TRACKING SDG 7

THE ENERGY PROGRESS REPORT

2024

A joint report of the custodian agencies

iea International Energy Agency

IRENA International Renewable Energy Agency

United Nations Statistics Division

THE WORLD BANK IBRD • IDA | WORLD BANK GROUP

World Health Organization

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Cover photo: Getty Images/Me 3645 Studio

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Detailed datasets with country data for each SDG 7 indicator can be accessed at no charge at https://trackingsdg7.esmap.org/downloads. The chapters of this report may be downloaded individually from the same site.

ACRONYMS AND ABBREVIATIONS

CAGR	compound average growth rate
CO_2e	carbon dioxide equivalent
COP28	2023 United Nations Climate Change Conference
CRS	Creditor Reporting System
DAC	Development Assistance Committee
EBRD	European Bank for Reconstruction and Development
EEO	energy efficiency obligation
EJ	exajoule
EPC	energy performance certificate
ESCO	electricity service company
EV	electric vehicle
FCV	fragility, conflict, and violence
FDI	foreign direct investment
GDP	gross domestic product
GHG	greenhouse gas
GW	gigawatt
Gt	gigatonne
HIC	high-income country
IEA	International Energy Agency
IRENA	International Renewable Energy Agency
km	kilometer
kWh	kilowatt-hour
LDC	least-developed country
LLDC	landlocked developing country
LMICs	low- and middle-income countries
LPG	liquefied petroleum gas
MEM	Modern Energy Minimum
MEPS	Minimum Energy Performance Standards

MJ	megajoule
Mt	megatonne
MTF	Multi-Tier Framework
OECD	Organisation for Economic Co-operation and Development
PPP	purchasing power parity
PV	photovoltaic
PVT	photovoltaic thermal
SDG	Sustainable Development Goal
SHS	solar home system
SIDS	small island developing states
TFEC	total final energy consumption
UNSD	United Nations Statistics Division
USD	United States dollar
WHO	World Health Organization

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ACKNOWLEDGMENTS

Partnership

The Energy Progress Report is a product of close collaboration among the five SDG 7 custodian agencies in the form of a specially constituted in a Steering Group:

- International Energy Agency (IEA)
- International Renewable Energy Agency (IRENA)
- United Nations Statistics Division (UNSD)
- World Bank
- World Health Organization (WHO)

The Steering Group was supported by the SDG 7 Technical Advisory Group, composed as follows.

- African Development Bank (AfDB)
- Ashoka Centre for a People-Centric Energy Transition (ACPET)
- Clean Cooking Alliance
- Denmark (Ministry of Foreign Affairs)
- ENERGIA
- European Commission
- FIA Foundation
- Food and Agriculture Organization of the United Nations (FAO)
- Germany (Federal Ministry for Economic Cooperation and Development)
- International Institute for Applied Systems Analysis
- International Labour Organization (ILO)
- Islamic Development Bank
- Kenya (Ministry of Energy and Petroleum)
- Latin American Energy Organization (OLADE)
- Modern Energy Cooking Services (MECS)
- Norway (Ministry of Foreign Affairs)
- Pakistan (Ministry of Foreign Affairs)
- Power for All

- Renewable Energy Policy Network for the 21st Century (REN 21)
- SDG 7 Youth Constituency
- Sustainable Energy for All (SEforALL)
- Swedish International Development Cooperation (SIDA)
- TERI School of Advanced Studies
- The Netherlands (Ministry of Foreign Affairs)
- The United Nations Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States (UN-OHRLLS)
- UAE (Ministry of Foreign Affairs)
- United Kingdom (Foreign Commonwealth and Development Office)
- United Nations Association of China
- United Nations Children's Fund (UNICEF)
- United Nations Department of Economics and Social Affairs (UN DESA)
- United Nations Development Programme (UNDP)
- United Nations Economic Commission for Africa (UNECA)
- United Nations Economic Commission for Asia and the Pacific (ESCAP)
- United Nations Economic Commission for Latin America and the Caribbean (ECLAC)
- United Nations Economic Commission for Western Asia (ESCWA)
- United Nations Economic Programme for Europe (UNECE)
- United Nations Environment Programme (UNEP)
- United Nations Framework Convention on Climate Change (UNFCCC)
- United Nations Human Settlements Programme (UN-Habitat)
- United Nations Industrial Development Organization (UNIDO)
- United Nations Institute for Training and Research (UNITAR)
- Vienna University of Technology

The financial and technical support of the Energy Sector Management Assistance Program (ESMAP) is gratefully acknowledged. A partnership between the World Bank and 24 entities, ESMAP helps low- and middle-income countries reduce poverty and boost growth through sustainable energy. ESMAP's analytical and advisory services are fully integrated within the World Bank's country financing and policy dialogue in the energy sector.

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- The chapter on clean cooking was prepared by WHO (Heather Adair-Rohani, Alina Cherkas, Wenlu Ye), with substantial contributions from Oliver Stoner (University of Glasgow).
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- The chapter on indicators and data was jointly prepared by the custodian agencies under the coordination of IEA (Bruno Idini).

Data sources

The report draws on two meta databases of global household surveys—the Global Electrification Database managed by the World Bank and the Global Household Energy Database and related estimates managed by WHO. Energy balance statistics and indicators for renewable energy and energy efficiency were prepared by IEA (Roberta Quadrelli and Pouya Taghavi, with support from Alexandre Bizeul and Juha Koykka) and UNSD (Leonardo Souza, Agnieszka Koscielniak, and Costanza Giovannelli). The renewable energy-generating capacity per capita indicator, compiled by IRENA (Gerardo Escamilla) is based on the IRENA electricity capacity database and the United Nations Population Prospects. The indicator on international financial flows to developing countries was prepared by IRENA (Gerardo Escamilla) based on IRENA's Public Investments Database and the OECD/DAC Creditor Reporting System. Data on gross domestic product and value-added were drawn chiefly from the International Monetary Fund database. Population data are from the United Nations Population Division.

Detailed datasets with country data for each SDG 7 indicator can be accessed at no charge at https://trackingsdg7.esmap.org/downloads.

Review and consultation

The public consultation and peer review process was coordinated by IEA. Comments were provided by the Council of Engineers for the Energy Transition (CEET); the Economic Commission for Latin America and the Caribbean (ECLAC); ENERGIA; the Economic and Social Commission for Asia and the Pacific (ESCAP); the Food and Agriculture Organization (FAO) of the United Nations; Norway (Ministry of Foreign Affairs); Sustainable Energy for All (SEforALL); the Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States (UN-OHRLLS); TERI School of Advanced Studies; the United Nations Environment Programme (UNEP); the United Nations Industrial Development Organization (UNIDO); and United Nations Institute for Training and Research (UNITAR). IEA's internal review process was led by Laura Cozzi with contributions from Daniel Wetzel, Bruno Idini, Kartik Veerakumar, Francois Briens, Pouya Taghavi, Roberta Quadrelli, and Gianluca Tonolo. IRENA's internal review process was led by Ute Collier and Raul Alfaro-Pelico, with contributions from Mirjam Reiner, Gerardo Escamilla, Hannah Guinto, Julian Prime, Laura El Katiri, Caroline Ochieng, Ntsebo Sephelane, Babucarr Bitaye, Wilson Mattekenya, and Francis Field. UNSD's internal review process was led by Leonardo Souza, with contributions from Agnieszka Koscielniak. The World Bank's internal peer review process was led by Demetrios Papathanasiou, with contributions from Chandrasekar Govindarajalu, Dana Rysankova, Sandeep Kohli, Jan Friedrich Kappen, Monali Ranade, Joern Huenteler, Chiara Rogate, and Zubair Sadeque.

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EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

Since its inception in 2018, *Tracking SDG 7: The Energy Progress Report* has become the global reference for information on progress toward the achievement of Sustainable Development Goal 7 (SDG 7) of the UN 2030 Agenda for Sustainable Development. The report is produced annually by the five custodian agencies responsible for tracking progress toward the goal. The custodian agencies are the International Energy Agency (IEA), the International Renewable Energy Agency (IRENA), the United Nations Statistics Division (UNSD), the World Bank, and the World Health Organization (WHO).

The aim of SDG 7 is to "ensure access to affordable, reliable, sustainable, and modern energy for all." This report thus summarizes global progress on energy access, energy efficiency, renewable energy, clean cooking, and international cooperation to advance SDG 7. It presents updated statistics for each of the indicators and provides policy insights on priority areas and actions needed to spur further progress on SDG 7.

Figure ES.1 offers a snapshot of the primary indicators for 2023, which was the mid-point of the implementation of the UN 2030 Agenda.

Despite some progress across the indicators, the current pace is not adequate to achieve any of the 2030 targets for SDG 7. As in previous years, rates of progress vary significantly across regions, with some regions making substantial gains and some slowing their progress or even moving backward. Among the major economic factors impeding the realization of the goal are the uncertain macroeconomic outlook, high levels of inflation, debt distress in a growing number of countries, inequitable distribution of finance and other resources, supply chain bottlenecks, and soaring prices for materials. The effects of the COVID-19 pandemic, the war in Ukraine, and the steady rise in energy prices since summer 2021 have been a further drag on progress, particularly in the most vulnerable countries and those that were already lagging behind.

FIGURE ES.1 • PRIMARY INDICATORS OF GLOBAL PROGRESS TOWARD THE SDG 7 TARGETS

INDICATOR	2015	LATEST YEAR
7.1.1 Proportion of population with access to electricity	**957.5 million** people without access to electricity	**685 million** people without access to electricity (2022)
7.1.2 Proportion of population with primary reliance on clean fuels and technology for cooking	**2.7 billion** people without access to clean cooking	**2.1 billion** people without access to clean cooking (2022)
7.2.1 Renewable energy share in total final energy consumption	**16.7%** share of total final energy consumption from renewables	**18.7%** share of total final energy consumption from renewables (2021)
7.3.1 Energy intensity measured as a ratio of primary energy and GDP	**4.9 MJ/USD** primary energy intensity	**4.6 MJ/USD** primary energy intensity (2021)
7.a.1 International financial flows to developing countries in support of clean energy research and development and renewable energy production, including in hybrid systems	**12.3 USD billion** international financial flows to developing countries in support of clean energy	**15.4 USD billion** international financial flows to developing countries in support of clean energy (2022)
7.b.1 Installed renewable energy-generating capacity in developing and developed countries	**250 watts per capita** installed renewables capacity	**424 watts per capita** installed renewables capacity (2022)

SDG 7.1.1 • Access to electricity

91 percent of the world's population has access to electricity, in contrast to 78 percent in the baseline year of 2000. There is much to celebrate in this progress. For example, 48 countries achieved universal access to electricity between 2010 and 2020. However, population growth outpaced access growth between 2020 and 2022, leaving 10 million more people without access in 2022 than in 2021. Multiple factors contributed to this reversal, among them disruptions to energy markets and prices stemming from global shocks such as COVID-19, the war in Ukraine, and instability in the Middle East. At the same time, the remaining unelectrified population is more challenging to serve because much of it is remote and low-income. Under current scenarios, the energy access gap is projected to improve modestly, closing to 8 percent in 2030, leaving an estimated 660 million people without access.

The largest growth in access between 2020 and 2022 was seen in Central and Southern Asia, where connections increased by an average of 40.1 million people per year—nearly double the growth in population (20.6 million). In contrast, the average annual increase in access in Sub-Saharan Africa during the same period (31.1 million) just barely exceeded average annual population growth (28.7 million). As a result, Sub-Saharan Africa's share of the global deficit ballooned from 49.6 percent in 2010 to 83.3 percent in 2022. In Latin America, 18 countries achieved universal access over these same years.

The urban-rural divide continues to shrink. Electricity access in urban areas increased from 96 percent in 2010 to 98 percent in 2022, staying ahead of population growth. Informal peri-urban settlements will present a stiff challenge to bringing urban access rates to 100 percent. Access deficits in rural areas shrank from 886 million globally in 2010 to 562 million in 2022. The steepest decline was in Central and Southern Asia (from 383 million to just 24 million). By contrast, the deficit grew in rural areas of Sub-Saharan Africa (from 376 million to 473million).

Decentralized renewable energy can bring electricity to the difficult-to-reach rural locations where much of the remaining unconnected population lives. In 2022, the IEA estimated that 2.5 million households gained electricity access thanks to solar-home systems and smaller solar lighting systems. The World Bank finds that in total, stand-alone off-grid solar solutions, including solar lights and solar home systems, were estimated to serve 490 million people in 2022. IRENA estimates that 158 of the 490 million had access to solar lights and home systems meeting international quality standards. The World Bank has estimated around 47 million people were connected to 19,000 mini grids as of 2022. Hydropower and solar technologies are increasingly being deployed and now account for a third of total mini-grids installed. Decentralized solutions (including stand-alone systems in remote and sparsely settled areas) offer a cost competitive alternative to grid expansion and can be rapidly deployed to meet levels of demand too low to justify grid investments. In addition, the productive uses in rural communities, such as solar water pumps, refrigerators, agro-processing machinery, and a wide range of equipment for microenterprises, contribute to socioeconomic development and improve quality of life. Together, these can increase incomes and raise productivity, contributing to job creation, the emergence of new enterprises, and economic growth.

Increases in access to electricity must accelerate to achieve SDG 7.1, and decentralized renewable energy will play a central role. Achieving SDG 7.1 by 2030 is possible only by deploying a combination of grid, mini-grid, and stand-alone off-grid solutions that leverage the faster deployment of distributed renewables to meet current levels of demand quickly. National and regional electrification programs using public funding to unlock private co-investment at scale can bring these solutions to life.

SDG 7.1.2 • Access to clean fuels and technologies for cooking

While there has been some progress in the global rate of access over the past two decades, the world is still not on track to achieve universal access to clean cooking by 2030. In 2022, 74 percent of the world's population had access to clean cooking fuels and technologies (such as stoves powered by electricity, liquefied petroleum gas, natural gas, biogas, or ethanol), up from 64 percent in 2015, but approximately 2.1 billion people still relied on polluting fuels and technologies (charcoal, coal, crop waste, dung, kerosene, and wood) as their main source of energy for cooking. If current trends continue, only 79 percent of the world's population will have access to clean cooking by 2030. This leaves nearly 1.8 billion people in 2030 vulnerable to the adverse effects of polluting cooking fuels and technologies on their health and livelihoods, not to mention their environment.

By region, the access deficit has fallen consistently in Eastern Asia and South-eastern Asia since 2000, and in Central Asia and Southern Asia since 2010. Looking at countries, the improvement has been driven chiefly by progress in the most populous low- and middle-income countries, such as India, China, Indonesia, Nigeria, and Pakistan. In Sub-Saharan Africa, however, there has been a clear upward trend in the deficit, as access to clean cooking has failed to keep pace with growing populations. Most of the global access deficit can be found in countries in that region, as well as in Central Asia and Southern Asia. In 2022, an estimated 79 percent of the population in Sub-Saharan Africa and 33 percent of people living in Central Asia and Southern Asia were still using polluting fuels and technologies for cooking.

The urban-rural gap across regions has been narrowing in all regions except Sub-Saharan Africa, where it is rising sharply. In Sub-Saharan Africa, only 7 percent of rural households have access to clean cooking, while the figure is 40 percent in urban areas. In Latin America and the Caribbean, one of the most urbanized regions in the world, around 35 percent of the rural population still lacks access to clean fuels and technologies for cooking, around twice as much compared to urban areas. The heavy use of traditional biomass among rural populations results in higher household air pollution and adverse health outcomes, particularly among women and children.

Among the specific fuels and technologies being used by low- and middle-income countries in 2022, gaseous fuels (liquefied petroleum gas, natural gas, biogas) remain the main energy source for cooking among 60 percent of people (4 billion), while electricity was the main fuel for 8 percent (550 million). Unprocessed biomass (wood, crop waste, dung), a polluting alternative, was the main fuel for 26 percent of people (1.7 billion) and charcoal for 4 percent (241 million). The use of gas (LPG, natural gas, and biogas) as the primary fuel is increasing at a faster rate than electricity, both in rural areas and overall. However, in urban areas, the use of electricity is rising faster than gas. It should be noted that the simultaneous use of several different fuels and technologies is extremely common, and that household energy survey data may not fully reflect the actual fuels and technologies being used or their proportions.

The vast majority of low- and middle-income countries will miss the 2030 universal access target unless efforts are strengthened. However, there is growing momentum on the international agenda to advance clean cooking efforts, particularly in Africa, through various multi-lateral for a, such as G7, G20, and COP, and increasing financial commitments from countries and companies. At the international level, collaborative efforts that focus on scalable and sustainable policies and interventions across governments, nongovernmental organizations, the private sector, and communities are the key to raising investment in universal access to clean cooking by 2030, and so reaping long-lasting health, social, and climate benefits.

