TRACKING SDG7

THE ENERGY PROGRESS REPORT 2021

A joint report of the custodian agencies

IEA International Energy Agency

IRENA International Renewable Energy Agency

United Nations Statistics Division

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World Health Organization

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CHAPTER 6

THE OUTLOOK FOR SDG 7

MAIN MESSAGES

- **Outlook for progress toward 2030 goals:** At today's rate of progress, the world is not on track to achieve Sustainable Development Goal 7 (SDG 7). In this chapter, forward-looking scenarios are used to outline how the energy system could further support the achievement of global climate and sustainable development goals. The Stated Policies Scenario of the International Energy Agency (IEA) shows that current and planned policies are not enough to meet the goals; in fact, under this scenario, none of the targets can be achieved by 2030 (IEA 2019). In contrast, IEA's Sustainable Development Scenario lays out ways to bridge the gap and put the world's energy system on track to achieve the SDG targets most closely related to energy (e.g., SDG 3.9, SDG 7, and SDG 13).[60] The Transforming Energy Scenario developed by the International Renewable Energy Agency (IRENA) presents a path toward the goal of boosting renewable energy while maximizing socioeconomic benefits—including during a post-COVID-19 recovery period.
- **Outlook for access to electricity:** Recent progress has been mixed, as is the outlook for 2030: IEA's Stated Policies Scenario projects that 660 million people will still lack access to electricity in 2030. Nonetheless, these numbers mask some positive outcomes. Thanks to well-designed policies and strong implementation measures, 98 percent of the population of Developing Asia will have access to electricity by 2030. The COVID-19 crisis, however, threatens progress elsewhere the world. In Sub-Saharan Africa, the number of people without access to electricity actually increased in 2020. In the IEA's Sustainable Development Scenario, the connection rate more than triples from previous levels, as 85 million people each year between now and 2030 electrify in sub-Saharan Africa, most notably in the Democratic Republic of Congo, Niger, Nigeria, Sudan, and Uganda. These countries have the largest population shares without access.
- **Outlook for access to clean cooking solutions:** If clean cooking fails to find a lasting place on the global political agenda, 2.4 billion people will remain without access in 2030, according to IEA's Stated Policies Scenario. Their continued reliance on polluting fuels and technologies will have dramatic consequences for the environment, economic development, and most notably, the health of women and children. The challenge in Developing Asia and Sub-Saharan Africa is to understand how cultural, economic, and social factors combine to slow progress. Affordable solutions are available: liquefied petroleum gas (LPG) and improved cookstoves, for example, offer obtainable and scalable solutions in many regions today. Alternative fuels, such as biogas or bioethanol, could also play a role, depending on local circumstances. Ultra-efficient electric appliances, such as electric pressure cookers, powered by the grid or by solar photovoltaic (PV) and a battery, also represent clean, stand-alone, and cost-effective ways to improve access.
- **Outlook for renewable energy:** Despite the impact of the COVID-19 pandemic, the outlook for renewables under IEA's Stated Policies Scenario is resilient in all regions with supportive policies and falling technology costs. In the power sector, IEA and IRENA scenarios both conclude that solar PV and wind will account for most renewables-based electricity generation by 2030. IEA's Sustainable Development Scenario further shows that intensified policy support and cost reductions could push the share of modern renewables in total final energy consumption (TFEC) to more than 25 percent, in which case renewables would account for just over half of all electricity supply. IRENA's Transforming Energy Scenario also shows how the rapid growth in renewable energy could continue over the coming decade, with renewables' share in TFEC reaching 28 percent by 2030 and 57 percent in power generation. The outlook for the use of renewables in transport and heating and cooling is not as strong. Despite its large share of final energy consumption, heat receives limited policy attention globally compared with other end-use sectors.[61] The number of countries with national targets for renewable heat is less than one-third of those with targets for renewable electricity. Policy support is also critical for the outlook in transport, particularly in an environment of lower prices for oil and gas.

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60 Most of this chapter is based on results from IEA's World Energy Model (IEA 2020a) and from analysis in the *World Energy Outlook* (IEA 2020b). Some of the geographical groupings in this chapter, unlike foregoing chapters, are those used in the *World Energy Outlook*. "Developing Asia" refers to non-OECD Asia.

61 "Heat" in this chapter refers to energy consumed to produce heat for industry, buildings, and other sectors. All of these will be referred to hereafter simply as "heat." They are not equivalent to heat as a final energy service, which refers to the energy available to end users to satisfy their needs.

- **Outlook for energy efficiency:** The rate of global primary energy intensity improvement—the percentage decrease in the ratio of global total primary energy supply per unit of gross domestic product—has slowed in recent years. In IEA's Stated Policies Scenario, lower fuel prices are a key reason for a further slowing of the rate at which the energy intensity of the global economy improves. The annual rate of improvement falls to 2 percent annually for 2019–25 before rising slightly in subsequent years. In contrast, in the Sustainable Development Scenario, the average rate of improvement required to meet the SDG 7.3 target has risen to 3 percent per year between 2018 and 2030, a difference of 0.4 percent from the 2.6 percent initially estimated when the SDGs were developed.
- **Investment needs:** IEA and IRENA project that renewables investment needs to increase considerably — in the power sector alone, investment would need to grow from USD 300 billion to USD 550-850 billion a year throughout 2019-30. This would need to be supported by additional flows to an expanded and modernized electricity network and grid battery storage (IEA 2020a; IRENA 2020b). Furthermore, according to the IEA scenario, annual investment for universal energy access in the period to 2030 totals USD 30 billion for electricity and USD 5 billion for clean cooking. Investment of USD 545 billion a year will be needed for energy efficiency, with transport and buildings accounting for the largest share of efficiency spending (IEA 2020a). Historically, the finance available for expansion and upgrades of access to electricity and clean cooking has been inadequate for achieving SDG 7. As a result of the COVID-19 disruptions, the perceived risk of lending money to developing countries has increased, making mitigation mechanisms more important than ever to maintain and accelerate progress on energy access.

PRESENTATION OF SCENARIOS

This chapter describes the results of global modeling exercises undertaken to determine, first, if current policy ambitions are sufficient to meet the SDG 7 targets, and second, to identify what additional actions might be needed. It also examines the investments required to achieve the goals. Scenarios for the various targets are taken from IEA's flagship publication, *World Energy Outlook* (IEA 2020b), which considers the estimated effects of the COVID-19 pandemic, assessed at the time of publication. With respect to developments in renewable energy, scenarios are also taken from IRENA's Global Renewables Outlook: Energy Transformation 2050 (IRENA 2020a).

IEA's Stated Policies Scenario (which, in earlier IEA publications, is called the New Policies Scenario) reflects the impact of existing policy frameworks and announced policy intentions. Its utility is to hold up a mirror to the plans of today's policy makers and elucidate their consequences for energy use, emissions, and energy security. The scenario spans a broad range of policies, starting with Nationally Determined Contributions under the Paris Agreement. In practice, the bottom-up modeling implied by the scenario involves a great deal of sector-level detail, including pricing policies, efficiency standards and schemes, electrification programs, and specific infrastructure projects.

IEA's normative Sustainable Development Scenario[62] describes an integrated, least-cost pathway that would deliver on the energy-related SDGs: to ensure universal access to affordable, reliable, sustainable, and modern energy services by 2030 (SDG 7); to curb the air pollution that causes deaths and illness (SDG 3.9); and to take effective action to address climate change (SDG 13). This scenario takes the SDG outcomes as its point of departure, working backward to set out what would be needed to achieve those outcomes in a cost-effective way. By 2030, under this scenario, universal access to both electricity and clean cooking is achieved; modern renewables reach 25 percent of TFEC, almost two and a half times their 2018 share; the energy efficiency aims of SDG target 7.3 are exceeded (with average annual improvements in global energy intensity accelerating to 3.8 percent annually between 2020 and 2030); and the global temperature rise over pre-industrial levels is held below 2°C.

