fuels. In 2020, renewables accounted for 8 percent of total energy consumed for heating worldwide. By 2030, this share increases to 18 percent under the Net Zero Emissions by 2050 Scenario. The share of traditional uses of biomass falls to 5 percent of TFEC by 2030 under the Stated Policies Scenario; under the Net Zero Emissions by 2050 Scenario, traditional uses of biomass are phased out completely, as developing countries replace them with more modern and efficient fuels and technologies.

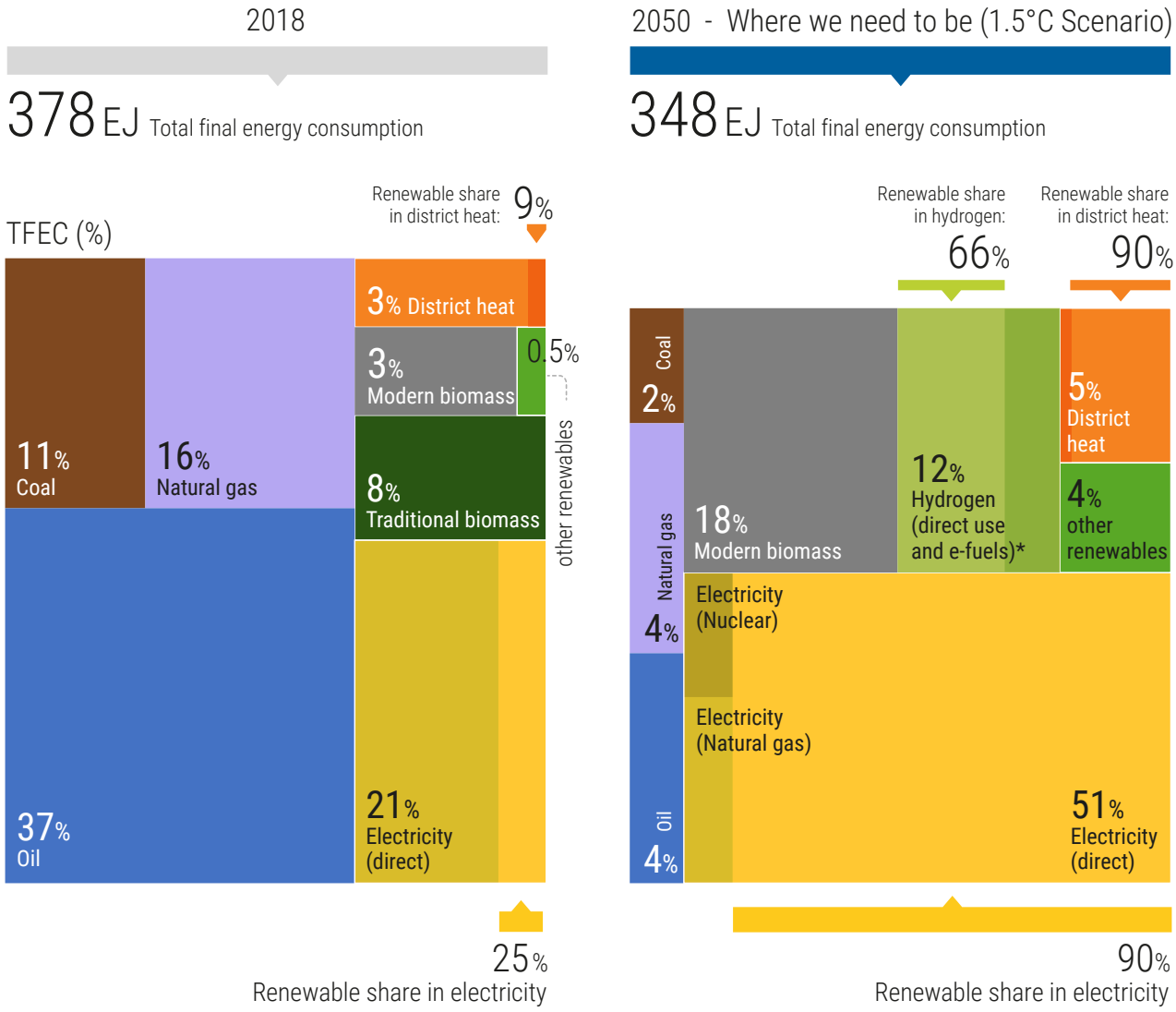
Across regions, variations in energy policy, socioeconomic trends, and natural resource endowments result in different growth trajectories for renewables. Developing economies account for two-thirds of the growth in electricity generation through 2030 under both the Stated Policies and Net Zero Emissions by 2050 Scenarios. Under the Stated Policies Scenario, the outlook for electricity generation from renewable sources ranges from 9 percent in the Middle East and 17 percent in North Africa, at the low end, to over 79 percent in Central and

South America, where hydropower is the backbone of the power mix. Under the Net Zero Emissions by 2050 Scenario, the share of renewable electricity generation increases in every region, approaching or surpassing half of all electricity generation by 2030 in many regions.

INSIGHTS ON BRIDGING THE GAP FROM IRENA'S 1.5°C SCENARIO

IRENA's 1.5°C Scenario requires the scaling up of all possible renewable energy and energy-efficient solutions (figure 6.5). It entails a massive transformation of how societies consume and produce energy. The decade to 2030 will be crucial for scaling up no-regret options such as electrification with renewable energy and energy efficiency solutions in industry, transport, and buildings. Under IRENA's 1.5°C Scenario, the share of renewables in TFEC will rise from 17 percent in 2018 to 38 percent by 2030.