SDG 7.2 • Renewable energy

Target 7.2 aims at increasing the share of renewable energy in the global energy mix and raising per capita generating capacity from renewable sources. In 2021, the share of renewable energy in total final energy consumption (TFEC) was 18.7 percent. The share of modern renewables—that is, excluding traditional uses of biomass—was a low 12.5 percent—just four percentage points higher than in 2010. This is despite significant growth in modern renewable energy consumption, which increased by over 30 percent during this period, owing chiefly to the deployment of electricity generated from renewable sources. While no quantitative milestone has been set, the current trend is neither in line with the target nor consistent with internationally agreed climate objectives.

To keep global climate targets in reach, the deployment of renewable energy must accelerate across the three key categories of electricity, heat, and transport. Renewable electricity represents one-third of global renewable energy consumption and half of modern renewable energy consumption. Use of renewable electricity increased by almost half between 2015 and 2021, driven mostly by wind and solar PV deployments. The rise increased renewables' share in total electricity consumption from 23 percent to 28.2 percent. Meanwhile, renewables' share in energy used for heating was 23.5 percent in 2021, but more than half of that came through traditional use of biomass (of which 95 percent was in Africa and Asia). Excluding renewable electricity and ambient heat, the share of modern renewables was just 10.4 percent. Renewables' share in transport energy demand climbed to 4.4 percent of in 2021, up from 3.5 percent in 2015, when biofuels (crop-based ethanol and biodiesel) still dominated. The growth was driven by the rise in electric vehicle sales and a higher proportion of renewables in transport-related electricity. Renewable electricity used in vehicles and trains grew 34 percent during this period, representing almost one-fifth of growth in renewables' share in total energy consumed for transport.

Renewables-based generating capacity continues to rise. In 2022, it reached 424 watts per capita globally: 1,073 watts per person in developed countries and 293 watts per capita in developing countries. The 2022 average is more than double that of ten years prior.

Progress across regions and countries varies widely depending on resource availability, policy support, consumption patterns, and energy efficiency performance. Latin America and the Caribbean show the highest share of use of modern renewable energy, at 28 percent of TFEC in 2021, chiefly due to the consumption of bioenergy for industrial processes and biofuels for transport, as well as the important role of hydropower in the region. Between 2010 and 2021, the United Kingdom and Indonesia made the greatest progress in the use of modern renewables (up 9 and 7 percentage points, respectively, in TFEC). The two countries were closely followed by China, India, and Germany, which chalked up increases of between 6 and 7 percentage points.

The actions needed to triple renewable capacity by 2030 as agreed at COP28 in Dubai vary significantly by country, region, and technology. The so-called UAE Consensus that emerged from the meeting calls for a tripling of the world's renewable power capacity by 2030. That consensus, agreed to by more than 130 countries, must now be embedded in national and international renewable energy targets and plans—accompanied by strong policy action. Deployment efforts in developing countries should be underpinned by international collaboration and finance to help achieve global energy and climate ambitions while reducing inequalities.

SDG 7.3 • Energy efficiency

Target 7.3 calls for doubling the globe's progress on energy efficiency and reaching rates of improvement in energy intensity of 2.6 percent annually between 2010 and 2030—double the average of the previous two decades. However, because global progress was slower than hoped in all years except 2015, the rate of improvement in energy efficiency required from 2022 to 2030 must now exceed 3.8 percent, roughly in line with the International Energy Agency's Net Zero Emissions by 2050 Scenario and the COP28 agreement to double progress in energy efficiency.

Regional trends show disparities in energy efficiency progress in 2021, following the COVID-19 slowdown during 2020. Despite increases in energy consumption, all regions reduced their energy intensities—a good sign in what is still an anomalous year in terms of energy trends due to the pandemic. The economic recovery boosted GDP growth to above 4.5 percent in all regions, with Central and Southern Asia growing at a 7.6 percent rate. With respect to energy intensity, Oceania achieved the greatest improvement (at 7 percent). However, Northern America and Europe improved by a mere 0.2 percent, putting downward pressure on global progress.

Between 2010 and 2021, 14 of the 20 countries with the largest energy supply accelerated their rate of improvement in energy intensity over the previous decade. But only three (China, the United Kingdom, and Indonesia) exceeded the 2.6 percent improvement target. This group formerly included Japan and Germany, until a slowdown in 2021 pulled their average below the threshold. Six countries (Mexico, France, Indonesia, Japan, Türkiye, and Italy) more than doubled their rate of improvement in 2010–21 compared with 1990–2010. That group includes both high-income and major emerging economies, suggesting that all types of countries can make major improvements in energy efficiency.

End-use trends showed improvements in energy intensity across all sectors in the 2010–21 period. In industry—comprising energy-intensive economic activities—energy intensity improved by an average of 1.6 percent per year. Passenger transport reached a similar rate (1.6 percent), though the rate of improvement in freight transport was significantly lower (0.4 percent). The residential sector (which comprises final uses such as heating, cooling, and cooking) showed an average annual improvement of 0.9 percent. Energy intensity in agriculture improved at an annual rate of 1.6 percent for the 2010–21 period, matching the rate for industry and passenger transport.

Shifts to more efficient and renewable sources for the generation of electricity and to the electrification of end uses are contributing to improvements in energy intensity. Increased generating efficiency reduces energy intensity through improvements in fossil fuel generation, phase-outs of inefficient technologies, and a growing share of renewables to the electricity mix. The efficiency of generation using fossil fuels has increased steadily since 2010, despite a stall in 2021, following the record increase in energy demand as the pandemic eased. End-use electrification is reducing energy intensity through the adoption of heat pumps and electric vehicles, the electrification of basic industries in emerging market and developing economies, and other means.

SDG 7.a.1 • International public financial flows to developing countries in support of clean energy

Although international public financial flows to developing countries in support of clean energy research and renewable energy production rebounded to USD 15.4 billion in 2022 (a 25 percent increase from 2021), support remains far short of the 2016 peak of USD 28.5 billion. While there is no quantitative target for international public financial flows under indicator 7.a.1, the current trend shows that the world is not on track to meet the goal of expanding access to clean energy research and technologies for countries in need, especially among least-developed countries, landlocked developing countries, and small island developing states.

A relatively small group of funders is responsible for most flows; their decision-making significantly affects flow levels and the technologies funded. The 2022 comeback was driven almost entirely by European sources. It was characterized by multipurpose financial instruments and a broad range of renewable energy technologies and electrification programs, technical assistance, energy efficiency programs, and other supporting infrastructure.

Regionally, international public investment flows changed substantially between 2021 and 2022 in all developing regions except Sub-Saharan Africa. After four years of decline from the 2016 peak and a year of stagnation during the pandemic, flows increased substantially between 2021 and 2022 in most world regions, led by Latin America and the Caribbean (which showed an increase of nearly USD 2 billion), Western Asia and Northern Africa (up by nearly USD 1 billion), and the category of "unspecified countries" (up by more than USD 1 billion). On the other hand, flows to Sub-Saharan Africa increased only modestly; those to Central Asia and Southern Asia decreased substantially (by nearly USD 1.2 billion); and those to Eastern Asia and South-eastern Asia also fell, but less dramatically.

Country commitments remain heavily concentrated, although they are gradually diversifying. In 2021, 80 percent of commitments were spread among 19 countries, as opposed to 25 countries in 2022. The top five recipients of international public flows in 2022 were Brazil, South Africa, Egypt, Uzbekistan, and India. The 45 least-developed countries received slightly more (+8 percent) international flows for clean energy in 2022 (USD 2.3 billion) than in 2021 (USD 2.1 billion), but relative to the total flows the share of money going to these countries decreased from 17 percent to 15 percent, below the historical average of 21 percent. The 40 small island developing states received the highest disbursements on a per capita basis. Some of these states are among the most successful in attracting international public flows.

Debt instruments accounted for two-thirds of flows in 2022, down from more than 90 percent in 2010, and the share of grants, equity, and guarantees grew by 50 percent over 2021. The choice of financial instrument is as important as the quantity of flows, as many recipient countries struggle with high ratios of debt to GDP. Incurring more debt would likely hinder their development and their capacity to repay loans. Ideally, international public financing for recipient countries should include larger shares of nondebt instruments and concessional loans rather than loans at market rates.

As 685 million people continue to live without access to energy and clean cooking, adequate financing to ensure universal access must be a key priority. More innovative financing instruments and initiatives are needed to support underinvested countries to benefit from the energy transition without compromising their fiscally constrained economies. Here, public finance will play a pivotal role in providing energy service solutions to unserved and underserved areas, mobilizing private capital to this end, and bridging end users' affordability gaps. Within the wider public finance ecosystem, multilateral development banks, governments, and other relevant actors should work together to shift the focus of energy transition projects from simple bankability toward impact at the program or portfolio levels.

The outlook for SDG 7

Certain policy responses to the global energy crisis appear likely to improve the outlook for renewables and energy efficiency. However, the energy crisis, inflation, and a dour macroeconomic outlook will probably hold back progress on access to electricity and clean cooking, as well as growth in financial flows.

Access to electricity. Despite setbacks between 2020 and 2022 due to recent global crises, initial data for 2023 gathered by IEA indicates that the number of people globally without access to electricity has returned to a downward trend, albeit tepidly, with increases in solar home system sales in Sub-Saharan Africa helping close some of the gap left by debt-laden utilities after the crisis. Still, 660 million people will still lack access in 2030, 85 percent of them in Sub-Saharan Africa. Achieving universal access by 2030 will require significant investment, policy support, and the deployment of renewable energy.

Access to clean cooking. The IEA and WHO estimate that 1.8 billion people will still lack access to clean cooking by the end of the decade under today's policies and if current trends continue. Significant progress has been made in Asia, but in Sub-Saharan Africa the number of people without access is growing, as access to clean cooking has failed to keep pace with population growth. New commitments to prioritize clean cooking within multi-lateral fora and in African countries, are improving the outlook, compared to previous years. This outlook has further upside potential due to the additional commitment of USD 2.2 billion at the Summit for Clean Cooking in Africa, which comes in addition to the African Development Bank's commitment of USD 2 billion over the next 10 years, as well as funding already available from the World Bank and GCF.

Renewable energy. Strong growth in electricity generation from renewable sources is expected to continue, with renewables surpassing coal as the largest source of electricity generation by 2025 under today's policies. In the UAE Consensus, more than 130 countries pledged to triple total global installed renewable power capacity by 2030 over the 2022 level. The current pipeline of announced renewable projects will bring the world around 80 percent of the way to this target, according to IEA. However, IRENA calls for more policy interventions and to further increase ambitions to close the final gaps with more international cooperation and financial support. Still more is needed outside the electricity sector. IEA's Net Zero Emissions by 2050 Scenario and IRENA's 1.5°C Scenario, both of which outline ambitious energy pathways to SDG 7, estimate that modern renewables must reach 32–35 percent of TFEC by 2030 to keep the world on track, whereas under current policies this share reaches only 23 percent by the end of the decade, up from 18 percent today.

Energy efficiency. The global push for energy efficiency has gained momentum, driven by increasing energy costs and concerns over energy security. Despite this, early estimates for 2023 show only a modest 1.3 percent rate of improvement in energy intensity. Achieving the 3.8 percent annual rate of improvement in energy efficiency to meet SDG 7.3 will require robust policy actions and a significant increase in investment. Doubling the current rate of energy efficiency, as agreed in the UAE Consensus, may require even more ambitious action.

Financing and investment needs. The achievement of the SDG 7 targets demands a substantial increase in clean energy investments. IEA estimates an average annual investment of around USD 3 trillion in the energy sector by 2030, with significant portions dedicated to renewable power and end-use efficiency. Simultaneously, IRENA's 1.5°C Scenario will require an average annual outlay of USD 4.5 trillion in investments through 2030. These investments would focus on renewables, energy efficiency, and low-carbon technologies and would include power grids, storage, and other enabling infrastructure. Closing the investment gap, particularly in developing countries, is paramount for advancing the energy transitions and ensuring universal access to clean energy and technologies.


Photo: © Gettyimages

CHAPTER 1
ACCESS TO ELECTRICITY

Main messages

- **Global trend.** The year 2022 saw a reversal in progress in efforts to expand access to electricity, with the number of people living without it growing for the first time in over a decade.[1] While the proportion of the global population with access held steady at 91 percent, the 53 million new connections added between 2021 and 2022 did not keep pace with a 63 million increase in global population over the same period. Thus in 2022, 685.2 million lacked access, compared with 675.1 million in 2021. The reversal of progress can be attributed in part to global shocks, notably COVID-19 and the disruption in energy markets caused by the war in Ukraine, as well as regional shocks, such as the increasing frequency and severity of droughts and floods in Sub-Saharan Africa because of climate change. Those still lacking access are becoming harder to reach because they live in more remote areas and have lower incomes. They are heavily concentrated in the least-developed countries, many of which are affected by fragility, conflict, and violence.
- **Regional highlights.** Sub-Saharan Africa is home to most of the global population lacking access, and the disparity between regions is widening. Sub-Saharan Africa now accounts for 83 percent of the global access deficit, up from 50 percent in 2010. While significant progress has been made toward universal access in Central and Southern Asia, where the access gap shrank from 414 million in 2010 to less than 33 million in 2022, the gap has flatlined in Sub-Saharan Africa as population growth has outstripped new connections. In that region, 571.1 million people lacked access in 2022, up from 566.1 million in 2010. Meanwhile, the region faces a shrinking fiscal space owing to persistent inflation, high interest rates, and low affordability thresholds.
- **Urban-rural divide.** Against a backdrop of rapid urbanization, eight out of ten people living without electricity in 2022 reside in rural areas. While progress in closing the access gap has been more rapid in rural areas than urban ones, the gain was largely driven by significant improvements in Central and Southern Asia, where the rural population without access shrank from 383 million in 2010 to around 24 million in 2022. Progress in other regions has been far slower.
- **Top 20 access-deficit countries.** Eighteen of the 20 countries with the largest access deficits in 2022 are in Sub-Saharan Africa. The top three—Nigeria (86 million), the Democratic Republic of Congo (78 million), and Ethiopia (55 million)—accounted for nearly a third of the entire global deficit. Concentrated efforts in these countries will be needed to ensure universal access to affordable, reliable, and modern energy services. This effort should also include a deeper focus on improved data collection and use of modern analytical tools to track progress and support data-driven decision-making.

1 Access to electricity is defined as having electricity for desired services. In about 20 countries where surveys based on the Multi-Tier Framework have been conducted, access includes Tier 1 and above (ESMAP 2022c). For other countries, electricity access is a binary measure drawn from national household surveys. Detailed datasets with country data for the SDG 7 indicator discussed in this chapter can be accessed at no charge at https://trackingsdg7.esmap.org/downloads.

- **Decentralized renewable energy.** Stand-alone off-grid solar solutions, including solar lights and solar home systems, were estimated to serve 490 million people in 2022, with the majority using it as their main source of light and power, and the rest using it as backup. Of the 490 million, 158 million had access to solar lights and home systems meeting international quality standards.[2] Mini-grids were estimated to be serving 47 million people; half of those mini-grids were powered by fossil fuels, with hydropower and solar accounting for 20 and 13 percent, respectively. The proportion of mini-grids powered by solar is expected to rise rapidly in the future. Least-cost modelling suggests that 439 million new connections from 2022 to 2030 will have to come from the grid (53 percent), with 363 million (44 percent) coming from stand-alone solar photovoltaic (PV) and a further 24 million (3 percent) from mini-grids. There is no viable path to Sustainable Development Goal (SDG) target 7.1—that is, to ensure universal access to affordable, reliable, and modern energy services—without accelerated deployment of decentralized solutions. But current investment flows fall far short of what is required for the sector to achieve its potential. This indicates a need to develop "self-help" eco-systems whereby consumers' knowledge and implementation capacities can be enhanced so as to productively absorb larger flows of capital and technology.
- **Strengthening interlinkages with other SDGs by promoting the productive use of renewable electricity.** Productive use is linked to increased productivity, income growth, and improved quality of life, contributing to SDG 2 on hunger, SDG 6 on clean water and sanitation, and SDGs 8, 9 and 12 on business, industry, and the economy. In on-grid and mini-grid settings, productive uses of renewable energy enhance the viability of rural electrification by stimulating demand. (Another benefit is that this increased demand helps strengthen the financial viability and performance of the grid where available.) In energy access settings, most productive uses of energy initially occur in agrifood settings, but as access improves these uses spread to a wide variety of sectors, from vocational work to the service-based economy. Hence, collaboration across energy, water, agriculture, and other economic sectors is needed to address challenges related to consumer awareness and affordability, as well as access to finance and capacity constraints at both the end-user and company levels.
- **Strengthening interlinkages with other SDGs by electrifying public institutions.** Affordable, reliable, and modern electricity services are key to improving nutrition, health, education, jobs, and skills, thus contributing to SDG 3 on good health and well-being, and SDG 4 on quality education, among others. Conventional approaches to the electrification of public institutions such as health facilities and schools have struggled to achieve sustainability because of limited capacity and funding to pay for ongoing maintenance costs. Innovative approaches can be used to leverage private sector expertise and investment, while ensuring that financing and incentives are structured to ensure sustainability over the long term.