The International Renewable Energy Agency's scenarios in its Global Renewables Outlook (IRENA 2020a) explores global energy development pathways to 2030 and beyond from two perspectives. The first is an energy pathway shaped by current and planned policies (the Planned Energy Scenario); the second is a cleaner, climate-resilient pathway based on a more ambitious, yet achievable, uptake of renewable energy and energy efficiency measures—the Transforming Energy Scenario.

62 More information on IEA's Sustainable Development Scenario can be found at: https://www.iea.org/reports/world-energy-model/sustainable-development-scenario

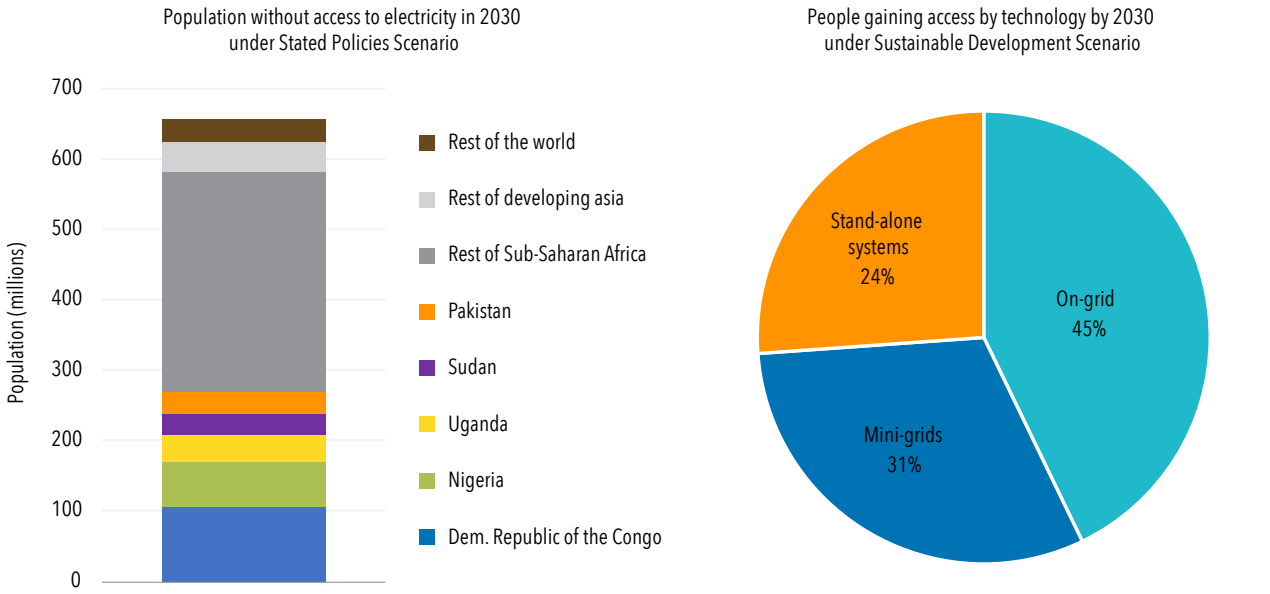
OUTLOOK FOR ACCESS TO ELECTRICITY

Despite the disruption caused by the COVID-19 pandemic in the early part of the decade, the outlook for access to electricity indicates continued progress to 2030 but without achieving the goal of universal access. The number of people remaining without access to electricity in 2030 is expected to decline under the policies set out in IEA's Stated Policies Scenario to 660 million (8 percent of the global population), of whom some 555 million (or 85 percent) reside in Sub-Saharan Africa (figure 6.1). SDG target 7.1 remains within reach, and policies implemented in several countries have put them on track to achieve universal access. The same cannot be said for many Sub-Saharan countries.

Developing Asia remains on track to reach an access rate of 98 percent by 2030, an improvement of close to 20 percentage points since 2010. The very populous countries of Bangladesh, India, Indonesia, and the Philippines are on a pathway to reach full access before 2030; a few million people remain without access in countries such as Pakistan. The region of Central and South America is projected to continue its steady progress, moving to 99 percent in 2030, with most of those remaining without access living in rural areas. Haiti remains the only major country in the region to have a substantial nonelectrified population.

In many less well-off regions, the economic downturn caused by COVID-19 is compounding the difficulties faced by governments as they seek to alleviate energy poverty and expand access. Past progress on energy access in many parts of Africa is being reversed: the number of people without access to electricity is set to increase in 2020, while basic electricity services have become unaffordable for up to 30 million people who previously had access. The COVID-19 crisis has brought into stark relief the sizeable global inequalities in access to reliable energy and health-care services, especially in rural and peri-urban areas, highlighting the need to expand access to help populations mitigate the effects of the pandemic (IEA 2020a).

FIGURE 6.1 • Population without access to electricity in 2030, and delivery of electricity connections by technology and region in IEA scenarios



Source: IEA 2020b.

Low-income countries are facing more stress because of the pandemic. Lack of access to sanitation and public health infrastructure, high household occupancy rates, and poorly paid, often informal jobs that cannot be done remotely make social distancing impossible and immediate health risks hard to avoid. In 27 Sub-Saharan African countries, close to 60 percent of health centers have no access to reliable electricity, in addition to the hundred million people lacking access in their homes, which severely limits their ability to store medicines and food, charge phones, access digital information, maintain remote access to education, and light buildings effectively (IEA 2019).

Those countries with the greatest need for better access to electricity may find that available finance diminishes, impeding their capacity to recover. The finance available for funding expansion and upgrades of electricity access in the past has never risen to the level of what is needed to achieve SDG 7. Between 2013 and 2017, USD 8 billion was spent each year to improve electricity access in 20 countries that house 70 percent of the world's population without access to electricity. The majority of this financing came in the form of debt from international public institutions, with most of the remainder funded privately (SEforAll 2019). The impact of the COVID-19 pandemic is likely to reduce the level of finance available, as evidenced by the withdrawal of USD 100 billion of capital from emerging economies during the first quarter of 2020, an amount greater than the total outflows during the 2008 crisis (IMF 2020). SDG target 7.1 can remain within reach only if governments and donors put access at the heart of their recovery plans and programs.

To bridge the gap and connect the remaining 660 million people without access by 2030, the connection rate would have to triple from its current level—to 85 million a year between 2020 and 2030. Most of the acceleration would have to occur in Sub-Saharan Africa, notably in Democratic Republic of Congo, Niger, Nigeria, Sudan, and Uganda, which together are home to half the region's population that would still lack access in 2030 under the Stated Policies Scenario. The delivery technology varies by region under the Sustainable Development Scenario: in Sub-Saharan Africa, 43 percent of connections are directly to the grid, 31 percent are mini-grids, and the remainder (26 percent) stand-alone systems. In Developing Asia, just over half the connections are directly to the grid, a third are mini-grids, and the remainder are stand-alone systems.

Under the Sustainable Development Scenario, governments and donors put access at the heart of recovery plans and programs to achieve universal access by 2030. This involves, for example, measures to support the emerging private solar sector and action-based targets to boost progress at the pace needed. Where finance is constrained, access projects will need to be smart (e.g., linked with agriculture to unlock related benefits), effective, and easy to jumpstart. Decentralized energy solutions will have to play an important role, particularly in reaching remote households 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 Ghana, Senegal, Ethiopia, Nigeria, and Rwanda (IEA 2019). Many of these plans aim to maximize the benefits of energy access by focusing on health services, schools, agricultural enterprises, and similar organizations, along with households. In its economic stimulus plan, Nigeria emphasized the role of both decentralized solar PV systems and LPG in providing modern fuel, while stimulus measures in Indonesia include a commitment to provide 1 gigawatt's (GW) worth of solar panels each year to poor households. Under the Sustainable Development Scenario, universal access to electricity by 2030 requires investing USD 30 billion annually from 2020 to 2030 in smart, efficient, and integrated generation and delivery programs along with full use of decentralized solutions.

BOX 6.1 • IEA'S SUSTAINABLE RECOVERY PLAN

The economic damage wrought by the COVID-19 pandemic has renewed the opportunity to support economic growth and jobs while boosting investment in clean energy technologies. It is in this context that IEA's Sustainable Recovery Plan was formulated (IEA 2020a). If the Sustainable Recovery Plan were to be implemented in full, it would increase annual investment in clean energy infrastructure by USD 1 trillion above historic levels in the three years from 2021 to 2023, kickstarting an accelerated program of spending on clean energy technologies under the Sustainable Development Scenario that would extend beyond the plan's initial three-year period.