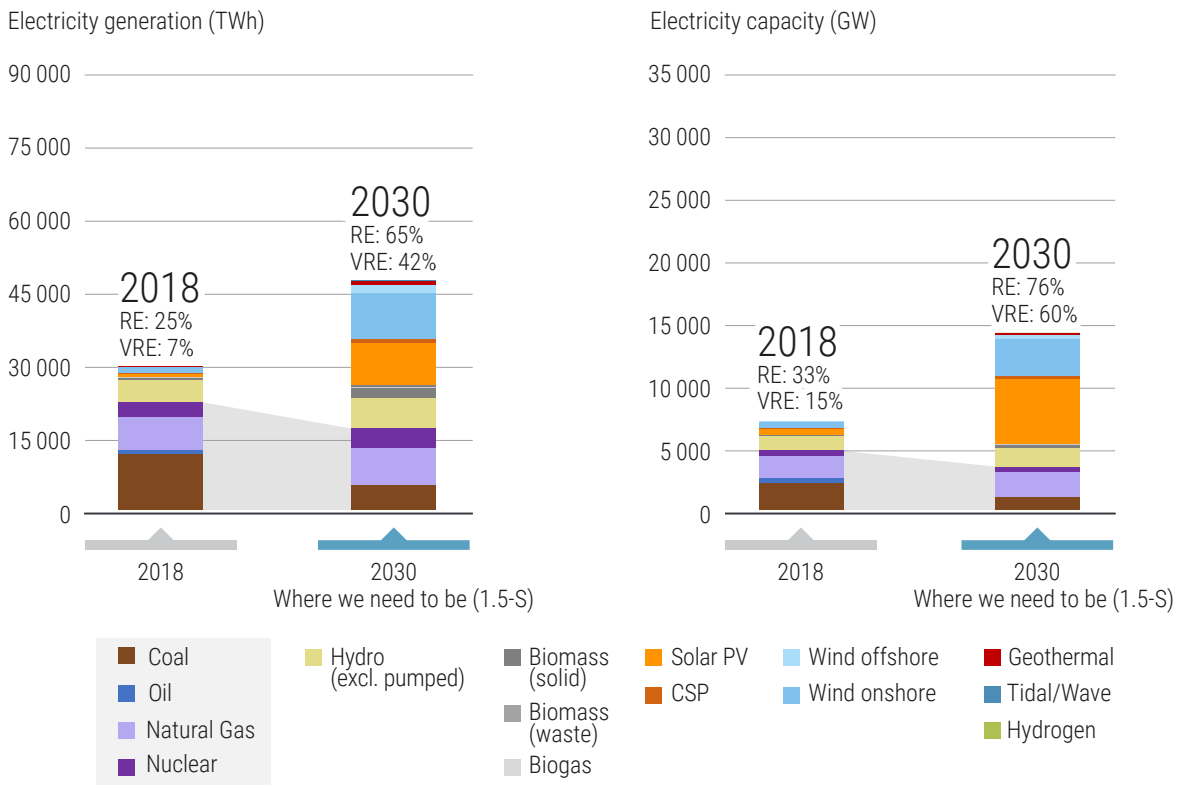
Figure 6.5 • Total final energy consumption by energy carrier in 2020 and 2030 under IRENA's 1.5°C Scenario



Source: IRENA 2021.
DH = district heat; RE = renewable energy.

Advancing the energy transition at the pace and scale needed would require the almost complete decarbonization of the electricity sector by mid-century. Under the 1.5°C Scenario, rapid electrification of heat and transport applications along with the rise of green hydrogen production would drive significant increased demand for electricity. By 2030, renewables would supply 65 percent of total electricity needs (figure 6.6). Such a transition in the global electricity sector could be realized by accelerating the deployment of all forms of renewable power technologies, including wind (onshore and offshore), solar PV, hydro, biomass, and geothermal. In parallel, additional flexibility in the power sector will be required. Although the types of technologies and solutions are power system specific, key technologies include storage, greater interconnection, market and regulatory reforms, and demand response, among many others.

Figure 6.6 • Electricity generation and capacity in 2018, 2030, and 2050 under IRENA's 1.5°C Scenario, by source



Source: Adapted from IRENA (2021).
Note: 1.5-S = 1.5°C; CSP = concentrated solar power; GW = gigawatts; PV = photovoltaic; RE = renewable energy; TWh = terawatt hours; VRE = variable renewable energy

Apart from deploying renewables in the electricity sector, direct uses of renewables—such as bioenergy, solar thermal, and geothermal—are bringing much-needed solutions in transport, buildings, and industry. Under the 1.5°C Scenario, the direct use of renewable energy would need to grow to 55 exajoules (EJ) in 2030, up from 45 EJ in 2020. TFEC will include approximately 111 EJ of direct electricity use by 2030.

Direct electricity consumption in end-use sectors (including direct use of electricity but excluding indirect uses, such as e-fuels) would increase by more than 31,000 TWh by 2030. Transport and hydrogen production would emerge as new electricity markets. In addition to the rapid rise in direct electrification needs, 5,200 TWh would be needed to produce green hydrogen by 2030. In total, the direct and indirect electrification share would reach 58 percent of final demand. Under the 1.5°C Scenario, transport would see the most

accelerated electrification in the coming decades. The stock of electric cars would rise from 10 million in 2018 to over 380 million by 2030. The share of electricity in final energy consumption would rise from 1 percent in 2020 to 9 percent by 2030. Technological progress, including the evolution of batteries, has greatly improved the economic case for electric vehicles in recent years, and the scope of application is quickly expanding to a broader set of road vehicle segments and types of services.

Under IRENA's 1.5°C Scenario, green and blue hydrogen production would grow from negligible levels today to 19 EJ (154 million metric tons) by 2030. The production of clean hydrogen and its derivative fuels must ramp up from negligible levels today to 154 Mt by 2030.[4]

Under the 1.5°C Scenario, the role of carbon capture and storage (CCS) is limited to targeting process emissions from cement, iron and steel, hydrogen, and chemical production, with limited deployment for waste incinerators. Total carbon dioxide (CO2) captured from CCS, carbon capture and utilization, bioenergy coupled with CCS, and other CO2 removal measures[5] must be aggressively scaled up to reach 2.2 gigatons of carbon dioxide (GtCO2) by 2030, from 0.004 GtCO2 today.