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2 This figure encompasses Asia (excluding China), Africa, Central America and the Caribbean, the Middle East, Oceania, and South America. The main quality standard used for off-grid solar lights and home systems up to 350 W is IEC Technical Standard 62257-9-8:2020, with other standards covering specific components. For more information, see IEC (2024).

Are we on track?

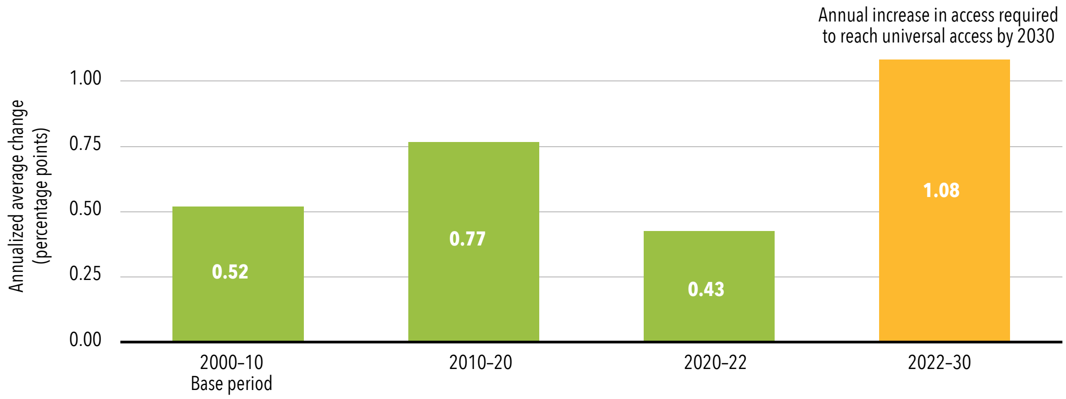
The number of people living without electricity around the world increased in 2022 for the first time in more than a decade. Although the percentage of people with access held steady at 91 percent, the number of people grew faster, leaving 685.2 million people still living without access—about 10 million more than in 2021 (figure 1.1). The reversal of progress can be attributed in part to global shocks, such as COVID-19 and the war in Ukraine. Those still lacking access are heavily concentrated in Sub-Saharan Africa and in least-developed countries, many of which have been more deeply affected by the ongoing global crises or are beset by fragility, conflict, and violence. Many governments in these areas continue to face a shrinking fiscal space owing to persistent inflation and high interest rates on borrowings. Moreover, those still lacking access are increasingly hard to reach because they live in more remote areas and have lower incomes. Under current scenarios, the energy access gap is projected to stall at 8 percent in 2030, leaving an estimated 660 million people without access. SDG target 7.1 is still achievable, but time is running out.

FIGURE 1.1 • PERCENTAGE OF POPULATION WITH ACCESS TO ELECTRICITY, 2000–30

Source: IEA and World Bank 2024b.

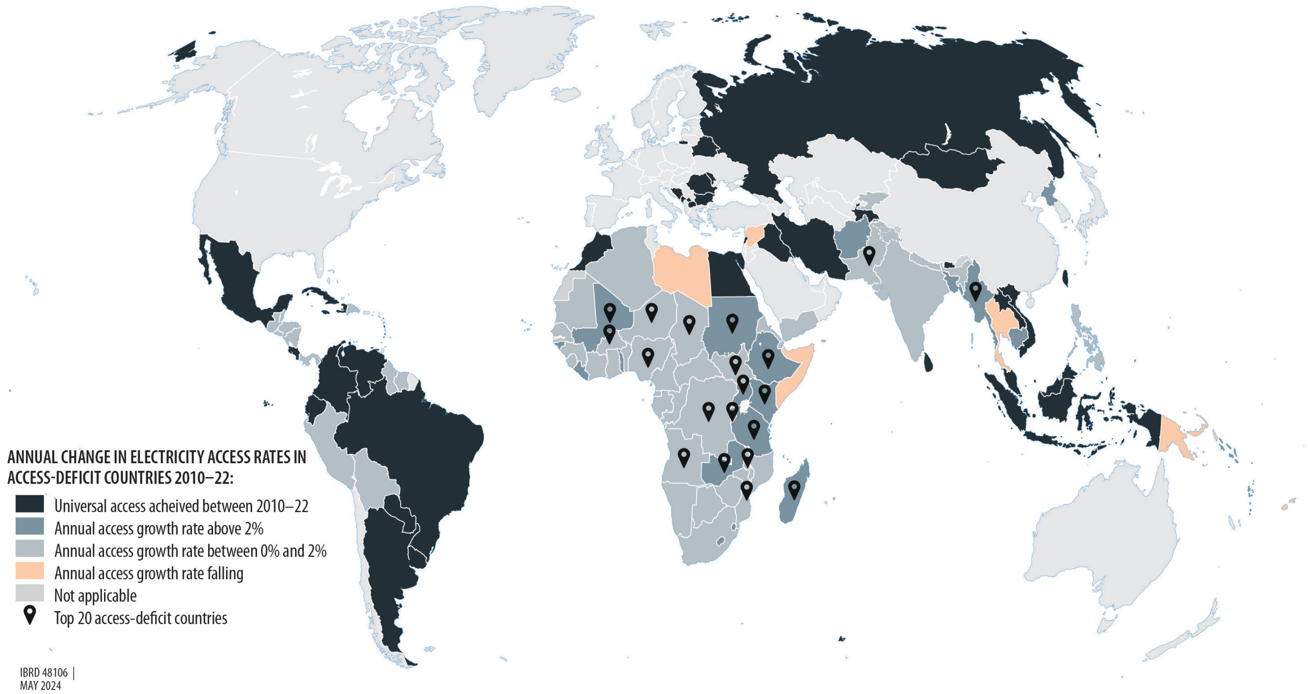
Significant progress was made between 2010 and 2020, with access to electricity growing by an average of 0.77 percentage points per year during the period. That pace dropped to 0.43 percentage points between 2020 and 2022, putting increased pressure on future efforts to achieve SDG target 7.1, which will now require an average annual increase in access of 1.08 percentage points through 2030 (figure 1.2).

FIGURE 1.2 • AVERAGE ANNUAL INCREASE IN ACCESS TO ELECTRICITY, 2000–30



Source: World Bank 2024b.

Since 2010, 48 additional countries were able to achieve universal access to electricity[3] (figure 1.3). The greatest progress was seen in Latin America and the Caribbean (18 of the 48 countries), whereas only 2 countries in Sub-Saharan Africa—Seychelles and Mauritius—were able to reach universal access. Ninety-three countries around the globe still fall short of this goal, the vast majority of them in Sub-Saharan Africa. A serious scale-up of efforts and fresh thinking is needed in order to more than double the average annual percentage increase in access (from 0.43 percent to 1.08 percent) that is needed to achieve universal access by 2030.



Source: World Bank 2024b.

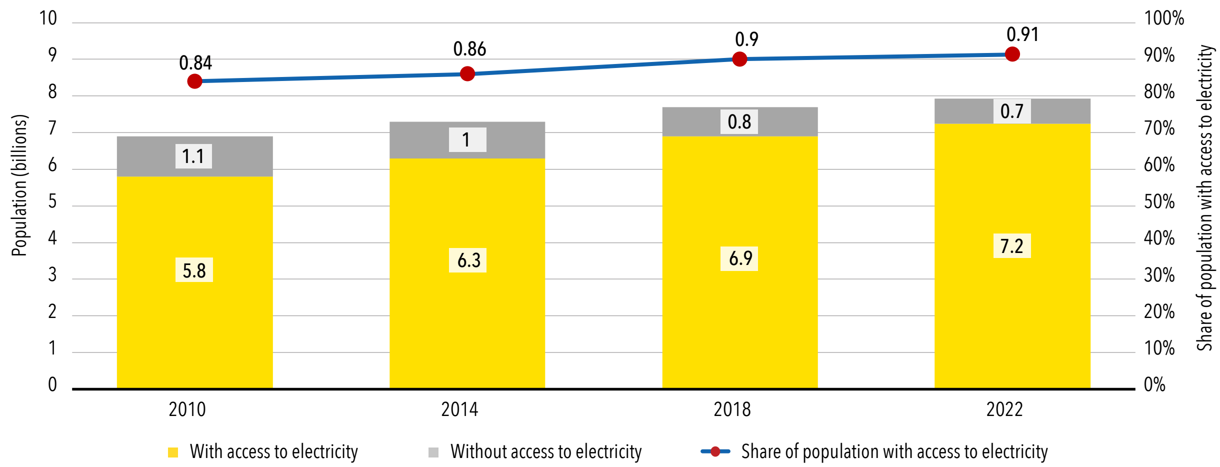
3 Universal access to electricity here is defined as everyone in a country having Tier 1+ access on MTF surveys (ESMAP 2022c) or according to binary measurements in existing household surveys, such as those of the DHS and LSMS (World Bank and IEA).

Looking beyond the main indicators

ELECTRICITY ACCESS AND POPULATION GROWTH

The percentage of the population with access to electricity grew from 84 percent in 2010 to 91 percent in 2022 (figure 1.4). A slowing of progress in the last five years of the period can be attributed in part to a combination of global shocks, notably COVID-19 and the disruption of energy markets stemming from the war in Ukraine, and regional challenges such as the increasing frequency and severity of droughts and floods caused by climate change in Sub-Saharan Africa. People still lacking access are also becoming harder to reach than those reached over the last decade because the live in more remote areas, have lower incomes, and are more likely to live in areas affected by fragility, conflict, and violence.

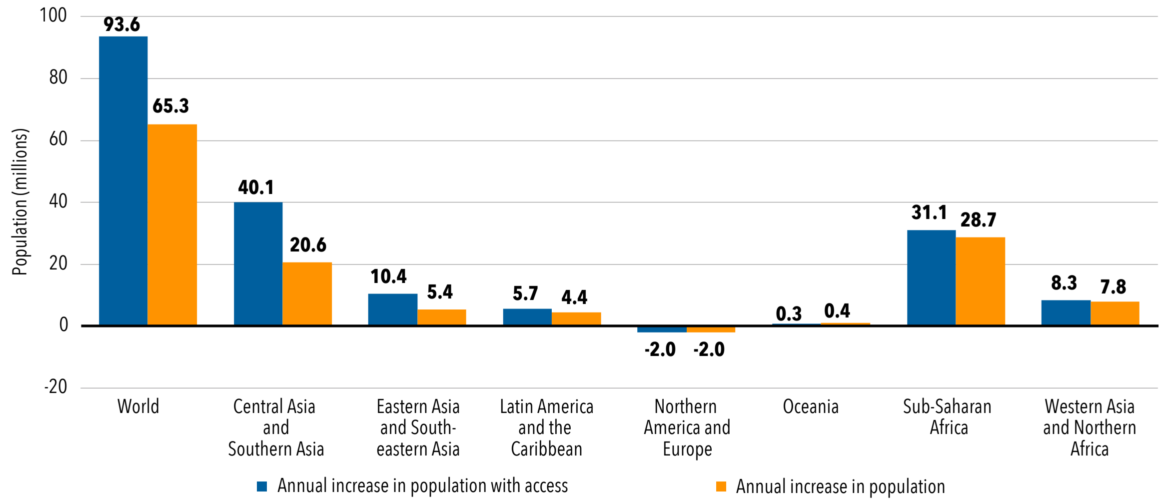
FIGURE 1.4 • GAINS IN GLOBAL ELECTRICITY ACCESS AND POPULATION GROWTH, 2010–22



Source: World Bank 2024b.

On average, an additional 94 million people gained a connection to electricity each year between 2020 and 2022, outpacing average population growth of a little over 65 million during the period—and this despite the reversal of the access trend observed in 2022. The largest growth in access could be seen in Central and Southern Asia, where connections increased by an average of 40.1 million people per year—nearly double the population growth rate of around 21 million. The vast majority of these connections can be traced to India, where the deficit dropped from about 49 million people lacking access in 2020 to just over 11 million in 2022; and to a lesser extent to Bangladesh, where the access deficit dropped from 6.4 million to 1.1 million over the same period. In contrast, the average annual increase of around 31 million in Sub-Saharan Africa was only slightly higher than population growth of around 29 million in the period (figure 1.5).

FIGURE 1.5 • ANNUAL INCREASES IN ELECTRIFICATION AND POPULATION, BY REGION, 2020–22

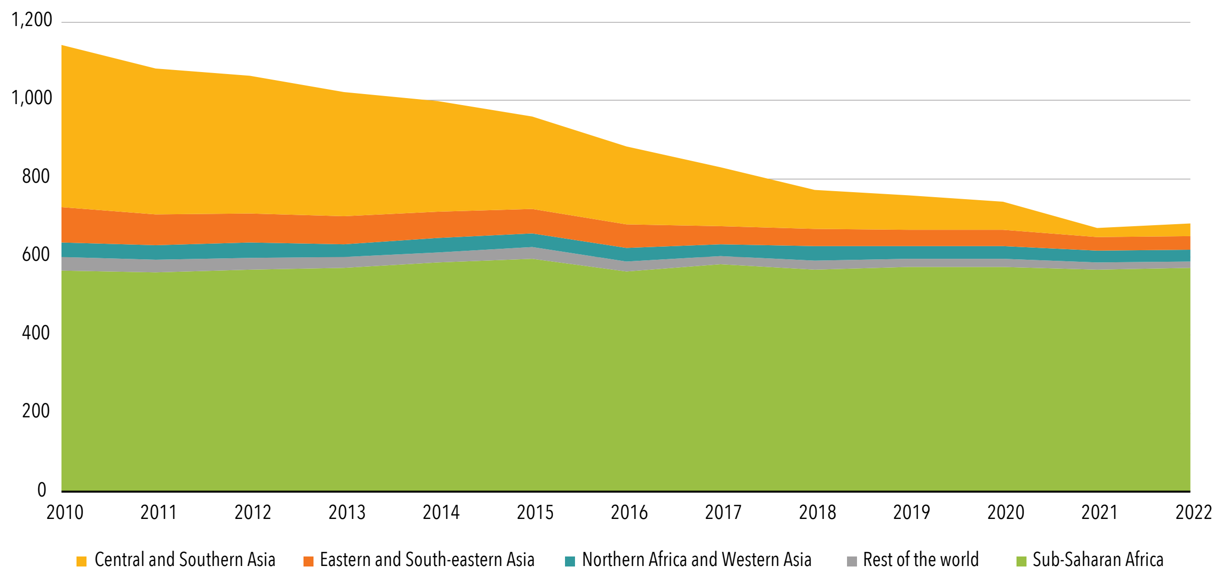


Source: World Bank 2024b.

ACCESS DEFICITS

While hundreds of millions of people have gained access to electricity since 2010, progress has been uneven. Vast regional disparities in access rates persist and continue to widen. While Central and Southern Asia accounted for 36.8 percent of the access deficit in 2010, immense progress in electrification in the region shrank its share of the global unconnected population to 4.8 percent in 2022. Meanwhile, Sub-Saharan Africa's share of the global deficit ballooned from 49.6 percent in 2010 to 83.3 percent in 2022, with a slight increase in the number of unconnected people in 2022 (figure 1.6).

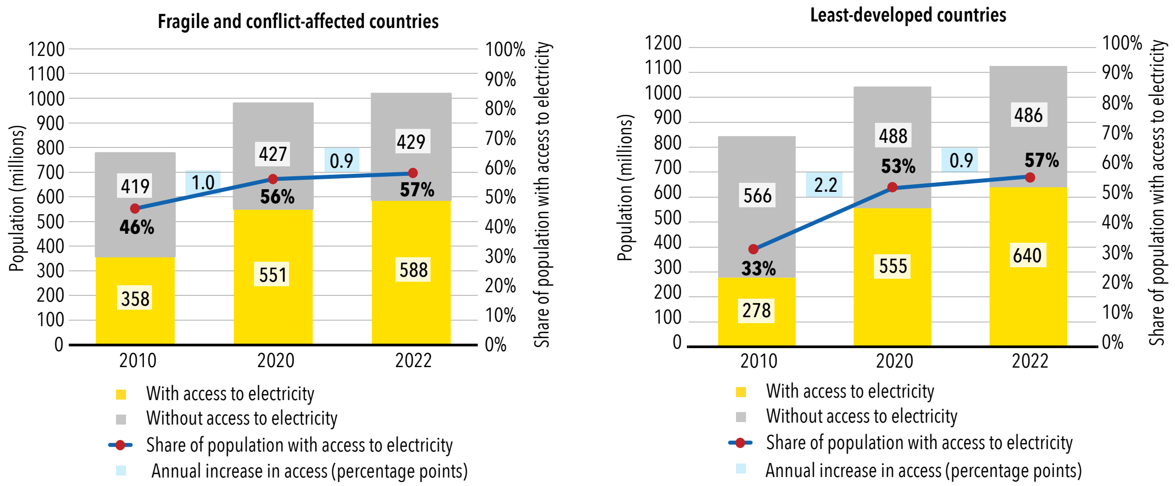
FIGURE 1.6 • POPULATION WITHOUT ACCESS TO ELECTRICITY, BY REGION, 2010–22



Source: World Bank 2024b.