The Sustainable Recovery Plan, which is fully embedded in the Sustainable Development Scenario, takes account of the circumstances of individual countries as well as existing energy project pipelines and prevailing market conditions. The plan would also accelerate the achievement of the Sustainable Development Goals: 420 million people would gain access to clean cooking solutions in low-income countries, and nearly 270 million people would gain access to electricity.

Around 40 percent of spending would be for efficiency measures across the transport, building, and industry sectors. A further one-third would support the growth of low-carbon electricity generation, expand and modernize electricity grids, and bring electricity to people who currently lack it. Full implementation of the Sustainable Recovery Plan in the Sustainable Development Scenario leads to an upsurge in investment in all low-emissions forms of electricity generation over the coming three years.

The remainder would be spent to:

- Electrify end uses (especially passenger cars and building heat)
- Make the production and use of fuels more sustainable
- Improve urban infrastructure by installing or expanding EV charging networks, public transport, and walking and cycling infrastructure
- Improve access to clean cooking in low-income countries
- Boost innovation in critical technology areas such as hydrogen, batteries, carbon capture, utilization, and storage, in addition to small modular nuclear reactors.

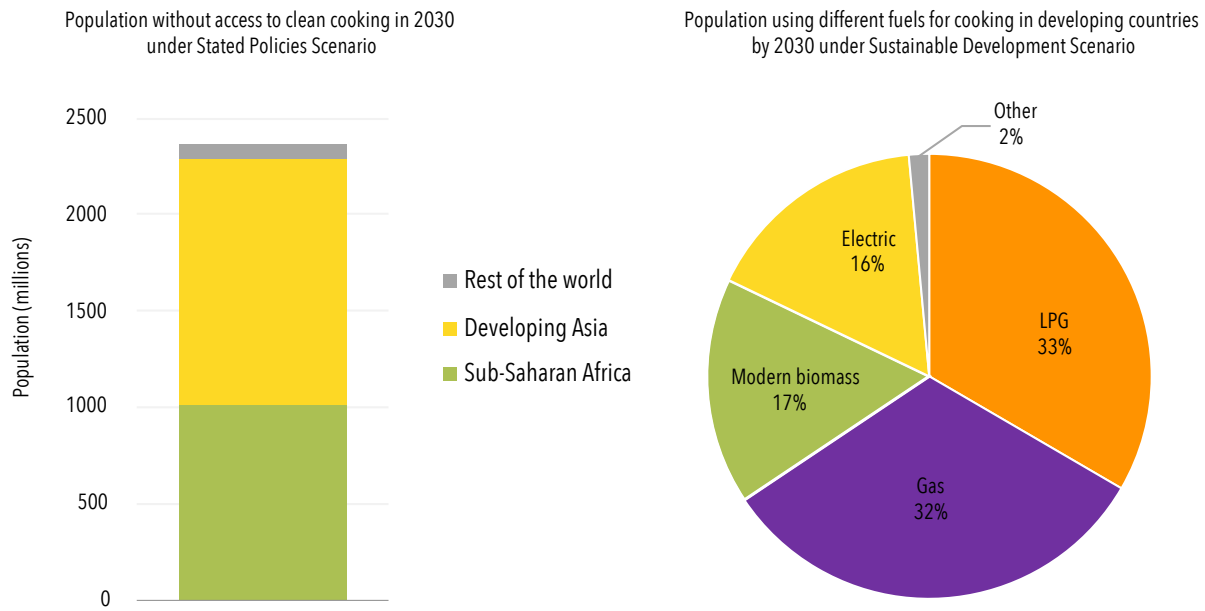
Full implementation of the Sustainable Recovery Plan would also raise global gross domestic product to 3.5 percent higher in 2023 than it otherwise would be; save or create 9 million jobs a year over the next three years; and lower annual energy-related greenhouse gas emissions to 4.5 Gt and air pollutant emissions by 5 percentage points.

THE OUTLOOK FOR ACCESS TO CLEAN COOKING FUELS AND TECHNOLOGIES

The global population without access to clean cooking shrank in recent decades in response to efforts to reduce the reliance of vulnerable populations on traditional uses of biomass. Interventions aimed to improve indoor air quality, reduce the amount of time spent gathering fuel, and curb deforestation and emissions from incomplete combustion of biomass. Progress has been uneven, however. The population without access to clean cooking continued to increase in Africa, while, elsewhere, mostly in Developing Asia, countries benefited from dedicated policies promoting LPG use. But the modest advances have been stalled by the COVID-19 pandemic. While some countries such as Uganda and India have implemented policies to counter this trend (removal of value-added tax on LPG in Uganda; free LPG refills for a limited period for the poorest in India), Sub-Saharan Africa appears destined to revert for the time being to traditional uses of biomass.

The outlook for clean cooking remains a serious concern, and the world has strayed far from the pathway to universal access to clean cooking solutions by 2030. The economic difficulties and risks arising from the COVID-19 crisis are moving some regions and countries further from the goal of universal access. According to IEA's Stated Policies Scenario, delayed progress in 2020 and 2021 means that by 2030 2.4 billion people will lack access to clean cooking—or 60 million more than projected in last year's report (figure 6.2).

FIGURE 6.2 • Clean cooking access in 2030 (left) and cooking fuel use in 2030 (right), in percentages



Source: IEA 2020b.

Note: In the figure above, "gas" is natural gas, while "modern biomass" is biomass consumed through improved or advanced biomass cookstoves. See https://www.iea.org/articles/defining-energy-access-2020-methodology for further information.

In the Stated Policies Scenario, the global population without access to clean cooking solutions in 2030 is split between Developing Asia and Sub-Saharan Africa. In Developing Asia, the projected access rate in 2030 is 70 percent, leaving nearly 1.3 billion people without access. In Sub-Saharan Africa, the rate is only 30 percent, leaving just over 1 billion people without access. Conversely, further progress is projected in India, which is projected to shrink the number of those without access from 655 million today to 500 million in 2030, thereby achieving a 67 percent access rate.

Under IEA's Sustainable Development Scenario, every household in the world would have access to clean cooking by 2030, an achievement that would require providing access to 2.8 billion people. Access to clean cooking solutions brings many health, economic, and social benefits, including reductions in household air pollution, improved health outcomes, and more time for productive activities, particularly for women and children.

In the Sustainable Development Scenario, as previously noted, access programs have a prominent place in recovery plans designed to achieve universal access by 2030. In the case of clean cooking, this worthy objective calls for a statement of clear ambitions and effective programs to support affordable access for the poorest households and the deployment of effective infrastructure (IEA 2020a). LPG and improved cookstoves, for example, offer readily available and scalable solutions in many regions. But alternative fuels, such as biogas or bioethanol, should also be part of clean cooking in many regions, depending on local circumstances. Other technologies could also boost the use of clean cooking fuels and solutions. Electric pressure cookers, for example, powered by solar PV and a battery, could be a clean, stand-alone, and cost-effective cooking solution without overburdening distribution or micro-grids, while creating synergies with newly gained access to electricity. In certain areas, renewable LPG could provide a locally produced, sustainable fuel source.

OUTLOOK FOR RENEWABLE ENERGY

SDG target 7.2 foresees a steep rise in the share of renewable energy in the energy mix. Although a quantitative objective is not specified, long-term scenarios charting various paths for the energy sector can help benchmark progress. IEA's Stated Policies Scenario and IRENA's Planned Energy Scenario both plot energy use under existing policy frameworks and stated policy plans.