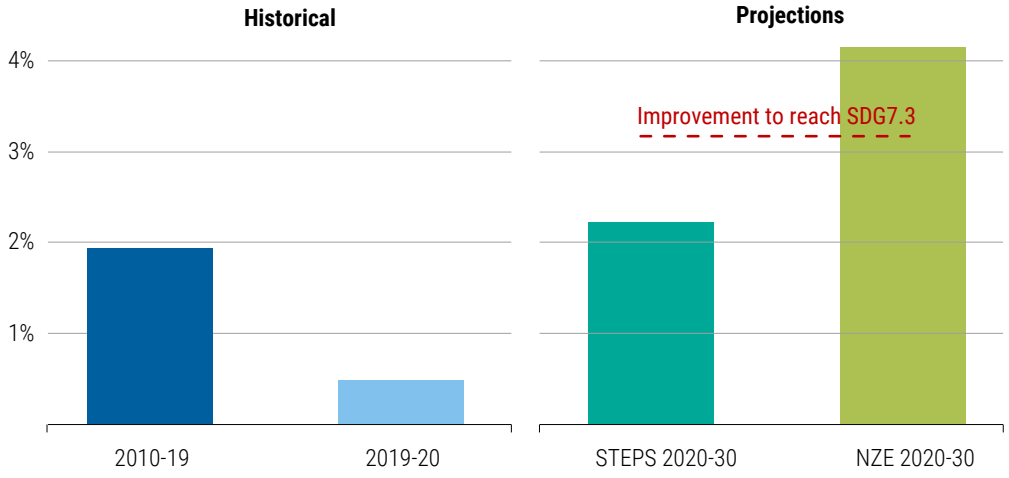
4 Clean hydrogen here refers to the combination of hydrogen produced by electrolysis powered from renewables (green hydrogen) and hydrogen produced from natural gas in combination with carbon capture and storage by steam methane reforming (blue hydrogen).

5 CO2 removal measures and technologies include nature-based measures such as reforestation as well as, direct CCS, bioenergy with CCS, and other approaches that are currently experimental.

THE OUTLOOK FOR ENERGY EFFICIENCY

Global energy intensity, measured by the ratio of total energy supply to GDP, is the key indicator used to gauge global progress on energy efficiency. The COVID-19 pandemic created distortions in this metric, as lockdowns constrained normal energy consumption habits and shifted GDP totals. However, it also slowed the progress of real energy efficiency gains, as the turnover of efficient equipment stocks slowed and projects to improve efficiency in buildings and industries slowed amidst constraints introduced by government responses to the pandemic. Early estimates for 2021 indicate a slight recovery, with an energy intensity improvement rate of 1.9 percent. Greater attention to energy efficiency policies and incentives for retrofits in Europe, North America, and East Asia raises the outlook in the Stated Policies Scenario to 2.3 percent, slightly stronger than progress on energy intensity over the decade ending in 2019 (figure 6.7).

Figure 6.7 • Historical and projected improvement in global energy intensity, by scenario, 2010–30



Source: IEA 2021.

The improvement in the Stated Policies Scenario came against the background of a previous slowdown that occurred in the wake of strong improvements in energy intensity in the mid-2010s. That slowdown was in large part triggered by trends in China, where decades of progress in phasing out inefficient industrial capacity have now replaced most capacity with modern production processes. Increased action in China and elsewhere has helped compensate for the slowdown, but annual improvements are still far below where they need to be. Annual improvement until 2030 will now need to average 3.2 percent if the world is to meet the target set in SDG 7.3.

The lingering effects of COVID-19 are expected to continue to affect the trends in the Stated Policies Scenario, as improvements some sectors, such as aviation, remain lower than in previous years, even though economic activity in many parts of the world has recovered to pre-COVID levels. In addition, the large increase in industrial activity in China as a result of increased demand for durable goods worldwide during the pandemic is expected to subside in the coming year.

The COVID-19 crisis has also altered assumptions about the coupling of energy use and GDP. Increased teleworking and reduced business travel are expected to be lasting trends, and increased consumption of durable goods is likely to subside, as more people resume spending on services and travel. Accordingly, the Stated Policies Scenario in 2021 assumes that some of these impacts improve energy intensity while others, such as increased preference for SUVs, continue to reduce it.

Volatile fuel prices coming out of the pandemic have also informed global policy responses and could have an important influence on the rate of energy efficiency improvements. Many importing countries are already implementing policies to shield consumers from price spikes in natural gas (concentrated in Europe), coal (concentrated in China), and LPG (concentrated in developing economies). These price shocks have resulted in many governments providing financial supports that are draining government coffers and driving a renewed zeal for energy efficiency projects. Although payback periods were extended by 20–40 percent for end users at the peak of the pandemic, they have been all but erased by the price rallies, which are set to continue with the war in Ukraine. Enhanced energy efficiency mandates and incentives could be seen as a more economic alternative to household price supports and could inform the next phase of recovery response measures, alongside mandates for fuel storage facilities, the increased use of renewables, and extensions of the life of existing plants, all of which are under consideration in many countries to reduce dependence on oil and gas, particularly in Europe.

Energy efficiency is one of the building blocks of IEA's Net Zero Emissions by 2050 Scenario. As a result of the pandemic, TFEC declined in 2020 and 2021, but it is now set to recover. The accelerated improvements in energy efficiency under IEA's Net Zero Emissions by 2050 Scenario occur across all energy end uses and cause global energy to peak before 2025 and decline rapidly thereafter. In order to realize the Net Zero Emissions by 2050 scenario, the world must overshoot the SDG 7.3 target, improving energy intensity by 4.2 percent between 2020 and 2030, instead of the 3.2 percent needed to reach the target. This acceleration requires more stringent standards and incentives as well as bans of the sale of inefficient stock.

Under the IEA Net Zero Emissions by 2050 Scenario, global primary energy demand declines by 6 percent between 2020 and 2030, with advanced economies leading the way, decreasing total primary energy demand by 15 percent over this period. This decline occurs despite strong economic growth.