The rate of Increases in energy access were rapid between 2010 and 2020, rising from 33 percent to 55 percent in least-developed countries and from 46 percent to 58 percent in countries affected by fragility, conflict, and violence (FCV). However, between 2020 and 2022 progress slowed. The absolute number of people living without electricity was nearly stagnant between 2020 and 2022, dropping from 488 million to about 486 million people in the least-developed countries, while rising from 427 to just over 429 million in FCV countries (figure 1.7).

FIGURE 1.7 • INCREASES IN GLOBAL ACCESS TO ELECTRICITY IN LEAST-DEVELOPED COUNTRIES AND COUNTRIES AFFECTED BY FRAGILITY, CONFLICT, AND VIOLENCE, 2010, 2020, AND 2022

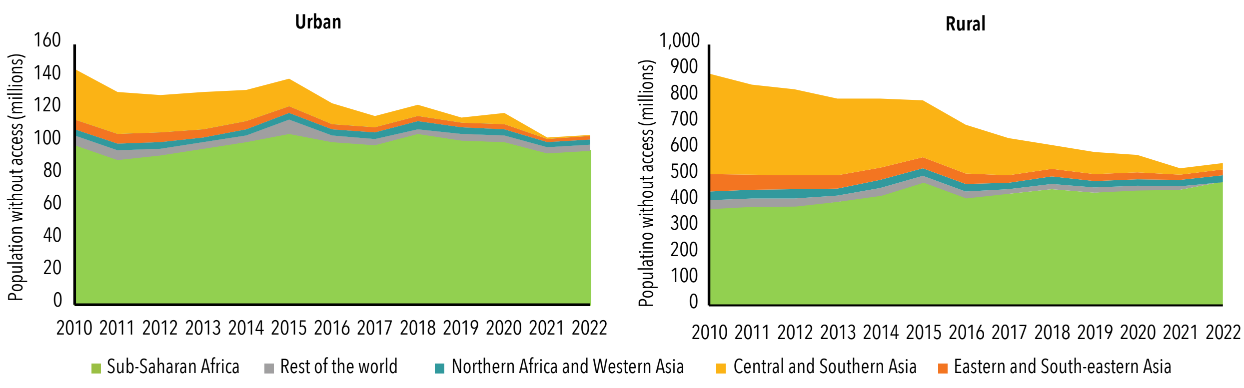


Source: World Bank 2024b.

THE URBAN-RURAL DIVIDE

Electricity access deficits in rural areas shrunk from 886 million globally in 2010 to 562 million in 2022. The steepest decline was seen in Central and Southern Asia (from 383 million to just 24 million), whereas the deficit grew in rural areas in Sub-Saharan Africa (from 376 million to 473 million). The improvements in access rates in urban areas, by contrast, were significantly slower, but also started from a much higher access level, with the deficit decreasing from 145 million in 2010 to 104 million in 2022. Progress was uneven and driven primarily by improved access in Central and Southern Asia, where the urban access gap declined from 30 million in 2010 to 1 million in 2022 (figure 1.8).

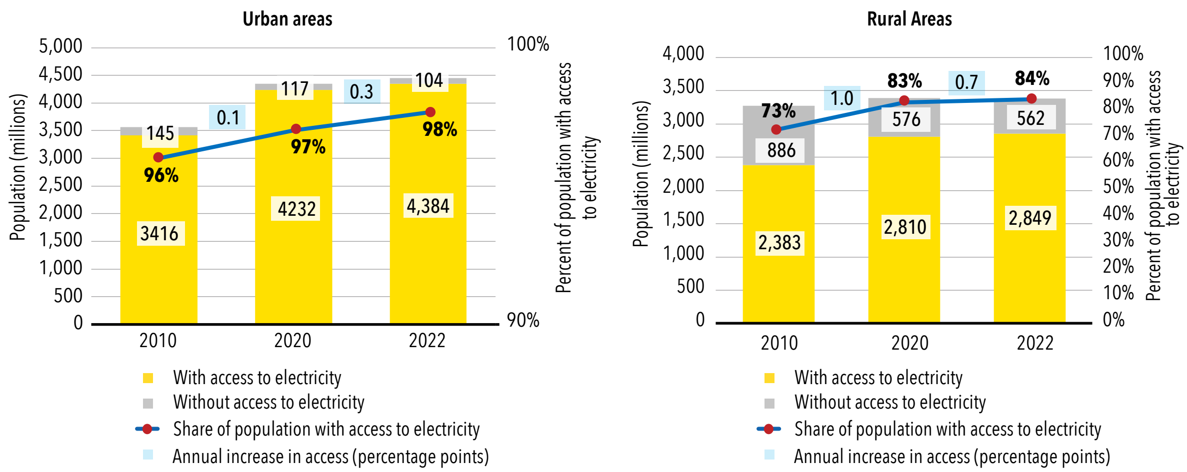
FIGURE 1.8 • ACCESS DEFICITS IN URBAN AND RURAL AREAS IN SELECTED REGIONS, 2010–22



Source: World Bank 2024b.

Overall, electricity access in urban areas increased slightly from 96 percent in 2010 to 98 percent in 2022, while electricity access in rural areas grew rapidly from 73 percent to 84 percent (figure 1.9).

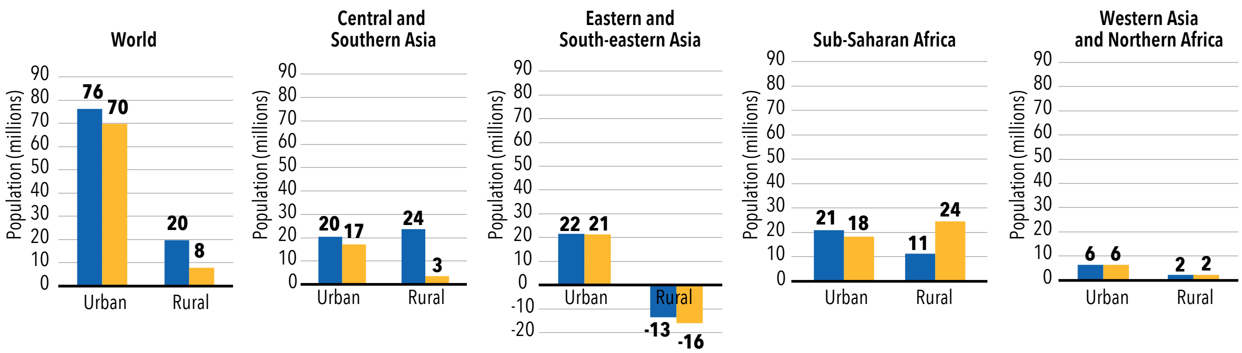
FIGURE 1.9 • INCREASES IN GLOBAL ACCESS TO ELECTRICITY IN URBAN AND RURAL AREAS, 2010, 2020, AND 2022



Source: World Bank 2024b.

The trend continued between 2020 and 2022. It was driven by Central and Southern Asia, where an additional 23.7 million people gained access in rural areas each year, while the rural population increased by only 3.5 million (figure 1.10). In Sub-Saharan Africa, by contrast, an average of 11.2 million people in rural areas gained access each year, far less than average annual rural population growth of 24.5 million people. Eastern and Southeastern Asia saw a significant decline in rural population in parallel with improving rural electricity access rates.

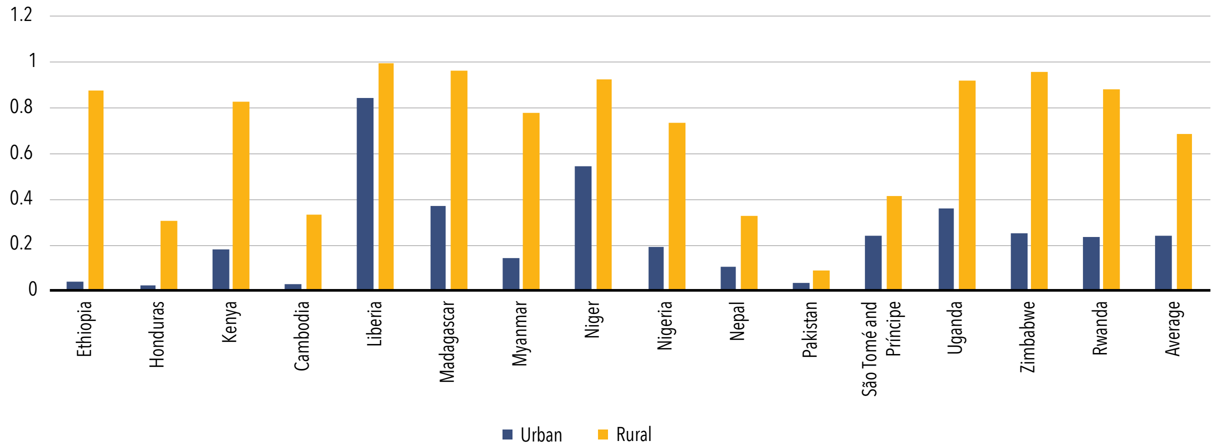
FIGURE 1.10 • ANNUAL GROWTH IN ELECTRICITY ACCESS AND POPULATION IN URBAN AND RURAL AREAS BY REGION, 2020–22



Source: World Bank 2024b.

The urban-rural divide is particularly notable in access to grid power. Figure 1.11 illustrates the stark contrasts in a selection of countries. For example, while just 4 percent of people in urban areas lack grid access in Ethiopia, this gap rises to 87 percent in rural areas (figure 1.11).

FIGURE 1.11 • PROPORTION OF HOUSEHOLDS LACKING GRID ACCESS IN URBAN AND RURAL AREAS



Source: ESMAP 2022c.

THE GENDER AND ENERGY NEXUS

SGD 5, which aims to achieve gender equality by ending all forms of discrimination, violence, and other harmful practices against women and girls has deep linkages with SDG 7. Energy access improves quality of life and the enabling environment for services, jobs, and markets.

Women and girls are disproportionately affected by energy poverty because of gender norms and traditions, which hinder access to modern energy services. At the household level, men and women have different energy needs and capacities when it comes to accessing energy services and appliances (ENERGIA n.d.). In addition, the imposed social and gender responsibilities, such as cooking and fuel collection, affect women and girls' health and safety by the exposing them to heavy work loads, indoor pollution, and violence. Thus, improvements in access to modern energy services bring women more opportunities, allowing them to enjoy greater rights and freedoms.

Policies on infrastructure investments, subsidies, tariffs, and reforms, often overlook gender considerations, yet they hold the potential to mitigate gender disparities. It is crucial to factor in aspects such as forced displacement, unequal land and property rights, employment in technical fields, and gender-based violence that may arise from new projects. These considerations are essential in the design and execution of initiatives aimed at enhancing access to reliable, modern electricity services.

Moreover, female-headed households, which are disproportionately poorer, may face greater challenges and hardships from sudden increases in tariffs compared to male-headed households. Given that men typically control household finances and decision-making under prevailing gender and social norms, it is critical for authorities and stakeholders to incorporate both women's and men's perspectives and suggestions during consultation processes.

Additionally, there is a noticeable gap in women's awareness and access to information about new technologies that can foster skill development and economic opportunities. The energy sector can bridge this divide by collaborating with various stakeholders in the public and private sectors to amplify women's participation and influence in decision-making processes. Employing gender-transformative strategies that challenge and reshape societal and gender norms through behavioral change programs can further this cause.[4]

Women's participation in the electricity access workforce as professionals and decision makers also remains limited. For example, only 27 percent of employees at off-grid solar companies companies are women, compared with women's 48 percent participation in the global labor force (GOGLA n.d.). Most household electricity access surveys are gender blind and therefore unable to shed light on inequality or inform gender-inclusive policy or program development. Few electrification plans specifically address the needs of female-headed households, with no region scoring more than 29/100 in this area, according to the World Bank's Regulatory Indicators for Sustainable Energy (RISE) framework (ESMAP 2022a). Viable paths to SDG 7.1 should include gender equality in energy; and policies and investments must do the same.

On a positive note, recent research by Duke University using survey data from the Multi-Tier Framework found a positive association between a women's empowerment index and energy access at household level in most countries (IOPscience 2023). Research in the stand-alone off-grid solar sector has found that inclusion of women as consumers, employees and entrepreneurs improves service delivery, enhances financial performance, supports employee retention,, and promotes innovation (ESMAP 2022b). Inclusion of vulnerable groups and gender sensitivity considerations in approved electrification plans also improved slightly from 2019 to 2021, with rapid improvement in Latin America and the Caribbean and some improvement in Sub-Saharan Africa, thanks in large part to Nigeria's consideration of gender in electrification expansion planning, according to RISE data (ESMAP 2022a).

There remains an urgent need to collect sex-disaggregated data to inform policies and programs; address inequity in asset ownership; improve women's access to markets, and technical skills for employability; strengthen participation in the electricity access workforce; and enhance access to finance and support for female-led businesses. Governments and development partners must design gender-inclusive programs that use public funding, capacity building, standards and other incentives to reach more women, maximize the benefit of electricity access to women, and enhance the participation of women in the sector at all levels (ESMAP 2022b).

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4 Information on the Multi-Tier Framework for Energy Access, a joint project of the World Bank, the Energy Sector Management Assistance Program, and Climate Investment Funds, can be found at ESMAP (2022c; 2024a).

Closing the access gap with decentralized renewable energy

The high cost of extending electricity grids into rural areas with low population density and low demand for electricity explains why decentralized solutions are playing an ever-greater role in rural electrification They offer a lower-cost alternative to grid expansion, because they can be rapidly deployed to meet lower levels of demand. In urban areas, by contrast, grid densification is needed to respond to rising demand from expanding populations. Here, the challenge is not only to raise access but to improve the quality of grid electricity supply. Overall, however, there is no viable path to SDG target 7.1 without a significant role for decentralized renewable energy solutions.

The level of service provided by stand-alone solar solutions, mini-grids, and grid electricity is typically measured using the Multi-Tier Framework (box 1.1). This measures energy access based on seven "attributes" across six tiers (figure B1.1.1). Solar lights and home systems typically provide partial Tier 1, Tier and Tier 2 access, while mini grids and grid electricity typically provide a Tier 3, 4, or 5 level of service.

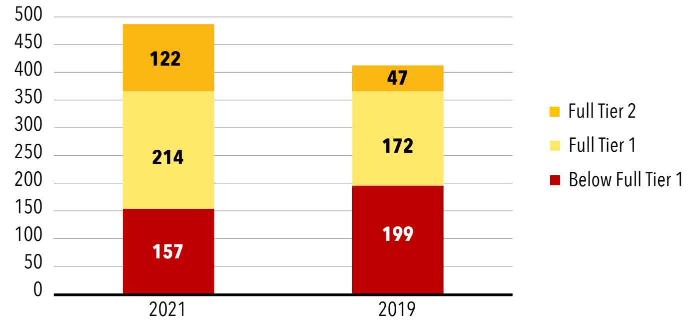
In 2022, the World Bank estimated that approximately 48 million people were connected to 21,500 mini-grids, with approximately half of installed mini grids are solar or solar hybrid, followed by those powered only by hydro (35 percent), fossil fuels (10 percent), and other generation technologies such as wind or fuel cells (5 percent).[5] A further 29,400 mini-grids were planned, 99 percent of them solar or hybrid. The latest "third generation" mini-grids—characterized by new technologies, business models, companies, partnerships, and tools, as well as tailored policy and regulatory systems—offer Tier 4–5 electricity access available 99 percent of the time (ESMAP 2022b). The number of off-grid customers worldwide enjoying Tier 1 and Tier 2 access rose substantially between 2019 and 2021 (figure 1.12).