Despite the impact of the COVID-19 pandemic, the global outlook for renewables under IEA's Stated Policies Scenario remains positive, helped by supportive policies and falling technology costs. The share of all renewables (including traditional uses of biomass) is projected to rise to 21.5 percent of TFEC by 2030, from 17 percent in 2018, while that of modern renewables would increase to 16 percent in 2030, up from 10.5 percent in 2018. IRENA's Planned Energy Scenario, by contrast, shows the total share of renewables in TFEC (including traditional uses of biomass) remaining largely flat until 2030, rising only slightly to 17.5 percent. The replacement of traditional uses of bioenergy with modern forms largely offsets growth in the renewable share over the period. The modern renewable energy share in TFEC increases from 10.5 percent in 2018 to 16.5 percent by 2030 (IRENA 2020a).

The use of renewables to generate electricity has grown the fastest in recent years, and the various scenarios project that this trend will continue. Renewable sources of electricity have been resilient during the COVID-19 crisis and are set for strong growth, rising by two-thirds from 2020 to 2030, with PV and wind driving growth. Over the decade, renewables overtake coal as the primary means of generating electricity. Solar PV is the strongest performer, meeting almost a third of electricity demand growth over the period thanks to widely available resources, declining costs, and policy support in more than 130 countries. Nonetheless, hydropower remains the largest low-emissions source of electricity globally through to 2030, while also providing flexibility and other power system services.

Expansion in the direct use of renewables in end-use sectors such as buildings and transport has remained slow but steady. Modern bioenergy accounts for the lion's share of growth through to 2030. In the transport sector, biofuels see strong growth, while the use of renewables for heat also grows, with modern bioenergy accounting for the largest share of the growth. Biogas and modern biomass for heating also see demand grow, driven by industry growth (IEA 2020b).

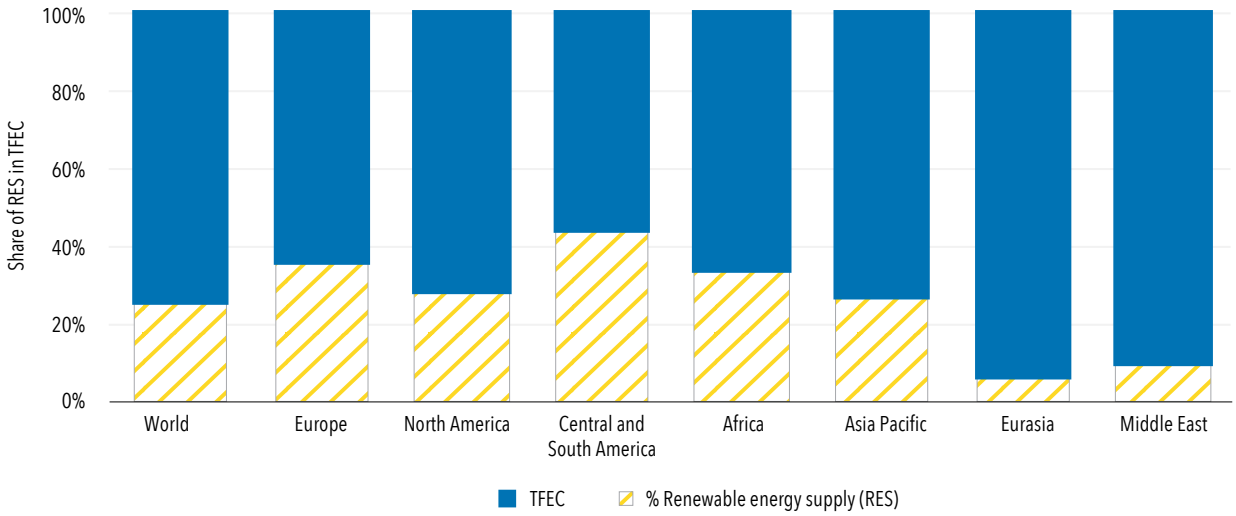
The outlook for end-use renewables depends largely on policy actions taken at a time of economic difficulty and competing budgetary pressures. Furthermore, there is a risk that some targets may not be enforced, or that implementation dates may be delayed as a result of pressures arising from the COVID-19 pandemic. Supportive policies may, however, play a major role in recovery packages, especially transport biofuels on the grounds that they would provide support for agricultural production while also reducing emissions.

How can we bridge the gap? Some insights follow.

INSIGHTS FROM IEA'S SUSTAINABLE DEVELOPMENT SCENARIO

Once again, the projected increases in the use of renewable energy under Stated Policies Scenario fall short of global goals for climate protection and sustainable development. In IEA's Sustainable Development Scenario, which charts a more-ambitious path toward these goals, renewables play a greater role, with their use growing twice as fast as under the Stated Policies Scenario. Under the more-ambitious scenario, modern renewables would reach just over 25 percent of TFEC in 2030 (figure 6.3).

FIGURE 6.3 • Share of renewables in total final energy consumption (TFEC), Sustainable Development Scenario, 2030



Source: IEA 2020b.

RES = renewable energy sources; TFEC = total final energy

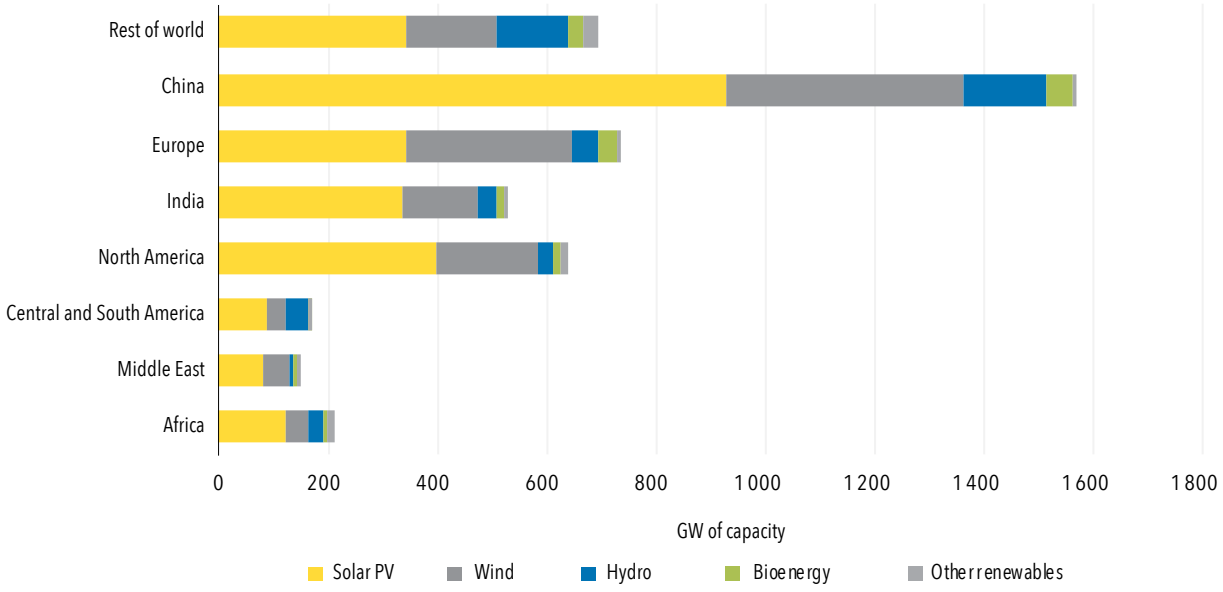
In IEA's Sustainable Development Scenario, the share of renewables-based electricity generation increases rapidly, expanding its current share to just over 50 percent by 2030, or almost 14 percentage points (3,800 TWh) higher than under the Stated Policies Scenario. At the global level, renewables-based electricity generation increases by 8 percent per year to almost 16,400 terawatt-hours (TWh) by 2030, or more than four times the amount of electricity generated in the United States today from all sources.

Increased electrification of energy end uses under the Sustainable Development Scenario means that the share of electricity in final energy demand rises to 24 percent by 2030 compared with a little over 21 percent under the Stated Policies Scenario. The electrification of transport and heat is indirectly increasing demand for renewables in end-use sectors and complements the direct use of renewables in efforts to decarbonize energy use. So-called direct renewables, principally biofuels, increase their share in demand for transport-related energy to 11 percent. Combined with growing electrification, renewables' share in transport rises to around 13 percent. Although light-duty vehicles are on a pathway to decarbonization by 2030, renewable fuels still account for just 4 percent of total fuel consumed by ships in 2030 and just 10 percent of fuel use in the aviation sector (IEA 2020b).