Early implementation of efficiency improvements across all sectors is essential to move to a more sustainable trajectory. In the transport sector, improvements in efficiency mean that on average, conventional passenger cars sold in 2030 will consume 30 percent less energy than they did in 2019, and new trucks will consume 20 percent less fuel. By 2030, electric cars will account for over 60 percent of car sales (up from 4.6 percent in 2020), and fuel cell or electric vehicles will account for 30 percent of heavy truck sales (up from less than 0.1 percent in 2020). There will also be substantial reductions in indirect emissions from appliances and air conditioners. By 2030, over 80 percent of household appliances and air conditioners sold in advanced economies will be the most efficient available technologies by 2025 under the Net Zero Emissions by 2050 Scenario. Emerging market and developing economies will reach this 80 percent level by the mid-2030s. In industry, the efficiency of industrial facilities will improve, thanks to the deployment of improved electric motors, heat pumps and agricultural irrigation pumps, and the wider implementation of energy management systems.

IEA's Net Zero Emissions by 2050 Scenario also requires a ramp-up of energy efficiency programs to incentivize efficiency construction of new buildings and efficiency retrofits. These programs also help manufacturers accelerate upgrades to production lines so as to produce higher-efficiency equipment. Improvements in efficiency across all end uses in the buildings sector, as well as the achievement of universal access to clean cooking, will cause total energy demand in residential buildings to decline by almost a quarter between 2020 and 2030, despite a 25 percent increase in the provision of energy services as a result of population and economic growth. In the existing building stock, deep energy retrofits can reduce energy use by more than 60 percent. Around 30 percent of the worldwide building stock that will exist in 2030 has yet to be built; in some countries, including India, the figure is over 50 percent. However, nearly three-quarters of countries do not have mandatory energy codes for new buildings. Under the Net Zero Emissions by 2050 Scenario, all countries introduce mandatory energy-related building codes, and existing codes become more rigorous, reducing the average energy intensity of new buildings by nearly 50 percent over the 2020–30 period.

Under IRENA's 1.5°C Scenario, the average annual rate of energy intensity improvement would need to increase by 40 percent over 2010–19 levels between 2020 and 2030. A key step is the deployment of energy efficiency measures that improve technical efficiency, such as more efficient boilers, air conditioners, motors, and appliances. In the buildings sector, all new building constructions would need to be zero energy from 2030 onward. For existing buildings, the rate of renovation will need to double, to 2 percent of the building stock a year through 2030.

INVESTMENTS NEEDED TO ACHIEVE SDG 7

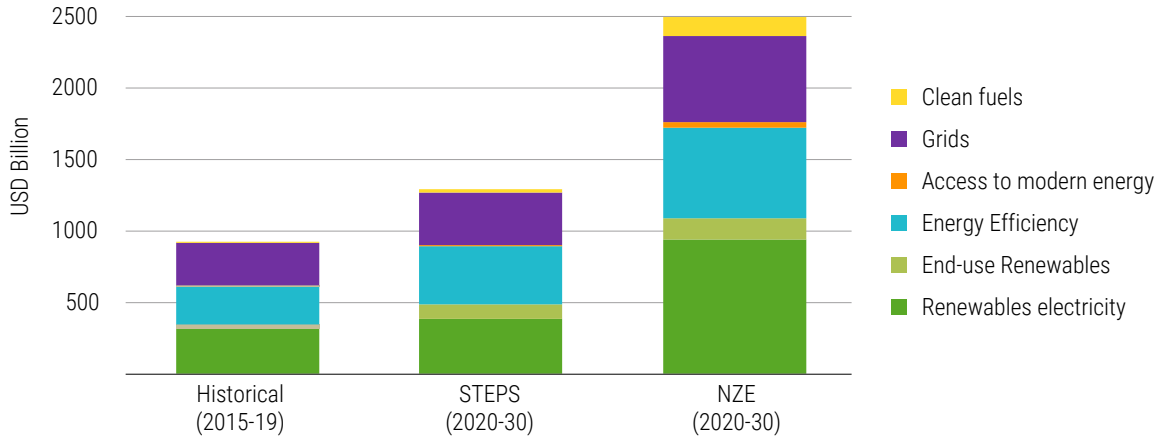
Outlooks from both IEA and IRENA stress the urgency of scaling up investments in the energy transition. Under IEA's Net Zero Emissions by 2050 Scenario, the total energy sector investments needed to achieve the SDG 7 targets must ramp up to USD 4 trillion by 2030, with an average of USD 2.7 trillion a year between 2020 and 2030 (figure 6.8). By 2030, investment under the Stated Policy Scenario reaches only USD 1.7 trillion, with the annual average being only USD 1.4 trillion.

The majority of the investment required to meet SDG 7 under the Net Zero Emissions by 2050 Scenario is directed toward the generation of renewable electricity (including batteries) and end-use efficiency, which account for USD 1,140 billion and USD 670 billion a year, respectively. Renewables-based power investment needs to be supported by additional average annual spending of USD 600 billion on the expansion and modernization of electricity networks.

Under the IEA Net Zero Emissions by 2050 Scenario, the average annual investment required from 2020 to 2030 to reach full energy access in developing economies is USD 35 billion for electricity access and USD 6 billion (more than six times the 2020 level) for clean cooking access; more than half of this investment takes place in Sub-Saharan Africa (IEA 2021). Reaching these levels of investment for access would represent only 2 percent of total energy investment worldwide in 2019.

Financial resources available for funding expansion and upgrades of electricity and clean cooking access have been inadequate to achieve full access. Between 2013 and 2019, an average of USD 12 billion a year was spent increasing electricity access in 20 countries representing 80 percent of the world's population without access to electricity; in the same period, about USD 70 million was spent each year on clean cooking in the 20 countries with the largest number of people lacking access (SEforAll 2019). International support through development aid and multilateral development banks will be essential to mobilizing these levels of investment and de-risking access and other energy investments in emerging market and developing economies.