Off-grid solar solutions contributed greatly to increasing the electricity access rate between 2016 and 2019, before disruptions linked to the COVID-19 pandemic led to a drop in sales in 2020. Sales have rebounded since, and off-grid solar is back on a path to accelerate electricity access, especially in rural areas. Sales and impact data from the Global Off-Grid Lighting Association (GOGLA), data covering only quality-verified products and sales reported by GOGLA members, show a return to growth from 2021 onward (GOGLA 2023a). Stand-alone off-grid solar solutions as a whole—including non-quality-verified systems—were estimated to be serving 490 million people at the end of 2021, up from 420 million in 2019, with a greater proportion achieving Tier 1 or Tier 2 levels of electricity access. IRENA estimates that 158 of the 490 million had access to solar lights and home systems meeting international quality standards (IRENA 2023).[6]

5 This is higher than IRENA's more conservative estimate that solar and hydropower mini-grids serve approximately 13.3 million people (IRENA 2023).

6 This figure encompasses Asia (excluding China), Africa, Central America and the Caribbean, the Middle East, Oceania, and South America. The main quality standard used for off-grid solar lights and home systems up to 350 W is IEC Technical Standard 62257-9-8:2020, with other standards covering specific components. For more information, see IEC (2024).

FIGURE 1.12 • OFF-GRID SOLAR USERS BY TIER OF ELECTRICITY ACCESS



Source: GOGLA and others 2022.

Box 1.1 • Measuring electricity access using the Multi-Tier Framework

The World Bank has sought to move away from a binary definition of electrification to a more nuanced approach, using the Multi-Tier Framework. In this approach, electricity access is measured based on seven attributes across six tiers of access with minimum requirements for each tier. Solar lights and home systems typically provide partial Tier 1 and Tier 2 access, whereas mini-grids and grid electricity typically provide a Tier 3, 4, or 5 level of service. Each attribute is assessed separately, and the overall tier for the household's access to electricity is calculated by applying the lowest tier obtained in any of the attributes.[a]

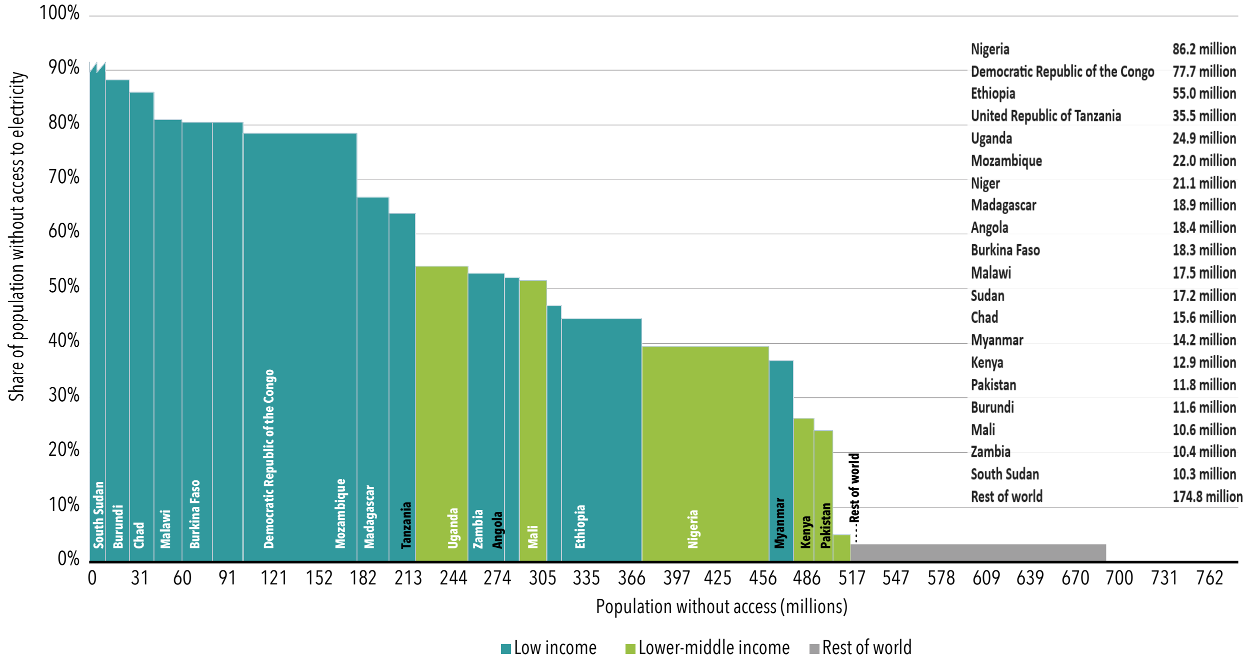
ATTRIBUTE		TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
Capacity	Power capacity ratings (In W or daily Wh)	Less than 3W	Min 3 W	At least 50 W	At least 200 W	At least 800 W	At least 2 kW
		Less than 12 Wh	At least 12 Wh	At least 200 Wh	At least 200 Wh	At least 3.4 kWh	At least 8.2 kWh
	OR Services		Lighting of 1,000 lmhr per day	Electrical lighting, air circulation, television and phone charging are possible			
	Electricity Source						
Availability	Daily availability	Less than 4 hours	At least 4 hours		At least 8 hours	At least 16 hours	At least 23 hours
	Evening availability	Less than 1 hour	At least 1 hour	At least 2 hours	At least 3 hours	At least 4 hours	
Reliability		-More than 14 disruptions per week			At most 14 disruptions per week or at most 3 disruptions per week with total duration of more than 2 hours	>3 to 14 disruptions/ week) or ≤ 3 disruptions/week with> 2 hours of outage	At most 3 disruptions per week of total duration less than 2 hours
Quality		Household experiences voltage problems that damage appliances				Voltage problems do not affect the use of desired appliances	
Affordability		Cost of standard consumption package of 365kWh per year			Cost of a standard consumption package of 365kWh per year less than 5% of household income		
Formality		No bill payments made for the use of electricity				Bill is paid to the utility prepaid card seller, or authorized representative	
Health & Safety		Serious or fatal accidents due to electricity connection				Absence of past accidents and perception of high risk in the future	

Source: Bhatia and Angelou 2015.
Note: Color signifies tier categorization. lmhr = lumen hours; W = watts; Wh = watt hours; kWh = kilowatt hours.
a. Previously referred to as "Duration," this MTF attribute is now referred to as "Availability," examining access to electricity through levels of "Duration" (day and evening). Aggregate tier is based on lowest tier value across all attributes.

Country trends

In 2022, the 20 countries identified as having the largest number of people living without electricity accounted for nearly 75 percent of the global access deficit (figure 1.13).[7] Eighteen of these countries are in Sub-Saharan Africa, and 17 are among the least-developed countries. The same three countries as in the previous two editions of this report again topped the list: Nigeria (86.2 million), the Democratic Republic of Congo (77.7 million), and Ethiopia (55 million). Together the three accounted for roughly a third of the entire global deficit. Progress in Nigeria and the Democratic Republic of Congo remains slow, with average annual increases in access rates of just 1 percent and 0.7 percent, respectively, between 2010 and 2022. Ethiopia made more rapid progress, with a 2.5 percent average annual increase in the period.

FIGURE 1.13 SHARE AND ABSOLUTE SIZE OF POPULATION WITHOUT ACCESS TO ELECTRICITY IN THE TOP 20 ACCESS-DEFICIT COUNTRIES, 2022

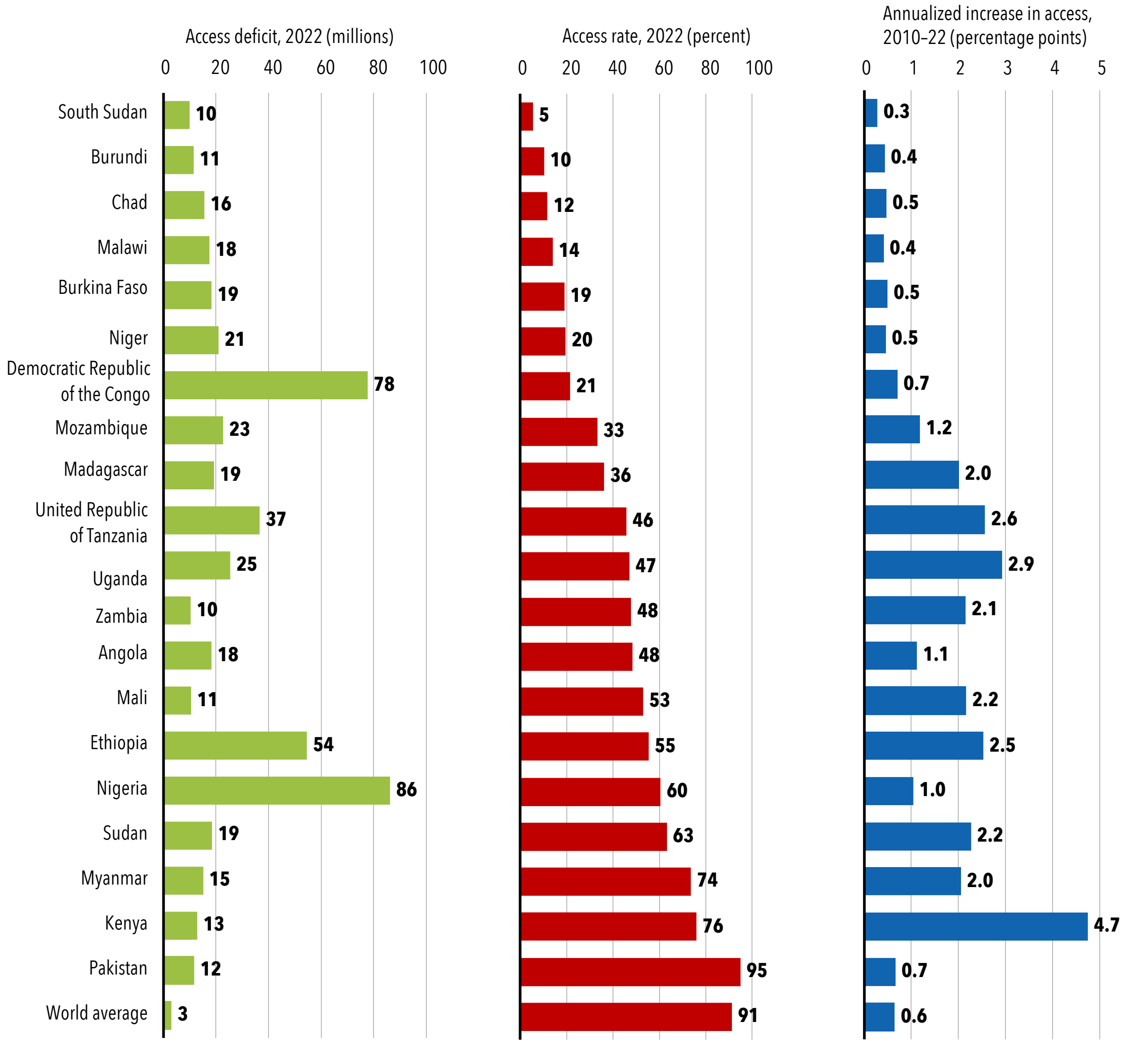


Source: World Bank 2024b.

The lowest national access rates in 2022 were observed in South Sudan (5.4 percent) and Burundi (10 percent), both of which showed only slight increases over the years since 2010 (figure 1.14). Madagascar and Tanzania, on the other hand, saw average annual growth of more 2 percentage points annually since 2010, despite starting from a low baseline. Aside from Nigeria, Pakistan, and Kenya, the countries with the lowest rates of electrification in 2022 were in the group of least-developed countries.

7 The top 20 countries are the countries with the largest populations lacking access for which reliable data are available.

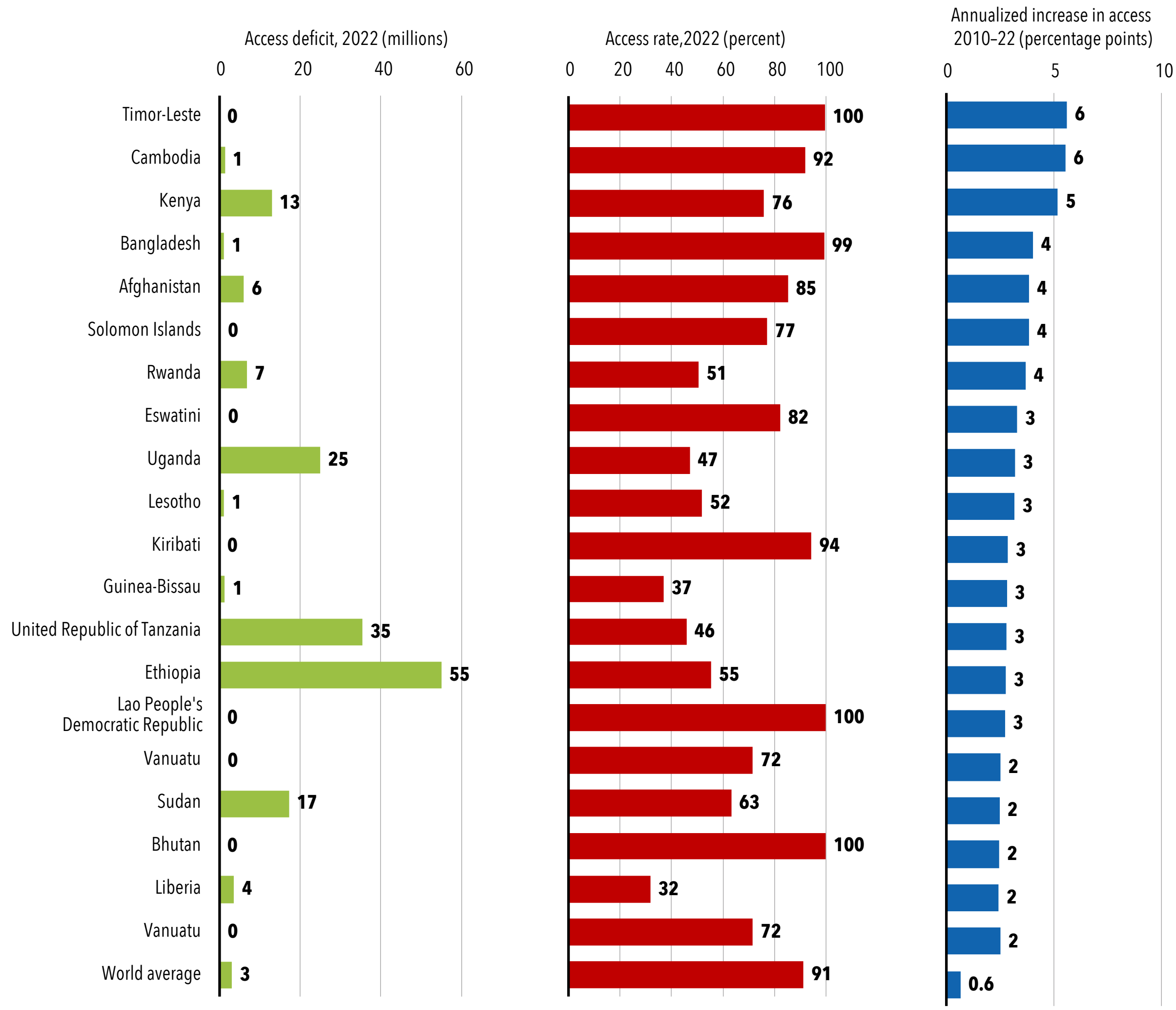
FIGURE 1.14 • ACCESS TO ELECTRICITY IN COUNTRIES WITH THE LOWEST RATES OF ELECTRIFICATION, 2022



Source: World Bank 2024b.

Kenya showed an impressive annual growth rate of 4.8 percent to reach 76 percent access by 2022, putting it both in the list of countries with the lowest rates of electrification and among the fastest electrifying countries (figure 1.15). Timor-Leste, the Lao People's Democratic Republic, and Bhutan also raised their access rates dramatically between 2010 to 2022, achieving universal electrification from very low starting points. Bangladesh very nearly closed the remaining access gap, reaching 99 percent access with an average annual growth rate of 4 percent.