The use of renewables for heat applies to space and water heating, cooking, industrial processes, and other uses (figure 6.4). It can be provided directly by bioenergy, solar thermal, or geothermal energy, or indirectly through electricity and district heat produced from renewable sources. Fuel switching to the direct use of renewables can also reduce the use of fossil fuels—for example, through the use of solar thermal water heating, biomass, and low-carbon gases. In 2020, renewables accounted for 8 percent of total energy consumed for commercial heat production worldwide. By 2030, this increases to 18 percent under the

Sustainable Development Scenario. The share of traditional uses of biomass falls to 5 percent of TFEC by 2030 under the Stated Policies Scenario, whereas under the Sustainable Development Scenario, traditional uses of biomass are phased out entirely, as developing countries replace them with more modern and efficient fuels and technologies.

FIGURE 6.4 • Cumulative renewable power generation capacity additions, by technology and region, in the Sustainable Development Scenario, 2019–30



Source: IEA 2020b.

Across regions, variations in energy policy, socioeconomic trends, and natural-resource endowments result in differing growth trajectories for renewables. Developing economies account for around 85 percent of the growth in renewable electricity generation through 2030 under both the Stated Policies and Sustainable Development scenarios, with developing economies in Asia, led by China and India, representing half the increase. Under the Stated Policies Scenario, the outlook for electricity generation from renewable sources ranges from 10 percent in the Middle East and 18 percent in North Africa, at the low end, to more than 70 percent in Central and South America, where hydropower dominates the power mix. Under the Sustainable Development Scenario, the share of renewable electricity generation increases in every region, approaching or surpassing half of all electricity generated by 2030 in many regions.

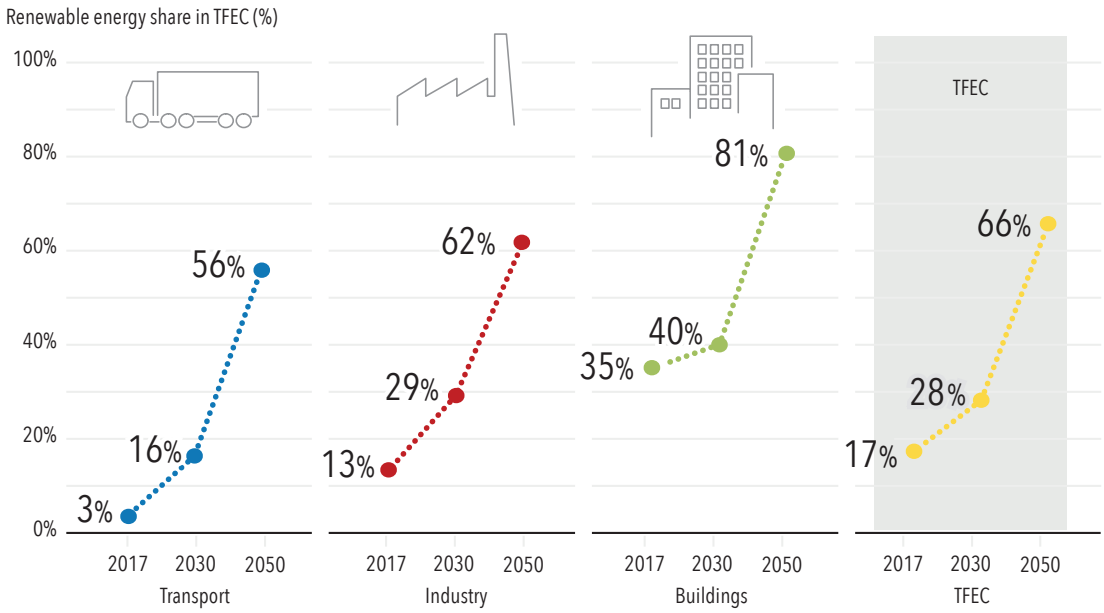
INSIGHTS FROM IRENA'S TRANSFORMING ENERGY SCENARIO

IRENA's Planned Energy Scenario describes a path set by current and planned policies for modern renewables, whereby its share would reach only 17.5 percent in 2030—far short of the global climate objectives and SDG 7. The agency's Transforming Energy Scenario, by contrast, presents a cleaner, climate-resilient pathway based on a more ambitious, yet achievable, uptake of renewable energy and energy efficiency measures. In it, the share of modern renewable energy in TFEC would rise steeply from 10.5 percent in 2018 to 28 percent by 2030. Several factors would be responsible: growth in renewable electricity generation, electrification of end uses, more direct use of renewable energy, and improved energy efficiency.

The developments vary based on sector (figure 6.5). At just 3 percent, the transport sector has the lowest renewables share, but it would see the most growth year on year, to 16 percent of renewables in the sector's final energy consumption by 2030—five times more growth over ten years. The industry sector sees the renewables share increase from 13 percent to 29 percent by 2030. The buildings sector would have the highest share of renewable energy in the end-use sectors, just like today, but with a marked shift in fuels

away from traditional forms of bioenergy to modern direct uses and renewable electricity. In the sector, the overall renewables share would ramp up from 35 percent (when including traditional use of biofuels) or 13 percent (excluding traditional uses of biofuels) in 2017 to 40 percent by 2030. The upward trajectory in renewables share would accelerate toward 2050, with shares increasing to 56 percent in transport, 62 percent in industry, 81 percent in buildings—while overall in TFEC the share would reach two-thirds.

FIGURE 6.5 • Share of renewable energy in TFEC by end use under the Transforming Energy Scenario

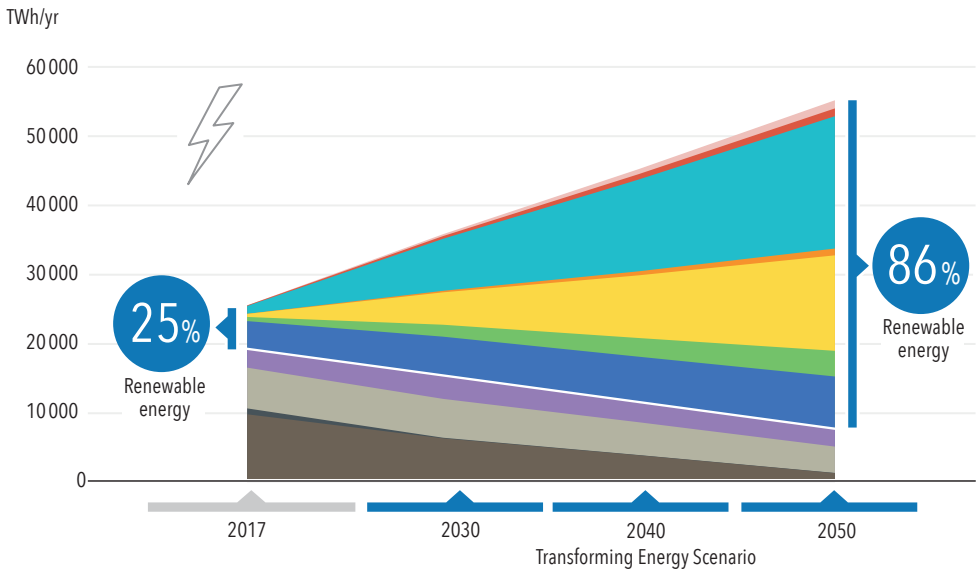


Source: IRENA 2020a.

Note: 2017 includes traditional uses of biofuels in the buildings sector and TFEC. By 2030 most traditional forms of biofuels are phased out of energy supply.

Electricity will increasingly become the crucial energy carrier as the world moves toward decarbonization of the energy system. In recent years renewable electricity has come to dominate new capacity expansion, and over the coming decades it will be the single largest driver for change in the global energy transformation. Over the next ten years, electricity would grow under the Transforming Energy Scenario from a 20 percent share of final energy consumption to a 29 percent share by 2030, with gross electricity consumption increasing 50 percent from 25,570 TWh in 2017 to 35,850 TWh in 2030 (figure 6.6). The share of renewable electricity generation will subsequently rise, with most new capacity provided through new renewables capacity, as the renewables share more than doubles to 57 percent by 2030, up from 25 percent in 2017. This trend would continue toward 2050, when renewable electricity would make up 86 percent of a total gross electricity generation of almost 55,000 TWh.