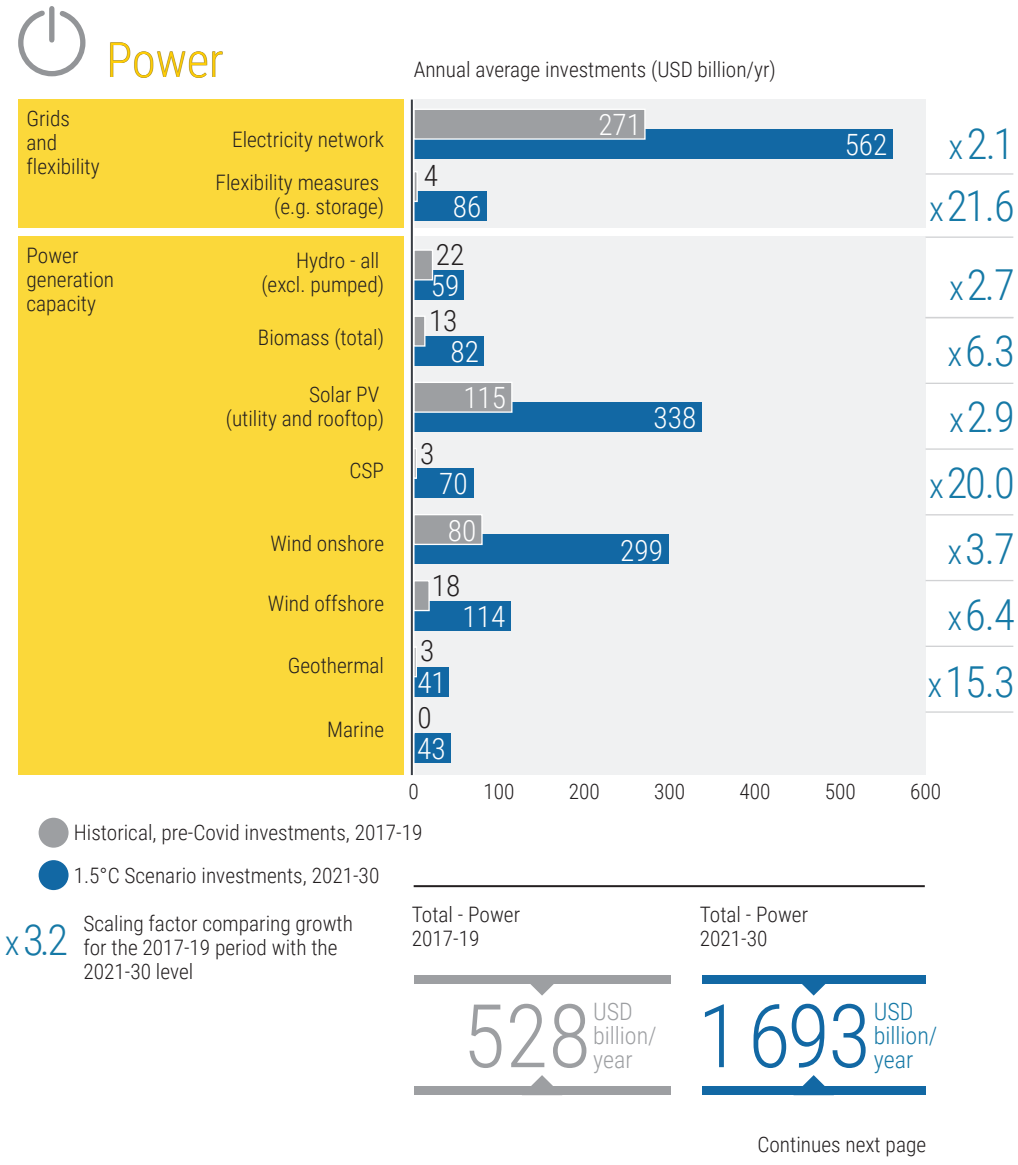
Figure 6.8 • Average annual investment in selected technologies under IEA's Net Zero Emissions by 2050 Scenario, 2020-30



Source: IEA 2021.

Under IRENA's 1.5°C Scenario, annual investment in renewables, efficiency, related electricity infrastructure/grids and flexibility measures, and hydrogen and biofuel supply amounts to just under USD 5 trillion a year through 2030 (figure 6.9)—more than a 60 percent over current plans and policies. In the power sector, increasing generation capacity would require accelerated investment of USD 1.7 trillion a year. Investments of USD 1.1 trillion a year would be required for related infrastructure, including grid extension and grid flexibility measures, ranging from better forecasting of renewable power generation to integrated demand-side flexibility and stationary battery storage (so-called Power to X). In the buildings sector, investment would be dominated by energy efficiency investments, which would account for USD 1.5 trillion a year. Investments in bioenergy supply would increase to USD 226 billion a year, and investments in electrolyzers, hydrogen supply infrastructure, and renewables-based hydrogen feedstocks for chemical production would average more than USD 88 billion a year. Investments in charging infrastructure for electric vehicles would rise to USD 26 billion a year. These increases in energy investment would have substantial socioeconomic implications for regions in which these investments are deployed (box 6.3).