FIGURE 1.15 • ACCESS TO ELECTRICITY IN THE 20 FASTEST ELECTRIFYING COUNTRIES, 2010–22

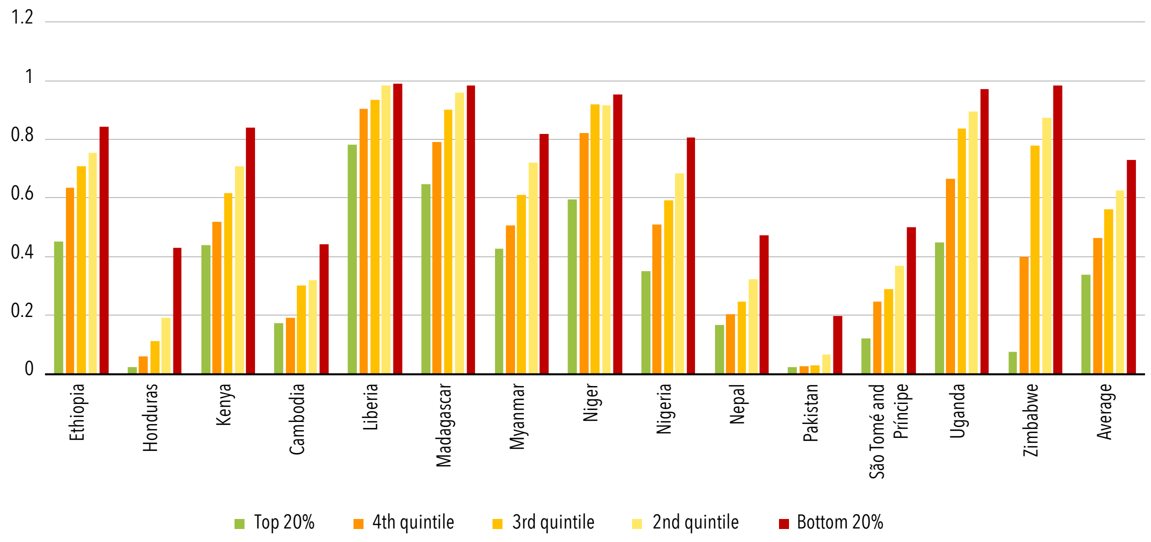


Source: World Bank 2024b.

Reaching the unserved population

As previously noted, the remaining population lacking electricity access has lower incomes and lives in more remote areas than those who have been newly connected over the past decade. Multi-Tier Framework (MTF) surveys that have gathered in-depth information on energy access in 14 countries over the past 9 years yield valuable insights regarding the population still to be reached.[8] According to data from the surveys, grid access is highly correlated with household incomes, with lower-income households less likely to be connected to the grid. For example, while 35 percent of households in the top income quintile in Nigeria lack grid access, the deficit rises to 81 percent for the lowest income quintile (figure 1.16).

FIGURE 1.16 • PROPORTION OF HOUSEHOLDS LACKING GRID ACCESS BY WEALTH QUINTILE



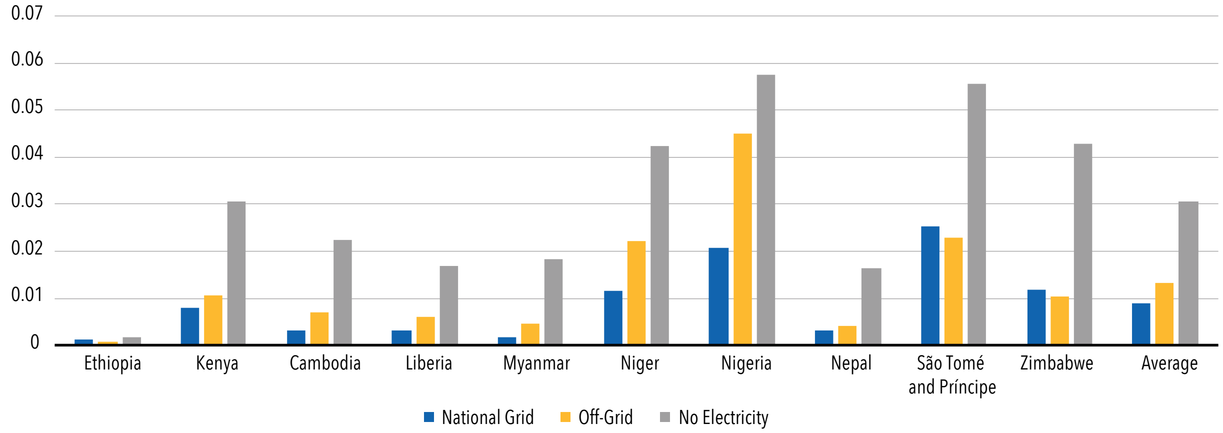
Source: ESMAP 2022c.

Thus, the access gap is increasingly concentrated in rural areas, which, again, are more remote and harder to reach. Moreover, in rural settings, where the load is smaller and more widely distributed, it is harder to justify the costs of grid expansion. The difference between urban and rural grid electrification rates is therefore stark, as seen in figure 1.11.

Households that lack access to electricity—whether from the grid or from off-grid solutions—allocate a substantial share of their monthly income to the purchase of inefficient and polluting energy sources such as kerosene, candles, and dry-cell batteries for lighting. Even after access is obtained, households may still need these inefficient lighting sources for outdoor cooking, walking in poorly lit neighborhoods, or access to places in the house where there is no electric lighting. However, the proportion of expenses on such non-electric lighting sources is lower for electrified households. For households that reported using such lighting solutions across 10 countries, people with no electricity access spend more than 3 percent of their household income on inefficient energy for lighting. Households with off-grid solutions spent only 1.34 percent on inefficient lighting, a rate that drops to 0.90 percent for those with grid access (figure 1.17).

8 The averages shown in figure 1.15 cover only the countries and locations surveyed and are not weighted according to sample size; nonetheless they offer a sense of overall correlations in the data. MTF surveys have been done by the World Bank's Energy Sector Management Assistance Program (ESMAP) and others since 2015. For more information, see ESMAP (2022c; 2024a).

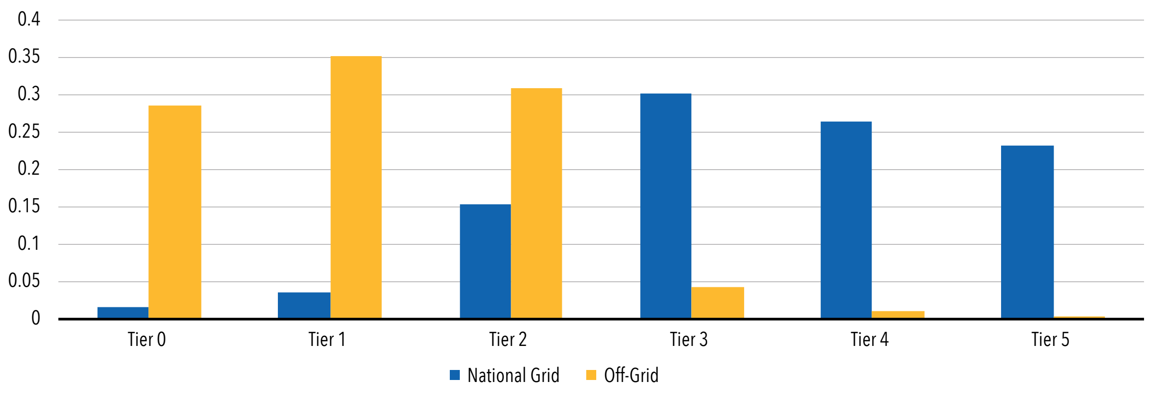
FIGURE 1.17 • SHARE OF MONTHLY HOUSEHOLD SPENDING ON INEFFICIENT ENERGY FOR LIGHTING



Source: ESMAP 2022c.

MTF data from 15 countries indicate that an average of 71 percent of households using any off-grid solution are gaining access to a Tier 1 level of electricity service or above, while 36 percent enjoy Tier 2 or above. The most commonly used off-grid solution is a solar lantern (50 percent), followed by solar home systems (17 percent), mini-grids (13 percent), generators (12 percent), and rechargeable batteries (10 percent). The percentage of grid-connected and off-grid households reaching each tier of access shows off-grid solutions providing most of the Tier 1 and 2 connections, with grid electricity providing most of the Tier 3–5 connections (figure 1.18).

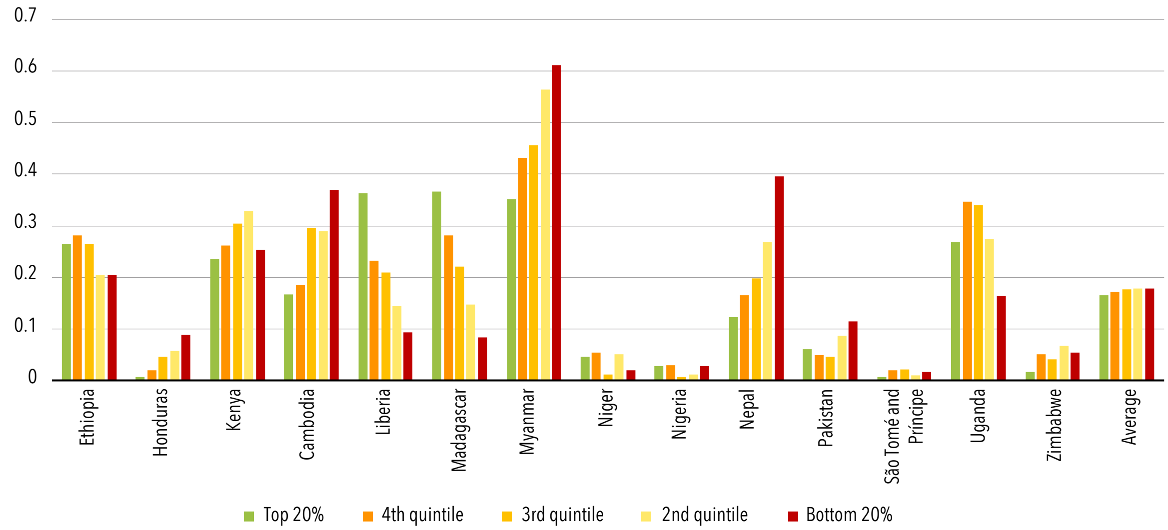
FIGURE 1.18 • PERCENTAGE OF GRID AND OFF-GRID HOUSEHOLDS REACHING EACH TIER



Source: ESMAP 2022c.

Across 15 countries, the penetration of off-grid solutions is typically higher in rural areas (the average is 20 percent) compared to urban areas (7 percent). The relationship between household income and the use of off-grid solutions varies, however. In countries such as Myanmar and Nepal, off-grid solutions are more likely to be used by lower-income households, perhaps because higher-income households are more likely to have access to a grid connection (figure 1.19). There is also likely to be a correlation between income and location, with higher-income households more likely to live in urban areas and lower-income households more likely to live in remote, rural areas where grid electricity is not available. In other countries, such as Liberia and Madagascar, higher-income households are more likely to use off-grid solutions, either because of limited grid access or because, where there is access, the quality of service is poor. In some cases, off-grid solutions can serve as a backup, particularly for more affluent households.

FIGURE 1.19 • PROPORTION OF OFF-GRID ENERGY SOLUTIONS BY WEALTH QUINTILE (PERCENT)



Source: ESMAP 2022c.

Modelling estimates of least-cost options for electricity access

Least-cost approaches to achieving universal electricity access under a range of demand scenarios are modeled in this section using the Global Electrification Platform (GEP n.d.). GEP is an open access, interactive online platform that models future electrification scenarios for countries with high access deficits. The scenarios present pathways for achieving universal electricity access, split into intermediate strategies from 2022 to 2025 and full electrification from 2020 to 2030. The tool, which uses data for 58 countries, was used to model pathways for achieving universal electricity access in the 20 countries with the largest access deficits.[9]

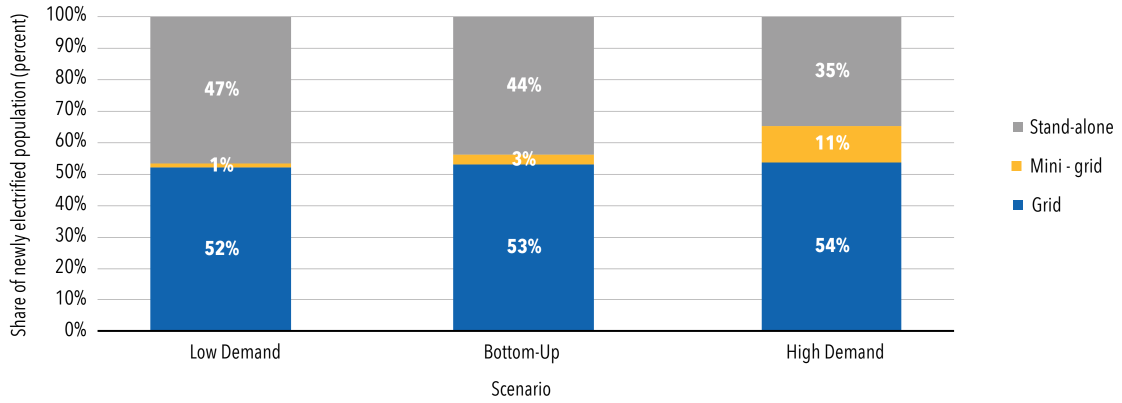
Residential electricity demand scenarios are modeled using projected population growth rates, combined with a target tier of electricity access and the associated electricity consumption level:

- In the "Bottom-Up" scenario, which is the base case, a unique demand target is set for each settlement, based on data on GDP and income levels.
- In the "Low Demand" scenario, urban demand is estimated based on 2020 levels of electricity consumption in electrified parts of the country, translated into the nearest equivalent access tier. Rural demand is set to Tier 1.
- In the "High Demand" scenario, the urban demand target is set one tier higher than 2020 levels of electricity consumption in electrified parts of the country (unless already Tier 5), while rural demand is set to Tier 2.

9 The top 20 access deficit countries are Burundi, Chad, Malawi, Burkina Faso, Niger, Democratic Republic of Congo, Madagascar, Uganda, Tanzania, Mozambique, Sudan, Zambia, Ethiopia, Angola, Mali, Kenya, Nigeria, Myanmar, Pakistan, and South Sudan.

In the Bottom-Up scenario, out of a total of 826 million new connections from 2022 to 2030, 439 million are made to the grid (53 percent), 363 million (44 percent) to stand-alone PV, and a further 24 million (3 percent) to mini-grids. By 2030, this results in 71 percent of the total population being reached by the grid, with a further 27 percent reached with stand-alone solar solutions and 2 percent served by mini-grids. In the Low Demand scenario, stand-alone PV plays a more prominent role; in the High Demand scenario, which envisages a Tier 2 level of household electricity access in rural areas, mini-grids provide 11 percent of new connections. In this latter scenario, there would also be greater productive use of electricity in commercial settings (figure 1.20).

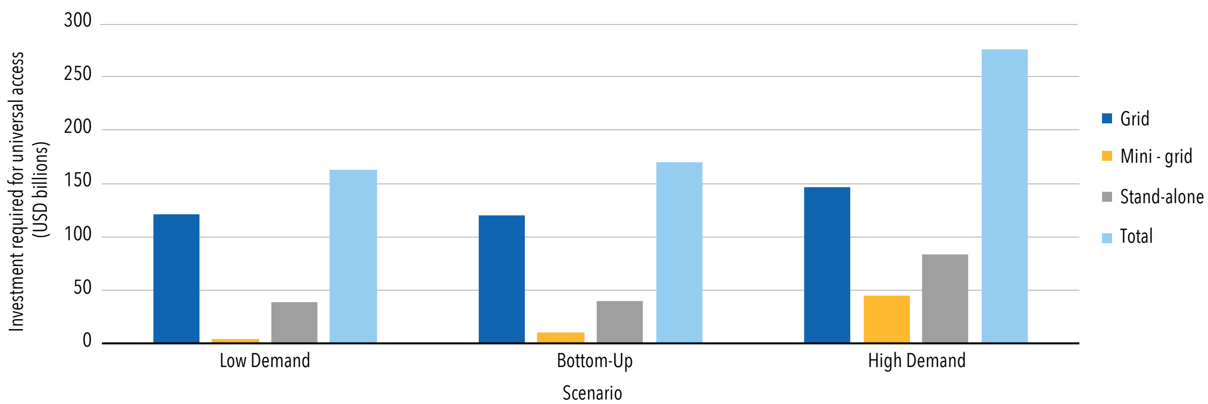
FIGURE 1.20 • NEWLY ELECTRIFIED POPULATION, BY SCENARIO, 2022–30



Source: World Bank 2024b.

The Bottom-Up scenario requires a total investment of USD 170 billion, with USD 120 billion invested in the grid, USD 40 billion in stand-alone PV, and a further USD 10 billion in mini-grids. The Low Demand scenario requires only slightly less investment (USD 163 billion), whereas the High Demand scenario requires a significantly greater total investment (USD 275 billion) (figure 1.21). These calculations are based on estimated up-front capital costs of each electrification solution and do not include ongoing operation and maintenance costs.[10] The GEP methodology is explained in box 1.2.

FIGURE 1.21 • GLOBAL INVESTMENT REQUIRED FOR UNIVERSAL ELECTRICITY ACCESS, BY SCENARIO (BILLIONS OF DOLLARS)



Source: World Bank 2024b.