FIGURE 6.6 • Electricity generation mix (TWh/year) under IRENA's Transforming Energy Scenario



Source: IRENA 2020a.

Wind and solar PV would dominate global electricity generation and capacity additions under the Transforming Energy Scenario. By 2030, more than a third of the world's electricity would come from solar and wind power, a trend that would increase over the succeeding decades, amounting to over 60 percent by 2050. Total installed wind and solar capacity would exceed 6,000 GW in 2030 and 8,800 GW by 2050, respectively. This can be achieved, however, only if power systems adapt and become more flexible. The Transforming Energy Scenario also requires widespread investment in enabling infrastructure, including grid expansion, flexible generation, demand-response, storage, and more.

Despite this transformation occurring in the power sector, it leaves the other half of final energy consumption unelectrified. To address this, the Transforming Energy Scenario takes several approaches.

First is energy efficiency, which includes improved technical efficiency and behavior changes. Energy efficiency would also contribute (together with use of renewables and electrification) to energy intensity improvements, which, under the Transforming Energy Scenario, amount to 3.2 percent per year through 2050.

Second, direct use of renewables is scaled up considerably. Sustainable uses of bioenergy would remain a pillar of a renewables-based energy system, used to provide heat in industry and as a biofuel. Heat produced from solar thermal energy plays an important role in residential, commercial, and some light industry; while geothermal is an important source in countries with the necessary resources.

Third, fossil fuels would still have a role in 2050, providing one-third of the energy supply. They would, however, be far below today's levels of production. Oil would largely be used in industry for some subsectors, and in aviation and shipping. Coal would be used only in industry, mostly for steel production. Natural gas would see production increase and peak in the mid-2020s, but then fall to two-thirds of 2017 levels by 2050, by which time it would have become the most widely used fossil fuel.

Fourth: indirect electrification via hydrogen (and synthetic fuels). Hydrogen is a promising energy carrier, which by 2030, under the Transforming Energy Scenario, has the potential to supply 11 EJ of global energy demand, of which 3.2 EJ would come from renewable sources. By 2050 nearly 29 EJ will be consumed, two-thirds of which will come from renewable sources.

BOX 6.2 • IRENA'S POST-COVID-19 RECOVERY AGENDA

COVID-19 has intensified the urgency of decarbonizing our societies and meeting the Sustainable Development Goals. By making the energy transition an integral part of the wider recovery, governments can accelerate the pursuit of a healthy, inclusive, prosperous, just, and resilient future.

The onset of the crisis upended economic trends and dynamics around the world, including in the energy sector. To date, renewable energy as a whole has fared better than fossil fuels. Renewables remain predominant in new electric power capacity and have proven flexible, cost-effective, and resilient in the face of the 2020 health and economic crisis.

IRENA's post-COVID-19 agenda links short-term recovery with medium- and long-term scenarios targeting 2030 and 2050. Annual investment in energy transition–related technologies would more than double from the 2019 level of USD 824 billion to nearly USD 2 trillion in the 2021–23 recovery phase, before reaching an annual average of USD 4.5 trillion in the decade to 2030 (IRENA 2020b).

With the added investment stimulus under IRENA's Transforming Energy Scenario, energy transition-related technologies would add 5.5 million more jobs by 2023 than would be possible under the less ambitious Planned Energy Scenario, while boosting GDP by an additional 1 percent on average. In the medium-term through 2030, 19 million more jobs would be created compared with the Planned Energy Scenario; GDP would be boosted an additional 1.3 percent per year.

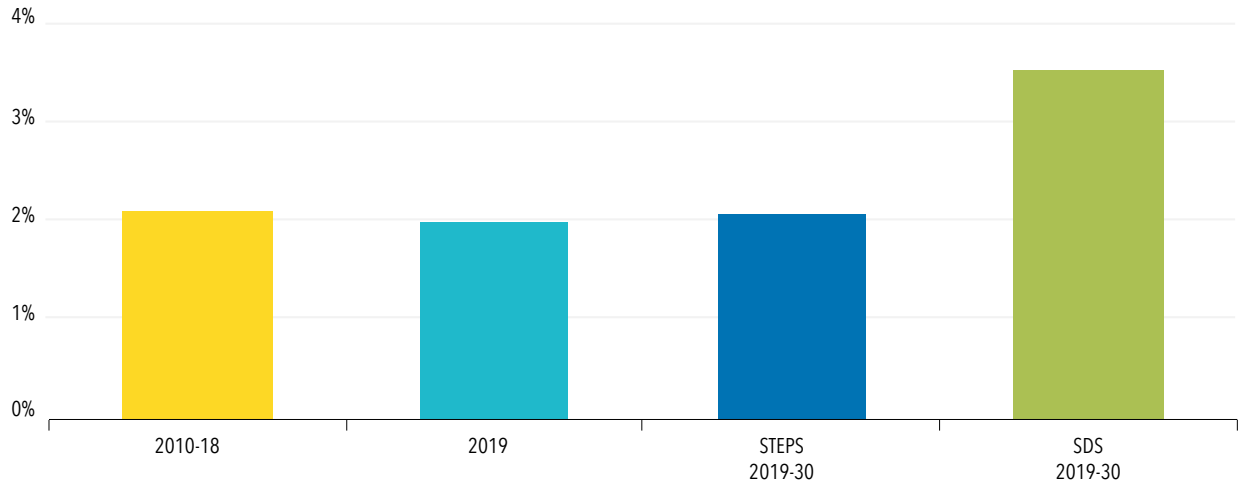
In 2019, jobs in the renewable energy sector worldwide reached an estimated 11.5 million, continuing a long-term growth trend (IRENA 2020c). By 2030, the absolute number of renewable energy jobs is expected to increase to 30 million. By 2050, IRENA's Transforming Energy Scenario foresees the renewable energy workforce numbering as much as 42 million. Additionally, 21 million jobs will be in energy efficiency and almost 15 million in power grid and energy flexibility. The overall energy sector will account for 100 million workers, including the conventional technologies.

This outcome is the result not only of shifting investment priorities within the energy sector, but also of the greater labor intensity of renewables compared with fossil fuels. Gains in energy transition–related fields would far outweigh the loss of jobs in fossil fuels (IRENA 2020b).

THE OUTLOOK FOR ENERGY EFFICIENCY

Global energy intensity, measured by the ratio of total energy supply to GDP, is the key indicator of global progress on energy efficiency. Global primary energy intensity in 2018 improved by just 1.1 percent over 2017. Annual improvement through 2030 will now need to average 3 percent if the world is to meet the target set by SDG 7.3. While early estimates for 2019 indicated a slight recovery, with an improvement rate of 2 percent, the outlook for 2020 suggests even lower levels of improvement than in 2018, at only 0.8 percent because of the COVID-19 disruptions. The slowdown likely reflects weaker implementation of energy efficiency policy and strong demand in energy-intensive economies and sectors.

FIGURE 6.7 • Average annual primary energy-intensity improvement in the Stated Policies and Sustainable Development scenarios, 2010–30, percent



Source: IEA 2020b; e for estimate.

SPS = Stated Policies Scenario; SDS = Sustainable Development Scenario.

The COVID-19 crisis has altered previously held assumptions about the development of the world's energy systems. In the Stated Policies Scenario, which assumes an annual efficiency improvement of 2 percent between 2019 and 2030, the improvement is accompanied by a rise in global final energy consumption to around 11,270 million tonnes of oil equivalent by 2030, lagging 2.5 years behind IEA's *World Energy Outlook* projections because of COVID-19 (IEA 2020b). In 2025, TFEC is predicted to remain below pre-crisis trajectories, before returning to annual growth rates of 1.2 percent for the remainder of the decade, consistent with growth rates anticipated in pre-pandemic projections.