Figure 6.9 • Average annual investments required between 2021 and 2030 under IRENA's 1.5°C Scenario, by technology and measure



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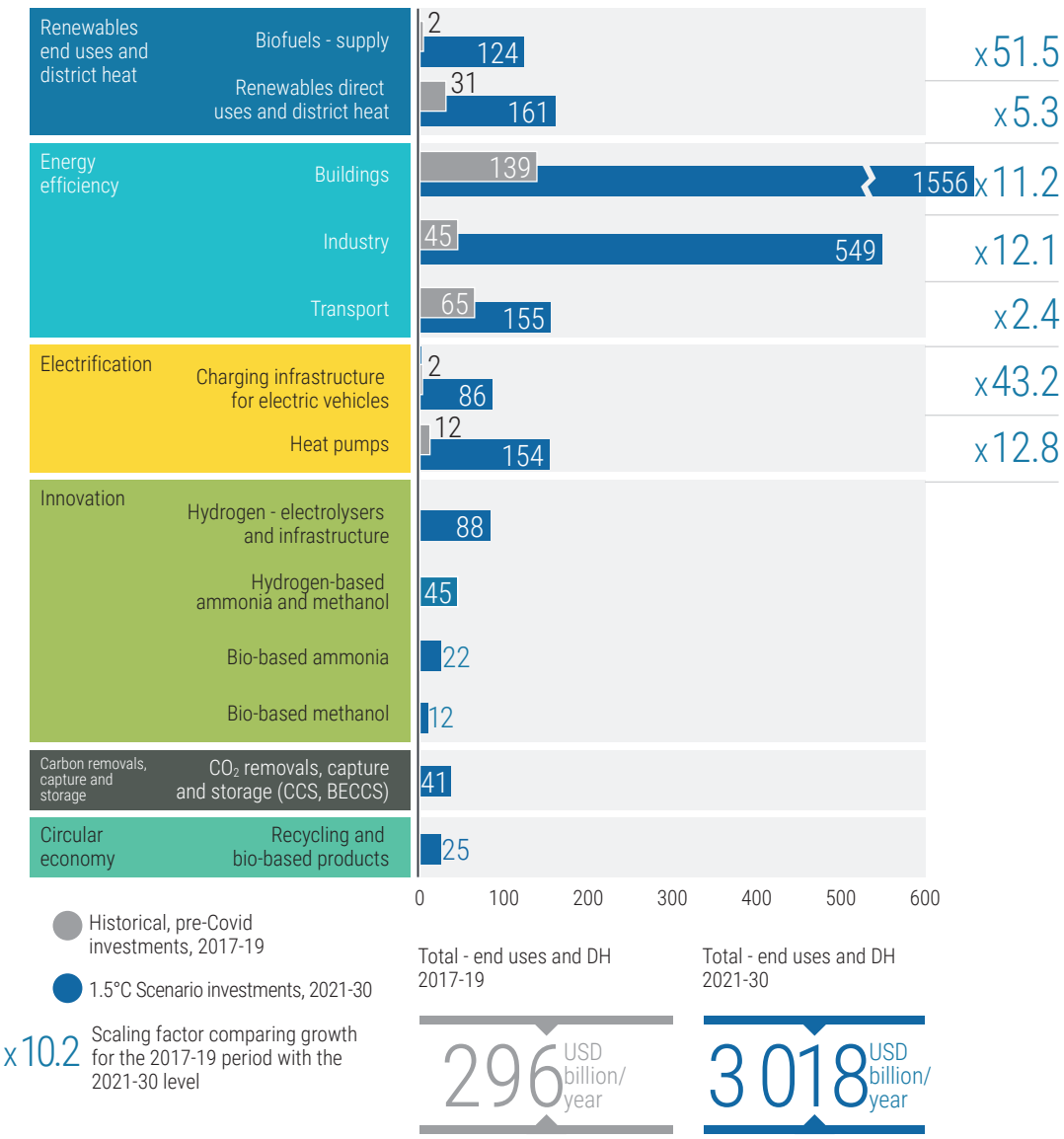
End uses and district heat



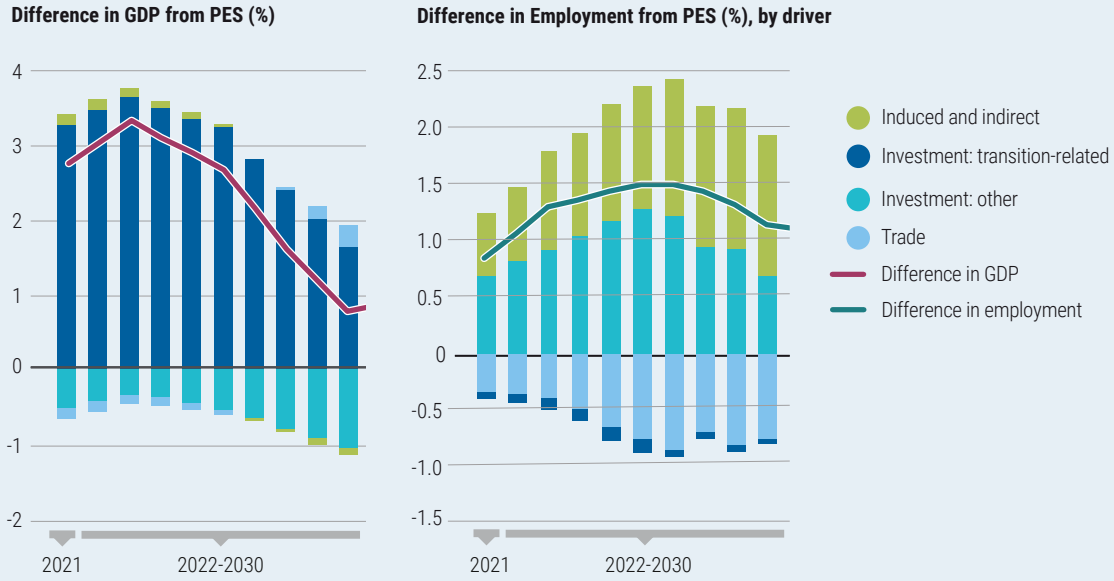
Source: Adapted from IRENA (2021).

Box 6.3 • Socioeconomic footprint of the energy transition

The energy transition will have positive impacts on socioeconomic structure. Compared with the Planned Energy Scenario, GDP is 2.4 percent higher under the 1.5°C Scenario over the period 2021–30. Investment under the 1.5°C Scenario, together with a set of enabling policies, also help create jobs throughout the economy, with the number of additional jobs peaking at 51 million in 2030.