10 For more information on OnSSET cost assumptions for each technology, see Korkovelos and others (2019).

Box 1.2 • Methodology of the Global Electrification Platform

To estimate demand, GEP uses population density maps to identify settlements. Geospatial information such as distance to the closest electricity grid, population density, and brightness at night (using satellite imagery) is used to determine the size and current electrification status of each settlement.

Commercial electricity demand is added as a multiplier of residential demand (30–60 percent), estimated using an economic index measuring GDP and accessibility (e.g., travel time to major cities). The location and size of education and health institutions are gathered from national data sets and OpenStreetMap, with electricity demand estimated based on the size of the institutions.

Least-cost technologies for each settlement are identified based on the levelized cost of electricity, taking into account the costs of transmission, distribution, and generation as applicable for each technology type and including both up-front capital costs and ongoing operation and maintenance costs.[a] The model assumes linear progress toward a final electrification rate of 100 percent by 2030. Based on a review of the rate of progress in a range of countries, it also assumes that the grid can at most double its generation capacity and connect an additional 2.5 percent of the population per year until 2025. Between 2025 and 2030, no such limitations are applied. The model indicates the technology mix, capacity, and investment requirements for achieving universal access in the modeled countries.[b]

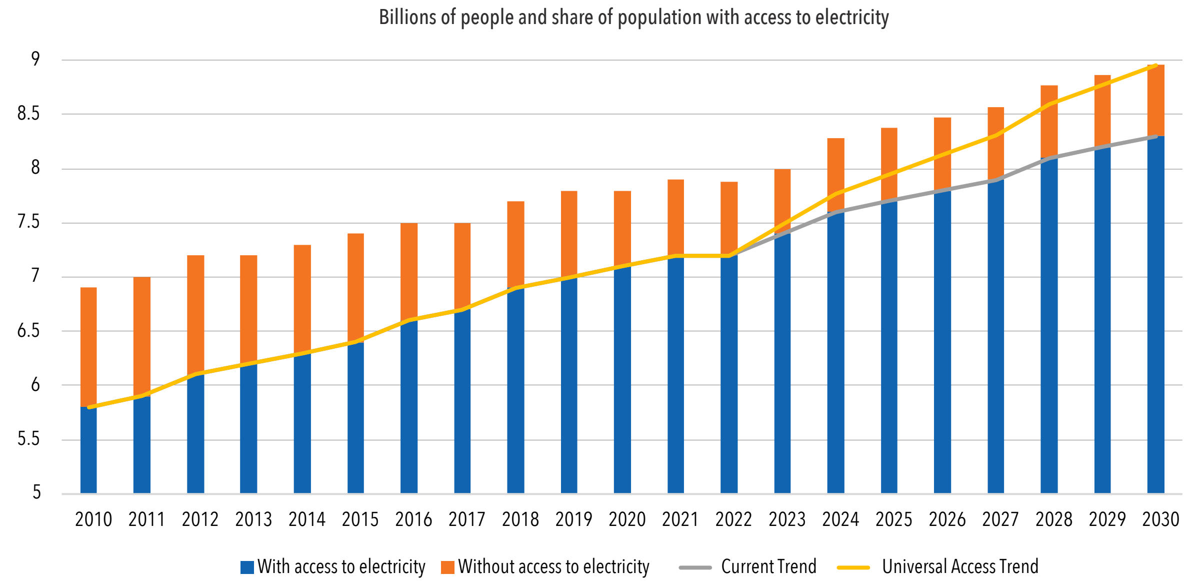
a. For more information on how the levelized cost of electricity can be calculated, see World Bank (2020).

b. For more information about the Open Source Spatial Electrification Tool (OnSSET) methodology that underpins the Global Electrification Platform, see Sahlberg and others (2020).

Looking ahead to 2030

Experience from several countries reveals the feasibility of accelerating the pace of electricity access, as pledged by the Global Roadmap for Accelerated SDG 7 Action in Support of the 2030 Agenda for Sustainable Development and in pursuit of the Paris Agreement on Climate Change (UN 2021). Attainment of the goal is particularly feasible through the promotion of off-grid solutions such as stand-alone PV and mini-grids. For example, Kenya moved from 36 percent access in 2011 to 75 percent in 2018 (Dubey and others 2019), while Rwanda has gone from an 11 percent access rate in 2011 to over 60 percent today (World Bank n.d.). Stand-alone off-grid solar solutions have made a significant contribution to progress in electricity access in both countries, providing Tier 1 and Tier 2 solutions. In Rwanda's case, notable success factors included government ownership, leadership, and commitment; an accountable and dedicated promotional structure; institutional strengthening; availability of funding; private sector involvement; and policy reforms (World Bank 2024a). These growth rates are even steeper than those achieved by past electrification champions, such as Vietnam, Thailand, and China. Figure 1.22 shows progress from 2010 to 2022, the current trend, and the trend required to achieve universal access.

FIGURE 1.22 • PROGRESS IN ELECTRICITY ACCESS FROM 2010 TO 2030



Source: IEA and World Bank 2024b.

But if mini-grid and stand-alone PV solutions are to fulfill their potential, a significant increase in the level of investment will be required—along with enabling policy and regulatory reforms, institutional strengthening, and capacity building. The stand-alone PV sector is projected to raise only USD 7.8 billion in investment between 2022 and 2030, and while data on mini-grid investment trends and projections are limited, this sector is also likely to be off-track (GOGLA and others 2022).

Scaling up the productive use of renewable electricity is critical to boosting incomes and resilience, while finding sustainable models for the electrification of public institutions will be essential for the reliable provision of health, education, and other social services. The total amount of funding for productive uses increased from USD 25 million in 2021 to USD 65 million in 2023 (GOGLA 2023b). Governments have steadily scaled up investments in electrification of public facilities through World Bank–funded projects since 2019; other major players include the UN Development Programme, GAVI, UNICEF, Power Africa, the SELCO Foundation, and the World Health Organization (SEforALL 2024).

The next two sections summarize recent developments in productive uses of electricity and the sustainable electrification of public institutions, before outlining what is needed for each sector to scale up.

PROMOTING THE PRODUCTIVE USE OF RENEWABLE ELECTRICITY

The productive use of electricity in rural communities contributes to socioeconomic development and improves quality of life. Productive use technologies such as solar water pumps, refrigerators, agri-processing machinery, and a wide range of equipment and tools for vocational, service, and other microenterprises increase incomes and raise productivity, contributing to job creation, the emergence of new enterprises, and economic growth. Much off-grid productive use to date has focused on improving agrifood systems, for example by improving the availability of water with irrigation and extending the shelf-life of food with refrigeration, which not only increases incomes but also enhances climate resilience and food security (World Bank 2023a).

A new generation of more affordable, high-performing tools and technologies for the productive use of renewable energy is emerging, promising a positive impact on incomes and quality of life for end users. In 2023, GOGLA reported continued growth of stand-alone solar appliances for productive uses, such as water pumps and refrigerators, with cumulative sales exceeding USD 1 million for the first time (GOGLA 2023a). A recent longitudinal study found that after four years, 86 percent of solar water pump users reported increased yields, and 70 percent found that their quality of life had very much improved. For refrigerator owners, 96 percent reported their businesses had gained more customers, logged more hours of operation, and increased inventory and supplies (Efficiency for Access and 60 Decibels 2023).

By increasing demand for electricity in grid- and mini-grid-connected settings, productive use technologies make an important contribution to the financial viability of rural electrification projects and businesses (World Bank 2023a). Research by the CrossBoundary Innovation Lab (2022) finds that average consumption per user was 48 percent higher in sites where appliance financing was made available (compared to control sites), with the top 20 percent of appliance financing customers consuming 16 times more than their peers. High-consuming customers ran equipment or machinery that met specific community needs, such as sewing, weaving, ice-making, and carpentry. An assessment of productive use programs implemented by Mlinda, India's leading mini-grid developer, found that microenterprises increased revenues by 28 percent.

Despite the growth in sales of productive use tools and technologies, adoption has been slow. This is due to challenges typical of emerging technologies and markets, such as low consumer awareness, product reliability, and affordability, as well as access to finance and capacity constraints at both the end-user and company levels (GDC 2022). There is a need for collaboration across the energy, water, and agriculture sectors to address these challenges, and for an enabling policy environment to accelerate adoption (WRI 2024).

According to a World Bank report, Accelerating the Productive Use of Electricity (2023a), five key building blocks are needed to accelerate access to productive use technology:

- **Planning.** Productive use needs to be integrated into rural electrification plans, both to maximize the development impact of energy access and to enhance the financial viability of rural electrification business models. GIS-linked data and analysis tools, as well as rural appraisals, can help to identify high-potential opportunities.

- **Technology and innovation.** Continued investment is needed to enhance the performance of productive use equipment while reducing its cost, alongside quality-assurance measures to mitigate technology risks. There is also a need to invest in innovative business models and digitalization, workforce skills, and stronger capacity among end users and companies. In particular innovations should focus on local needs and capacities to absorb and adapt technologies and business models to archive rapid replication and scale-up.
- **Access to finance.** End-user finance, essential to overcoming affordability constraints, could be provided either through suppliers of productive use technology, microfinance institutions, or local banks. Financial instruments such as up-front grants, results-based financing, credit lines, and guarantees can help to attract private debt and equity into the sector, enabling suppliers of productive use equipment to scale up.
- **Market and business development.** Raising awareness and marketing productive use technologies to local leaders, small businesses, and savings and cooperative groups, among others, is essential to accelerating adoption. Once small businesses have adopted productive use technologies, it is crucial that they be able to find buyers for their products and services. Collaboration across the energy, water, and agriculture sectors is essential to ensure that businesses have clear value propositions, ample access to technical and promotional information, adequate support to develop their businesses, and access to markets for their products.
- **Policy and regulation.** Tax exemptions or subsidies are needed to accelerate growth of the market in productive uses of renewable energy. Standards covering both productive use technologies and the services provided by the companies making use of those technologies are vital to protect consumers. Those standards must extend into areas such as consumer financing, repair, and e-waste management. Geospatial mapping exercises, household surveys, agricultural surveys, and market intelligence studies undertaken by governments can all help to inform data-driven decision-making by private sector, governments, and investors.

ELECTRIFICATION OF PUBLIC INSTITUTIONS

Affordable, reliable, and modern electricity services are key to improving nutrition, health care, education, jobs, and skills—all of which contribute to human capital development. Close to 1 billion people in low- and lower-middle-income countries are served by health-care facilities without reliable electricity access or with no electricity access at all. Approximately 12 percent of health-care facilities in South Asia, and 15 percent in Sub-Saharan Africa, have no access to electricity (WHO 2023). About 186 million children go to primary schools without any access to electricity (UNICEF 2023). Access to reliable electricity facilitates education by powering schools, enabling students to study after dark, and providing resources like computers and internet access. It supports health-care systems by allowing for the operation of medical equipment and refrigeration of vaccines.

Most unelectrified public institutions are in remote, hard-to-reach areas where grid electricity is not available—and not likely to become available in the near term, given the high cost and slow pace of grid extension. In these cases, the most cost-effective solution to electrifying such facilities is typically via stand-alone solar systems and storage solutions. The conventional approach is through engineering, procurement, and construction (EPC) contracts. In this model, once systems are installed, ownership is transferred to the relevant ministries, which often lack the capacity and funding required to cover operation and maintenance. Despite efforts to ensure longer-term operation and maintenance, EPC approaches have not passed the test of time.

To reverse this trend, the World Bank and other development partners—including SEforALL, the UN Development Programme, and Power Africa—are deploying new strategies to ensure sustainable electricity service provision to health centers and schools, such as the "energy as a service" model. The EaaS model leverages the expertise and capital of the private sector to deliver electricity services to public institutions, while ensuring that financing and incentives are structured over the long term, usually 10 to 15 years (SEforALL and ESMAP 2021). Electricity service companies (ESCOs) are responsible for installation, operation, and maintenance. Asset ownership is typically retained by the ESCO during the payment period and transferred at the end of the contract. Remote monitoring platforms are used to track performance, with payments made to ESCOs based on availability of service. Capital grants may be offered to cover part of the up-front system cost in order to ensure that payments made over time are affordable for the public sector, while also ensuring bankability for the private sector. Derisking mechanisms such as guarantees are used to cover cases of nonpayment by health facilities or schools.

The EaaS model is being implemented in several countries, with the World Bank's Uganda Electricity Access Scale-Up Project representing the largest application so far, initially targeting 700 facilities (World Bank 2022a). Further pilots are being undertaken in Nigeria and Benin within the World Bank's Regional Off-Grid Electricity Access Project (World Bank 2019). Through the Distributed Access through Renewable Energy Scale-Up Platform (DARES) the World Bank, International Finance Corporation, and Multilateral Investment Guarantee Agency have committed to work together to electrify 100,000 public institutions using the DARES model (World Bank 2022b). As a first step, the Accelerating Sustainable and Clean Energy Access Transformation program was launched in 2023; ASCENT targets 50,000 schools and health centers in East and Southern Africa (World Bank 2023b). To support these projects, tools and resources have been developed by the World Bank, the Energy Sector Management Assistance Program, and SEforALL, including quality-assurance frameworks, bid-specification templates, design templates, and market assessments.[11]

The World Bank, SEforALL, the UN Development Programme, Power Africa, and other development partners are assembling the building blocks needed to implement EaaS and other private sector–led models. Such building blocks include a conducive enabling environment that encompasses coordination among energy and education stakeholders; fiscal reforms to increase the health and education sector's ability to pay for ongoing electricity services; data resources to ensure demand-driven design; capacity building; and financial risk mitigation mechanisms to support both service providers and public sector agencies.

The World Bank's and SEforALL's report, From Procurement to Performance (SEforALL and ESMAP 2021), makes the following recommendations to scale up modern, affordable, sustainable, and reliable electricity services for public institutions via EaaS in low- and lower-middle-income countries:

- **Invest in data.** Data are needed on the location and electrification status of public institutions, as well as their level of demand and ability to pay for electricity services.
- **Support demonstration.** Donors and development finance institutions should support experimentation and the demonstration of service-based models through pilots. Their support should also help identify and address risks faced by different stakeholders, including government, donors, companies, and investors. Grants and loans will be needed to scale up, including concessional financing and derisking mechanisms, as well as technical assistance and capacity building.
- **Foster dialogue and knowledge exchange.** For this model to be successful, stakeholders need to come together to exchange best practices and to identify remaining barriers. A platform needs to be in place—especially at the national level—to allow the process to be inclusive of public and private sector actors, as well as stakeholders in energy, education, and health.
- **Rally the sector behind sustainable delivery models.** To be truly viable and scalable, service-based models will eventually require greater buy-in, support, and coordination among a range of stakeholders, including governments, development finance institutions, service providers, and investors.

11 For more information, see ESMAP (2024b) and SEforALL (2024).

ACHIEVING SDG TARGET 7.1

SDG target 7.1 can be met by 2030 only through a combination of grid, mini-grid, and stand-alone solutions. Distributed solutions that can leverage a much larger set of stakeholders, including consumers themselves, can lead to faster deployment speeds and thus help close the access gap quickly. There is a parallel need to improve the performance, condition, and financial viability of the grid so that government funds are used efficiently, thereby freeing up resources to help close the access gap. The 2022 edition of this report highlighted the need to reinforce policy and regulatory frameworks; enhance the socio-economic inclusiveness of energy access; align the costs, reliability, quality, and affordability of energy services; and catalyze, harness, and redirect financing for energy access (IEA, IRENA, UNSD, World Bank, WHO 2022). The 2023 edition made further policy recommendations about how to strengthen linkages with other SDGs (IEA, IRENA, UNSD, World Bank, WHO 2023).

These recommendations can be implemented through national and regional electrification programs that use public funding to unlock private co-investment. The World Bank has partnered with the African Development Bank Group on an ambitious effort to provide at least 300 million people in Africa with electricity access by 2030 (World Bank 2024c). It has also launched ASCENT, a USD 5 billion program designed to attract an additional USD 10 billion in investment for the purpose of exponentially accelerating sustainable and clean energy access and providing life-transforming opportunities for 100 million people in up to 20 countries across Eastern and Southern Africa over the next seven years. With 365 million people without electricity and 558 million without clean cooking, the region accounts for more than half of the world's unelectrified population and nearly a quarter of people without access to clean cooking fuels. As described in this chapter, the lack of access hinders the region's economic recovery, resilience, and progress toward poverty reduction.

ASCENT, one of the world's largest energy access programs to date, is organized into three pillars. The first focuses on the development of regional and national platforms to enable economies of scale and cost-reduction strategies. The second pillar provides investment and technical assistance for grid densification and expansion; grid connections, reinforcement, and upgrading; and investments in integration of variable renewable energy. The third pillar finances investments in distributed renewable energy and clean cooking to expand energy access for households, enterprises, farmers, schools, health clinics, and other institutions. ASCENT leverages digital technologies for remote monitoring of solar home systems and mini-grids, verification of results, planning, and reporting. The program will begin in four countries (Rwanda, São Tomé and Príncipe, Somalia, and Tanzania) before expanding to up to 20 countries in the region over the next seven years (World Bank 2023b).