Low fuel prices are an important reason in the Stated Policies Scenario for a slowing of the rate at which the energy intensity of the global economy improves. In this scenario, the annual rate of improvement falls to 2 percent annually for 2019–25 before rising slightly in subsequent years. This is much lower than pre-crisis projections of 2.4 percent per year and far short of the improvement required to meet the goals of the Sustainable Development Scenario. Lower fuel prices have implications for measures to improve efficiency. Payback periods for investments to improve efficiency, for example, are extended by 20–40 percent for buildings and by 20–30 percent for transport, compared with last year's projections. Enhanced energy efficiency mandates and incentives may be needed to compensate for weakened price incentives, and the extent to which these measures are built into COVID-19 recovery strategies may help to determine the uptake of more efficient goods.

In contrast, energy efficiency is one of IEA's building blocks for its Sustainable Development Scenario. The COVID-19 lockdowns and disruptions saw TFEC fall in 2020 and 2021—before a predicted recovery, peaking in 2024. The accelerated improvements in energy efficiency across all energy end uses under this scenario would cause global energy demand to decline after 2024 . The adoption of the measures outlined in the

scenario translates to energy savings of 1,600 million tonnes of oil equivalent in 2030 annual consumption over the Stated Policies Scenario, overshooting SDG target 7.3. The annual 3.5 percent improvement in energy intensity under the Sustainable Development Scenario between 2019 and 2030 is obtained through a combination of well-implemented policies and regulations.

In the Sustainable Development Scenario, total energy supply declines by 7 percent between 2019 and 2030, with demand in advanced economies falling by more than 15 percent over this period. This drop occurs despite strong economic growth, itself a reflection of two developments, the first of which is the widespread deployment of both demand- and supply-side efficiency measures. The second development is the increased electrification of end-use sectors. The primary energy intensity of the global economy under the Sustainable Development Scenario falls by 3.4 percent on average each year in the 2019–30 period, compared with a decline of 2 percent on average each year between 2010 and 2019.

Early implementation of efficiency improvements across all sectors is essential to move toward a more sustainable trajectory. In the transport sector, efficiency improvements under the Sustainable Development Scenario mean that the average conventional passenger car sold in 2030 consumes 50 percent less energy than those sold in 2019, while new trucks consume 26 percent less fuel. There are also substantial reductions in indirect emissions from appliances and air conditioners. By 2030, household appliances and air conditioners in the Sustainable Development Scenario are on average 10 percent more efficient than 2019. In industry, efficient industrial facilities improve with the deployment of better electric motors, heat pumps, and irrigation pumps, and the wider implementation of energy management systems.

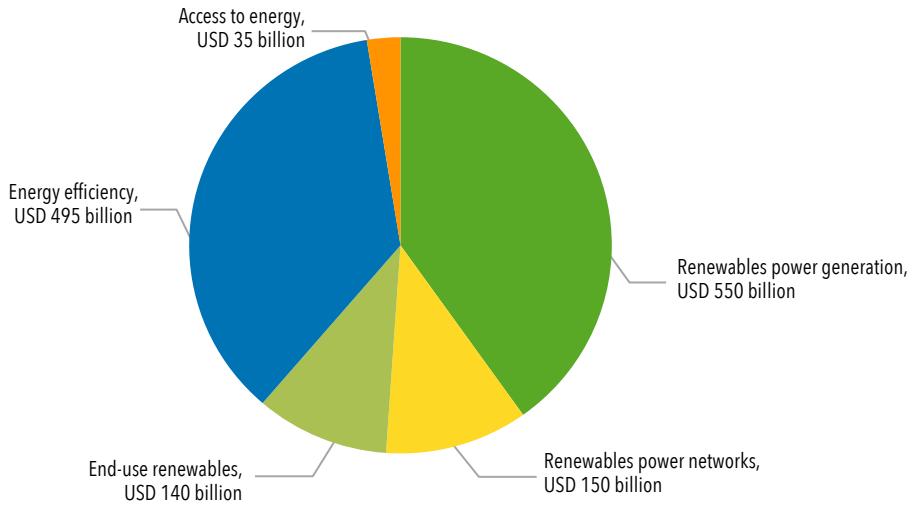
The Sustainable Development Scenario also contains a suite of measures to speed up programs to improve the energy efficiency of new and existing buildings; it also provides assistance to manufacturers to accelerate upgrades to production lines to produce higher-efficiency equipment. Improvements in efficiency across all end uses in the building sector, and achievement of universal access to clean cooking, will produce declines in total energy demand in residential buildings by almost 15 percent over the 2019–30 period, despite a 25 percent increase in the provision of energy services reflecting 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, and in some countries, including India, the figure is over 50 percent. Nearly three-quarters of countries today do not, however, have mandatory energy codes for new buildings. In the Sustainable Development Scenario, mandatory energy-related building codes are introduced in all countries, and existing codes become more rigorous. These measures reduce the average energy intensity of new buildings by nearly 50 percent over the 2019–30 period (IEA 2020b).

INVESTMENTS NEEDED TO ACHIEVE SDG 7

The economic damage brought about by the pandemic has created an opportunity to support economic growth and jobs while boosting investment in renewable energy technologies. In the Sustainable Development Scenario, total energy sector investments needed to achieve all targets of SDG 7 are estimated to average USD 1.4 trillion per year between 2019 and 2030 (figure 6.8). As part of post-COVID-19 economic stimulus packages, the Sustainable Development Scenario sees USD 35 billion average annual investment toward energy access from 2021 to 2030 (three-times more than in the Stated Policies Scenario), with universal access by 2030. This is predicated on strong policy support and international co-operation, particularly in Sub-Saharan Africa.

The finance available for funding expansion and upgrades of electricity and clean cooking access in the past has been much less than what is needed to achieve full access in line with SDG 7. Between 2013 and 2017, USD 8 billion was spent on average each year to improve electricity access in 20 countries, with 70 percent of the world's population lacking access to electricity; in the same period, USD 70 million was spent each year on clean cooking in the 20 countries that have the highest numbers of people lacking access (SEforAll 2019).

FIGURE 6.8 • Average annual investment in selected technologies, Sustainable Development Scenario, 2020–30



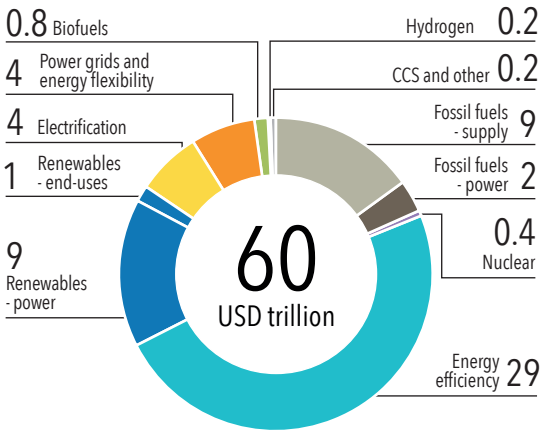
Source: IEA 2020b.

In the Sustainable Development Scenario, USD 30 billion is the average annual investment required from 2020 to 2030 in order to reach full electricity access in emerging market and developing economies; and around USD 5 billion, or more the six times the present level, for clean cooking access, with more than half this investment occurring in Sub-Saharan Africa (IEA 2020b). It is critical that clean cooking remains on the political agenda during the present crisis. Even modest investments in this sector can deliver sizable social and environmental improvements, while boosting resilience and public health.

The majority of the investment required to meet SDG 7 in the Sustainable Development Scenario is directed toward renewable electricity generation (incl. batteries) and end-use efficiency, which account for USD 550 billion and USD 495 billion average investment each year, respectively. Renewables-based power investment needs to be supported by additional spending on expanding and modernizing electricity networks of USD 150 billion on average each year. Finally, investments on end-use renewables account for the remaining USD 140 billion that makes up the USD 1.4 trillion annual investments necessary to achieve SDG 7, according to the Sustainable Development Scenario.