As policy ambition and investment in the energy transition climb, so does energy sector employment. Sector employment is set to reach 137 million jobs under the 1.5°C Scenario, 26 million more than under the Planned Energy Scenario (figure B6.3.1). Nearly 80 percent of these jobs are energy transition related. By 2030, the number of jobs reaches 45 million in energy efficiency and almost 38 million in renewables—a total increase of 130 percent over 2021. Solar energy creates the largest number of jobs, followed by bioenergy and wind energy.

Figure B6.3.1 GDP and employment under the Planned Energy and 1.5°C Scenarios, 2021-30



Source: Adapted from IRENA (2021).
PES = Planned Energy Scenario

IRENA's Energy Transition Welfare Index captures five dimensions of prosperity and well-being—economic, social, environmental, distributional, and energy access—combining them in an index that ranges from 0 to 1. This index reaches 0.34 under the 1.5°C Scenario, well above the 0.25 under the Planned Energy Scenario. Reaching universal access under the 1.5°C Scenario contributes significantly to this improved outcome. It has cross-cutting impacts across several welfare dimensions, including economic (through higher incomes, consumption, and employment); social (through lower health impacts of traditional fuels); and distributional. The Energy Transition Welfare Index measures access itself (the share of the population with access) as well as its sufficiency over time (progression along the energy ladder). Use of both indicators concurrently facilitates a discussion beyond the achievement of universal access by 2030, which is usually defined in binary terms, to address inequalities in consumption across regions and opportunities to link energy access with income-generating services that generate strong socioeconomic dividends over the long term. In sum, the more ambitious transition pathway is not only fully compliant with the needs of the Paris Climate Agreement, but it also offers significant benefits in terms of GDP, jobs, and welfare.

Source: IRENA 2021.

CONCLUSION

Innovative policies and technologies continue to emerge and bring benefits to the energy sector, but the impact of the COVID-19 pandemic set progress back in ways that were not foreseen in 2019. Not only is the world not on track to reach SDG 7 under current and planned policies, some targets are even farther away than they were.

Recent improvements in increasing energy access in Africa are being reversed. After declining over the previous six years, the number of people without access to electricity increased in 2020.

At the same time, the perceived risk of lending money to a number of developing countries has increased dramatically, making it more expensive for those countries to raise debt finance for energy technologies and improve energy access.

The outlook looks more positive for renewables and efficiency. Low oil and gas prices were originally projected to be a barrier to the uptake of clean energy technologies and energy efficiency under IEA's Stated Policies Scenario. Rising prices in 2021 and recovery plans in key economies focused on renewables and efficiency make the outlook for renewables and efficiency stronger than it was a year ago. Recent price spikes and the crisis in Ukraine have also increased uncertainty in global oil and gas markets, putting renewed pressure on net importers to reduce exposure. Renewables, efficiency, and electrification are likely to play major roles in the policy responses to these events. These responses need to be substantial and reach beyond advanced economies if the world is to achieve the energy-related SDGs.

Continued efforts are also required in terms of annual improvements in global energy intensity need to double to an average of 3.2 percent if the world is to meet the target set in SDG 7.3; in the Net Zero by 2050 Scenario, energy intensity needs to reach 4.2 percent. The ongoing slump in economic activity and lingering economic uncertainty are likely to result in slower turnover of capital stock, but the inclusion of provisions for efficiency in some countries' economic recovery packages partially offsets that effect. Solar PV and wind remain the fastest-growing sources of energy globally. To align with the Net Zero by 2050 and 1.5° scenarios, more policy support for renewable integration, electrification, and decarbonization will be needed.

Getting on track toward meeting SDG 7 depends partly on how governments continue to support clean energy and energy access investments. In advanced economies, initial support from recovery plans needs to evolve to more nuanced support that relies less on direct cash injections into the economy and more on de-risking and guarantees to continue advancing these objectives. More pressingly, significant investments in the energy transition in emerging market and developing economies are needed, particularly in light of diminishing fiscal leeway.

As policy makers chart the path ahead, it is worth bearing in mind that an energy transition ambitious enough to fulfill SDG 7 can also help meet other social and economic objectives. With holistic policies in place, the energy transition can foster sustainable economic growth, create jobs, and improve welfare.

METHODOLOGY

IEA METHODOLOGY

The analysis presented in this chapter is based on results from the World Energy Model (WEM) and IEA analysis in the *World Energy Outlook* (WEO). Detailed documentation of the WEM methodology can be found at https://www.iea.org/reports/world-energy-model/documentation#abstract.

IEA models two scenarios. The Stated Policies Scenario is designed to give feedback to decision makers about the course they are on today, based on stated policy ambitions. This scenario assumes that the COVID-19 pandemic is brought under control in 2021. It incorporates IEA's assessment of stated policy ambitions, including the energy components of announced stimulus or recovery packages (as of mid-2020) and the NDCs under the Paris Agreement. Broad energy and environmental objectives (including country net-zero targets) are not automatically assumed to be met. They are implemented in this scenario to the extent that they are backed up by specific policies, funding, and measures. The Stated Policies Scenario also reflects progress with the implementation of corporate sustainability commitments.

The Net Zero Emissions by 2050 Scenario is a normative IEA scenario that shows a narrow but achievable pathway for the global energy sector to achieve net-zero CO2 emissions by 2050, with advanced economies reaching net-zero emissions in advance of others. This scenario also meets the key energy-related SDGs, achieving universal energy access by 2030 and major improvements in air quality. This scenario is consistent with limiting the global temperature rise to 1.5°C without a temperature overshoot (with a 50 percent probability), in line with reductions assessed by the IPCC in its *Special Report on Global Warming of 1.5°C*. This scenario is based on the following assumptions:

- Uptake of all available technologies and emission reduction options is dictated by costs, technology maturity, policy preferences, and market and country conditions.
- All countries cooperate toward achieving net-zero emissions worldwide.
- An orderly transition occurs across the energy sector that ensures the security of fuel and electricity supplies at all times, minimizes stranded assets where possible, and avoids volatility in energy markets.