IRENA's Transforming Energy Scenario shows that cumulative investments into the energy system over the period from 2016 to 2030, including infrastructure, supply, efficiency, and electrification, would reach USD 60 trillion. Compared to the Planned Energy Scenario, investments of nearly USD 10 trillion would need to be redirected from fossil fuels and related infrastructure to low-carbon technologies by 2030. Of the total investments, the largest investment need is energy efficiency, with USD 29 trillion, or roughly half the investment. This is followed by USD 9 trillion of cumulative investments needed to scale up renewable power generation capacity through 2030 (on an annual basis between 2019-30, this would mean around USD 850 billion as referred to in the main messages). To enable the broad shift to electricity, and renewable power, USD 8 trillion needed to be invested in power grids, energy flexibility, and enabling electrification infrastructure. Fossil fuel supply and nuclear would see investments of more than USD 11 trillion; while renewable direct use and supply (including hydrogen) would require USD 2 trillion in investment. In line with the Transforming Energy Scenario, IRENA's post-COVID-19 agenda for the 2021–23 recovery phase states that annual investment in energy-transition-related technologies should reach USD 2 trillion to maximize socioeconomic benefits (box 6.2).

FIGURE 6.9 • Transforming Energy Scenario investments from 2016 to 2030 (USD trillion)



Source: IRENA 2020a.

Closing investment gaps will require substantial and coordinated efforts from a variety of stakeholders. While the bulk of investments will continue to come from private sources, public finance institutions and international donors will play a key role in mobilizing private capital at scale, in particular in developing countries.

CONCLUSION

While innovative policies and technologies continue to bring benefits to the energy sector, the impact of the COVID-19 pandemic has left us in a far different place from that foreseen in early 2020. Not only is the world not on track to meet SDG 7 under current and planned policies, some goals are even more elusive than ever. For example, recent successes on energy access in Africa are being reversed, while the number of people without access to electricity rose in 2020 after falling the previous six years. Meanwhile, basic electricity services are now too costly for up to 30 million people, people who could previously afford access.

The perceived risk of lending money to a number of developing countries has increased dramatically, making it more expensive for them to raise debt finance for energy technologies and energy access. In IEA's Stated Policies Scenario, the economic fallout from COVID-19 adds to the difficulties that governments and other agents face in expanding access. These obstacles will leave 660 million people without access to electricity in 2030 (most of them in Sub-Saharan Africa) and close to 2.4 billion people worldwide lacking access to clean cooking. If we are to achieve our 2030 goals, expanding access must be at the center of recovery plans and programs. This involves, for example, measures to support the emerging private solar sector, setting action-based targets to boost progress at the required pace. In a world where finance is constrained, access projects will need to be smart (e.g., linked with agriculture to unlock related benefits), effective, and capable of being kickstarted. Decentralized energy solutions will also play an important role, in particular, in reaching remote households far from a grid.

The impact of the pandemic on meeting SDG 7 goes beyond access. Low oil and gas prices could act as a barrier to the uptake of clean energy technologies for some end uses. The payback period for many energy efficiency retrofits in buildings, for example, is longer when fossil fuel prices are lower. In some sectors, the ongoing decline in economic activity and lingering economic uncertainty are likely to bring slower turnover of capital stock—meaning that more carbon-intensive and inefficient capital stock may operate for longer.

Yet the pandemic could also have positive outcomes. In a number of advanced economies, a decline in interest rates and accommodative monetary policy by central banks means that base lending rates will stay lower for longer. Given the capital-intensive nature of many clean energy technologies, this could translate into lower deployment costs. Recovery plans designed to kickstart economic growth, protect workers, and create jobs could provide a substantial boost to the deployment of clean energy technologies, for example, by developing strategies that harness existing skills in the energy sector to support clean energy transitions. Lower fossil fuel prices could make it easier for governments to reform fossil fuel subsidies. Part of how we get on track toward meeting SDG 7 depends on how governments respond to the economic crisis and what role recovery packages play in shaping a more sustainable future.

METHODOLOGY

IEA METHODOLOGY AND SCENARIOS

The analysis presented in this chapter is based on results from the World Energy Model (WEM) and IEA analysis in the *World Energy Outlook* (IEA 2019). Detailed documentation of the WEM methodology can be found at https://www.iea.org/reports/world-energy-model/documentation#abstract.

The analyses shown above are built on two scenarios described below.

Stated Policies Scenario

The Stated Policies Scenario provides decision-makers with feedback about their current course, based on stated policy ambitions. This scenario assumes that the COVID-19 pandemic is brought under control over the course of 2021. It incorporates IEA assessments of stated policy ambitions, including the energy components of announced stimulus or recovery packages (as of mid-2020) and the Nationally Determined Contributions 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 supported by specific policies, funding, and measures. The Stated Policies Scenario also reflect progress on implementation of corporate sustainability commitments.

Sustainable Development Scenario

The Sustainable Development Scenario is designed so the energy-related United Nations Sustainable Development Goals might achieve universal access to affordable, reliable, and modern energy services by 2030; substantial reductions in air pollution, and craft effective actions to address climate change. The Sustainable Development Scenario is fully aligned with the Paris Agreement to hold the rise in global average temperature to "well below 2 °C … [while] pursuing efforts to limit [it] to 1.5 °C." The Sustainable Development Scenario assesses what combination of actions would be required to achieve these objectives. In this Outlook, investments in the 2021–23 period are fully aligned with those in "Sustainable Recovery: World Energy Outlook Special Report" (IEA 2020). In the Sustainable Development Scenario, many of the world's advanced economies reach net-zero emissions by 2050, or earlier in some scenarios, and global carbon dioxide (CO_2) emissions are on course to fall to net zero by 2070.

Methodology for access to electricity and access to clean cooking

The projections presented in the WEO, and this chapter, focus on two elements of energy access: electricity and clean cooking facilities at the household level. These elements are measured separately. The IEA maintains databases on 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 shown in the Stated Policies Scenario take into account current and planned policies, recent progress, as well as population growth, economic growth, urbanization rate, and the availability and prices of different fuels. In the Sustainable Development Scenario, we identify least-cost technologies and fuels to reach universal access to both electricity and clean cooking facilities. For electricity access, this is done by incorporating a Geographic Information Systems model based on open-access geospatial data, with technology, energy prices, electricity access rates and demand projections from the WEM. This analysis has been developed in collaboration with the KTH Royal Institute of Technology, Division of Energy Systems Analysis (KTH-dESA) in Stockholm. Further details about IEA methodology for energy access projections are in this document.

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 World Energy Model, 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 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 modeling incorporates a process of learning-by-doing, which affects costs. By including financial incentives for the use of renewables and nonfinancial barriers in each market, technical and social constraints as well as 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 OECD, 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. This is dependent 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—liquefied petroleum gas (LPG), naphtha, gasoline, kerosene, diesel, heavy fuel oil, and ethane—are modeled separately for each final demand sector.

In most of the equations, energy demand is a function of activity variables, which again are driven by:

- Socioeconomic variables: In all end-use sectors, 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 influencing the demand for energy services.
- Technological parameters—e.g., recycling in industry, or material efficiency.

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

- 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 differentiated 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 and scenarios

IRENA's scenarios referenced in this report were developed by the Renewable Energy Roadmaps (REmap) team at IRENA's Innovation and Technology Centre in Bonn. Since 2014, REmap has produced roadmaps that provide ambitious, yet feasible pathways for deploying low-carbon technologies to create a clean, sustainable energy future at global, regional, and country levels.

The findings presented in this report are based on IRENA's 2020 flagship publication, *Global Renewables Outlook: Energy Transformation 2050*. It presents two scenarios:

- The Planned Energy Scenario is the primary reference case in IRENA's *Global Renewables Outlook*, providing a perspective on energy system developments based on governments' energy plans and other ca. 2019 targets and policies, including Nationally Determined Contributions under the Paris Agreement, unless the country has more recent climate and energy targets or plans.
- The Transforming Energy Scenario describes an ambitious energy transformation pathway based largely on renewable energy sources and steadily improved energy efficiency (though not limited exclusively to these technologies). This scenario would set the energy system on the path needed to keep the rise in global temperatures to well below 2 degrees Celsius (°C) and toward 1.5°C during this century.

More information can be found on the IRENA website www.irena.org/remap

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