METHODOLOGY FOR ACCESS TO ELECTRICITY AND ACCESS TO CLEAN COOKING

The projections presented in the WEO and in this chapter focus on two elements of energy access— household access to electricity and clean cooking facilities—which are measured separately. IEA maintains databases on the levels of national, urban, and rural electrification rates. For the proportion of the population without clean cooking access, the main sources are the World Health Organization (WHO) Household Energy Database and IEA's Energy Balances. Both databases are regularly updated and form the baseline for WEO energy access scenarios to 2040.

The projections in the Stated Policies Scenario consider current and planned policies; recent progress; and population growth, economic growth, the urbanization rate, and the availability and prices of different fuels. The Net Zero Emissions by 2050 Scenario identifies least-cost technologies and fuels to reach universal access to both electricity and clean cooking facilities. For electricity access, the analysis incorporates a Geographic Information Systems (GIS) model based on open-access geospatial data, with technology, energy prices,

electricity access rates and demand projections from the WEM. This analysis was developed in collaboration with the KTH Royal Institute of Technology, Division of Energy Systems Analysis (KTH-dESA), in Stockholm. Further details about the IEA methodology for energy access projections can be found at https://www.iea.org/reports/world-energy-model/sustainable-development-scenario-sds#abstract.

METHODOLOGY FOR RENEWABLE ENERGY PROJECTIONS

The annual updates to WEO projections reflect the broadening and strengthening of policies over time, including for renewables. The projections of renewable electricity generation are derived in the renewables submodule of the WEM, which projects the future deployment of renewable sources for electricity generation and the investment needed. The deployment of renewables is based on an assessment of the potential of and costs for each source (bioenergy, hydropower, photovoltaics, concentrating solar power, geothermal electricity, wind, and marine) in each of the 25 WEM regions. In all scenarios, IEA modelling incorporates a process of learning-by-doing that affects the costs. By including financial incentives for the use of renewables and nonfinancial barriers in each market, technical and social constraints, and the value each technology brings to system in terms of energy, capacity, and flexibility, the model calculates deployment as well as the resulting investment needs on a yearly basis for each renewable source in each region.

METHODOLOGY FOR ENERGY EFFICIENCY PROJECTIONS

The key energy efficiency indicator refers to GDP and total final energy demand. Economic growth assumptions for the short to medium term are based largely on those prepared by the Organisation for Economic Co-operation and Development, the International Monetary Fund, and the World Bank. Over the long term, growth in each WEM region is assumed to converge to an annual long-term rate that depends on demographic and productivity trends, macroeconomic conditions, and the pace of technological change.

Total final energy demand is the sum of energy consumption for each end use in each final demand sector. In each subsector or end use, at least six types of energy are shown: coal, oil, gas, electricity, heat, and renewables. The main oil products—LPG, naphtha, gasoline, kerosene, diesel, heavy fuel oil, and ethane—are modelled separately for each final demand sector.

In most of the equations, energy demand is a function of activity variables that are driven by the following factors:

- Socioeconomic variables: GDP and population are important drivers of sectoral activity variables that determine energy demand for each end use within each sector.
- End-user prices: Historical time series data for coal, oil, gas, electricity, heat, and biomass prices within each sector are compiled based on IEA's Energy Prices and Taxes database and several external sources. End-user prices are then used as an explanatory variable affecting the demand for energy services.
- Technological parameters include recycling in industry and material efficiency.

All 25 WEM regions for energy demand are modelled in considerable sectoral and end-use detail:

- Industry is separated into six subsectors (with the chemicals sector disaggregated into six subcategories).
- Building energy demand is separated into residential and services buildings, which are then separated into six end uses. Within the residential sector, appliances energy demand is separated into four appliance types.
- Transport demand is separated into nine modes, with considerable detail for road transport.

IRENA METHODOLOGY

IRENA scenarios (REmap)

The IRENA energy transformation scenario outlined in this report was developed by the Renewable Energy Roadmaps (REmap) team at IRENA's Innovation and Technology Centre, in Bonn. Since 2014, this team has produced a succession of roadmaps with ambitious yet technically and economically feasible pathways for deploying low-carbon technologies to create a clean, sustainable energy future at the global, regional, and country levels.

The findings presented in this report are based on IRENA's 2021 flagship publication *World Energy Transitions Outlook: 1.5°C Pathway*. It considers policy targets and developments through April 2020. The analysis in this report does not reflect any policy changes and targets announced since then.

The Planned Energy Scenario provides a perspective on energy system developments based on governments' energy plans and other planned targets and policies, including NDCs under the Paris Agreement. It also provides the reference case for IRENA's 1.5° Scenario. The 2021 Planned Energy Scenario covers the first round of NDCs.

The 1.5°C Scenario describes an energy transition pathway aligned with the ambition of limiting the average increase in the global temperature by the end of the century to 1.5°C relative to pre-industrial levels. It prioritizes readily available technology solutions that can be scaled up at the necessary pace to meet the 1.5°C goal.

For more information on the scenarios, methodology and scope of this work, please visit www.irena.org/remap.

IRENA socioeconomic modelling

IRENA has been analyzing the socioeconomic implications of transition roadmaps since 2016. Based on a global econometric model with high regional and sectoral resolution (E3ME, from Cambridge Econometrics), IRENA's methodology holistically captures the multiple interactions between energy transition roadmaps with its accompanying policy baskets and global and national economic systems.

The resulting socioeconomic footprint is evaluated at a high level of detail, generating insights that inform policy making for a successful transition. Socioeconomic footprint results include GDP (aggregated economic activity); employment (economywide and with high resolution within the energy sector); and welfare (using an index with five dimensions—economic, social, environmental, distributional, and access—each informed by several indicators).

A detailed driver's methodology is used to facilitate understanding of the mechanisms producing the socioeconomic footprint results, providing clearer insights on the links between transition goals and policies and their resulting impacts.

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