Conclusion

There is much to celebrate as we take stock of global progress in efforts to expand access to electricity. From the baseline year of 2000, when 78 percent of the world's population enjoyed access to electricity, we have now reached an access rate of 91 percent. This has been achieved despite significant population growth and global disruptions such as COVID-19 and the conflict in Ukraine.

Even as we recognize this success, however, we must remember that 685 million people were still living without electricity in 2022—the vast majority in Sub-Saharan Africa. They represent some of the world's most vulnerable people, located in remote areas with limited institutional capacities, often in areas beset by conflict and poverty. All of this makes them more difficult to serve than most of those already reached. Since 2000, the highest rate of increase achieved in electricity access was 0.77 percent per year over the period 2010–20, but over the next six years we must reach an increase of at least 1.08 percent each year to meet our target of universal access by 2030.

While daunting, this challenge is not insurmountable. But it will require thinking outside the box, strong commitments, deep partnerships, increased investments, and collaboration to meet the common goal of universal access. Some suggestions along these lines are outlined below:

- Sub-Saharan Africa, which accounts for 83 percent of the remaining access deficit, must remain a key focus of electrification activities. A particular focus on those countries with the largest populations lacking access—the Democratic Republic of Congo, Nigeria, and Ethiopia—will be critical.
- Even as we accelerate efforts to expand the grid, attention and investment must focus on off-grid and mini-grid options that can be deployed rapidly and affordably through combined public-private efforts.
- In parallel, modern tools must be deployed to improve the performance of the grid and off-grid infrastructure, as well as to gather more accurate information to track access and inform data-driven decision-making, all for the purpose of squeezing efficiencies and freeing up resources in a constrained fiscal space.
- Scarce public funding must be targeted toward those with lower affordability thresholds, requiring a deeper understanding of consumers so that funds can be directed to have the greatest impact. Public funds must also be used to catalyze private investment, in order to maximize total investments in the achievement of access goals.
- Productive uses of renewable energy and the electrification of public facilities in off-grid settings can be promoted through cross-sectoral approaches involving energy stakeholders collaborating with counterparts in agriculture, water, education, health, and other sectors.
- Building capacity in planning, management, data gathering, and monitoring is crucial. Improving the quality and frequency of data collection on energy access—while ensuring that data are disaggregated by gender—will be essential in building a just and inclusive energy sector. By scaling up household surveys and using new tools for outreach and analysis, the pace and efficacy of implementation can be accelerated.
- Access efforts must move beyond a focus on connections toward one of ensuring sustainable service over time, factoring in reliability, social impact, resilience, and social justice.

The exercises just described should encourage South-South learning, particularly in view of the successes achieved in Latin America, East Asia, and most recently in Central and South Asia between 2010 and 2022.

We hope that this edition of the SDG 7 Tracking Report will highlight the need to accelerate efforts through deeper partnerships and increased investments, particularly toward decentralized solutions, to enable universal access to electricity by 2030.

Photo: © Adobe Stock by Joshua Resnick

CHAPTER 2
ACCESS TO CLEAN FUELS AND TECHNOLOGIES FOR COOKING

Main messages

- **Global trend.** In 2022, 74 percent (70–77)[12] of the global population had access to clean cooking fuels and technologies, an increase of 16 points from 2010. Despite the progress, some 2.1 billion (1.8–2.4) people were still using polluting fuels and technologies for most of their cooking.
- **Target for 2030.** Urgent efforts are required to accelerate progress toward universal access to clean cooking by 2030. If current trends continue, only 79 (75–81) percent of the world's population are expected to have access to clean cooking fuels and technologies by 2030, leaving close to 1.8 billion reliant on traditional and inefficient stoves paired with solid fuels (wood, charcoal, coal, crop waste) and kerosene for cooking. It is estimated that if no action is taken, 6 out of 10 people lacking access to clean cooking will reside in Sub-Saharan Africa in 2030, with little or no improvement expected by 2050.
- **Regional highlights.** The access deficit has decreased consistently in Eastern Asia and South-eastern Asia since 2000, and in Central Asia and Southern Asia since 2010. By way of contrast, in Sub-Saharan Africa the deficit in access has a clear upward trend as progress toward clean cooking has not kept pace with the region's growing populations.
- **Urban-rural divide.** Urban areas continue having greater access to clean cooking fuels and technologies compared to rural areas. But the urban-rural disparity is fading. Over the past decade, rural areas have benefited from a remarkable rise in access, while urban areas have seen slower rates of improvement. In 2010, 82 percent (78–84) of urban residents had access to clean cooking, rising slightly to 88 percent (85–90) in 2022. Meanwhile, the percentage of rural residents with access to clean cooking grew from 30 percent (27–35) in 2010 to 54 percent (49–59) in 2022, marking a five-fold improvement compared to urban areas during the same period.
- **The 20 countries with the largest access deficits.** The 20 countries with the largest access deficits accounted for 74 percent of the global population without access to clean cooking, including 10 countries in Sub-Saharan Africa, where in 2022 more than 923 (888–954) million people had no access to clean cooking fuels and technologies. In 14 of the 20 countries, less than half the population had access to clean cooking fuels and technologies. Moreover, in 8 of the 20 countries (all in Sub-Saharan Africa), less than 10 percent of the population had access.
- **Global and regional fuel trends.** In low- and middle-income countries (LMICs) in 2022, gaseous fuels (liquefied petroleum gas [LPG], natural gas, biogas) were used by 60 percent (55–64) of people (4 billion) as their main energy source for cooking. Unprocessed biomass (wood, crop waste, dung) was the main fuel for 26 percent (22–30) of people (1.7 billion); electricity, for 8 percent (6–11) of people (550 million); and charcoal, 4 percent (3–4) of people (241 million). In 2022, coal and kerosene were the main fuels for only 1 percent of people.
- Integrating electric cooking into a country's broader electrification efforts creates synergies that enhance energy security, manage fuel costs, and align with global energy and climate goals on the path toward universal access to clean cooking.

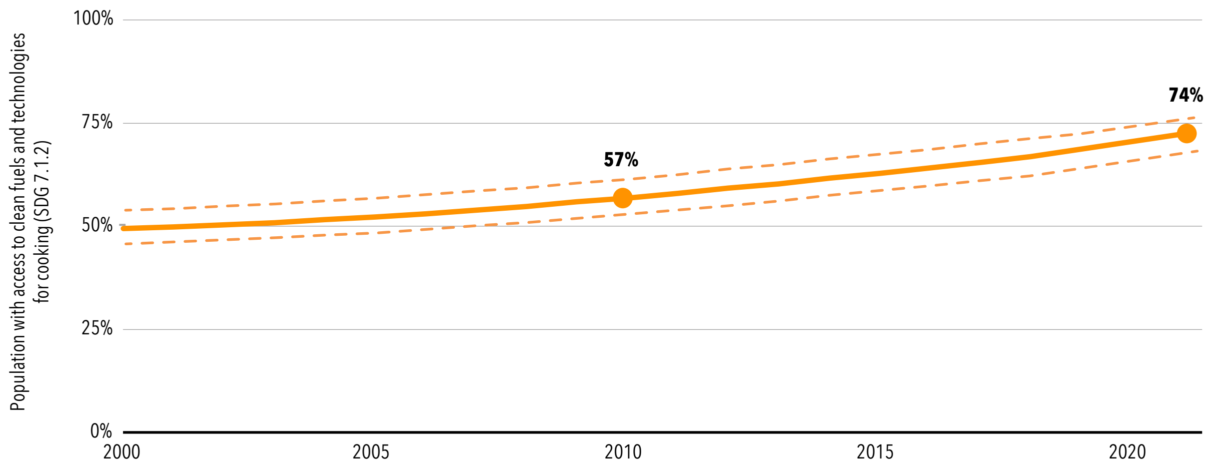
12 Throughout the chapter, parenthetical figures appearing after estimates are 95 percent uncertainty intervals, as defined in the methodology section at the end of the chapter. Clean fuels and technologies include stoves powered by electricity, LPG, natural gas, biogas, solar, and alcohol. Clean fuels and technologies are as defined by the normative technical recommendations by the World Health Organization (WHO 2014). Detailed datasets with country data for the SDG 7 indicator discussed in this chapter can be accessed at no charge at https://trackingsdg7.esmap.org/downloads.

Are we on track?

The world is not on track to achieve universal access to clean cooking by 2030. In 2022, 74 percent (70–77) of the world's population had access to clean cooking fuels and technologies (e.g., stoves powered by electricity, LPG, natural gas, biogas, solar, and alcohol). Approximately 2.1 billion (1.8–2.4) people still relied on polluting fuels and technologies (e.g., charcoal, coal, crop waste, dung, kerosene, and wood) as their main energy source for cooking. These estimates refer to the use of main fuels only and exclude the cookstove and fuel combinations.[13]

Some progress has been seen in the global access rate over the past two decades, as seen in figure 2.1. Yet if current trends continue, only an estimated 79 percent (75–81) of the global population will have access to clean cooking fuels and technologies by 2030. This falls far short of the 2030 target of universal access and leaves nearly 1.8 billion people exposed to the adverse effects of polluting cooking fuels and technologies on human health, livelihoods, and the environment.

FIGURE 2.1 • PERCENTAGE OF THE GLOBAL POPULATION WITH ACCESS TO CLEAN COOKING FUELS AND TECHNOLOGIES, 2000–22

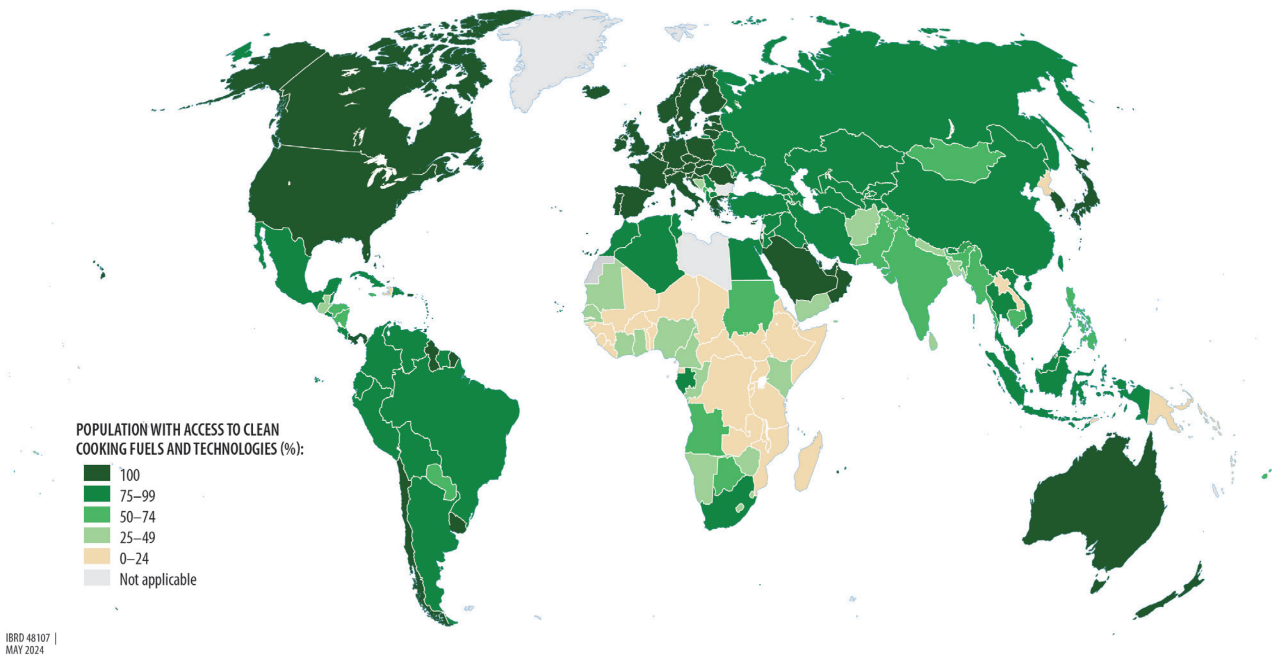


Source: WHO 2024a.
Note: Dashed lines are 95 percent uncertainty intervals.
SDG = Sustainable Development Goal.

The number of people worldwide without access to clean cooking continues to fall each year, although regional variability exists (figure 2.2). The number of people without access in Sub-Saharan Africa is growing at a rate of nearly 20 million people per year. Although there have been some improvements in the percentage of those with access, these gains have not kept up with the region's population growth, to the detriment of the almost 1 billion people already suffering the negative effects of polluting cooking in the region. The growing access deficit in Sub-Saharan Africa, if not addressed, has the potential to stall or reverse the current upward trajectory in global access.

13 Because of the limited availability of source data in nationally representative surveys on stove stacking, this chapter examines cooking fuel rather than fuel and technology combinations. Considering this limitation, lack of reporting on stove stacking, where both clean and traditional fuels are used, might undermine the perceived health and environmental benefits, as it does not take into account the limited household air pollution exposure to GHG emission reductions. The Annex 1 provides additional details on the methodology. Population estimates are from 2022. Population data from the 2018 revision of World Urbanization Prospects were used to derive the population-weighted regional and global aggregates. Low- and middle-income countries without data were excluded from all aggregate calculations; high-income countries were excluded from aggregate calculation for specific fuels.

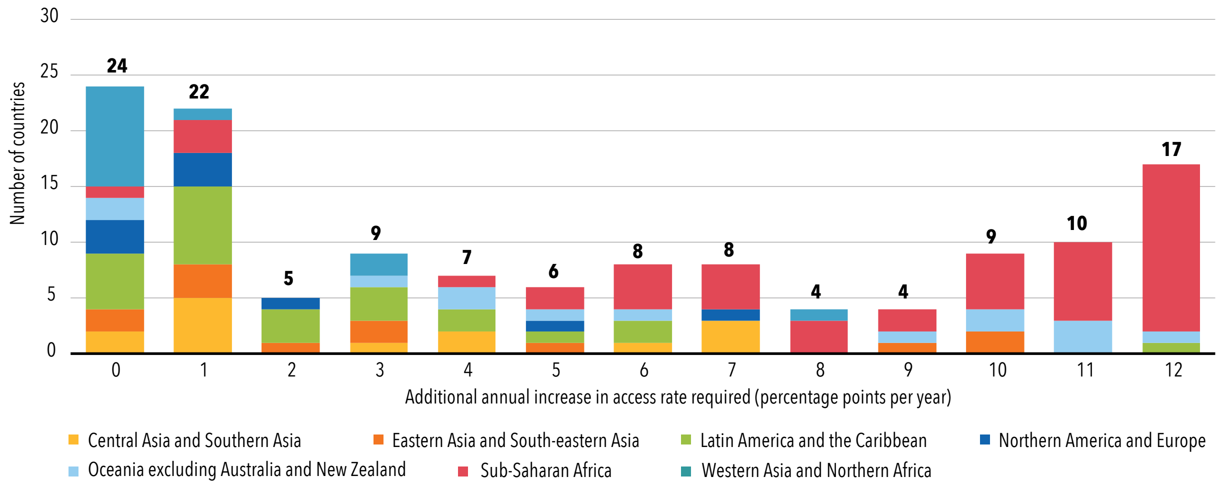
FIGURE 2.2 • SHARE OF POPULATION WITH ACCESS TO CLEAN COOKING FUELS AND TECHNOLOGIES, 2022 (PERCENT)



Source: WHO 2024a.
Disclaimer: This map was produced by the Geospatial Operations Support Team of the World Bank based on the Cartography Unit of the World Bank. The boundaries, colors, denominations, and other information shown do not imply any judgment on the part of the custodian agencies concerning the legal status of or sovereignty over any territory or the endorsement or acceptance of such boundaries.

Without a greater effort, the vast majority of LMICs will miss the 2030 universal access target. Greatly accelerated progress is therefore urgently needed if the world is to achieve universal access by 2030. In 44 countries, predominantly in Sub-Saharan Africa, a rise of 8–12 percentage points per year above current trends is needed to reach 100 percent access from 2022 to 2030 (figure 2.3).

FIGURE 2.3 • NUMBER OF COUNTRIES REQUIRING ADDITIONAL ANNUAL INCREASES IN ACCESS, ABOVE CURRENT TRENDS, TO ACHIEVE 100 PERCENT CLEAN COOKING BY 2030



Source: WHO 2024a.
Note: Additional required increases are calculated over the period 2022 to 2030 and rounded to the nearest percentage point. The number displayed above each bar represents the count of countries.
SDG = Sustainable Development Goal.

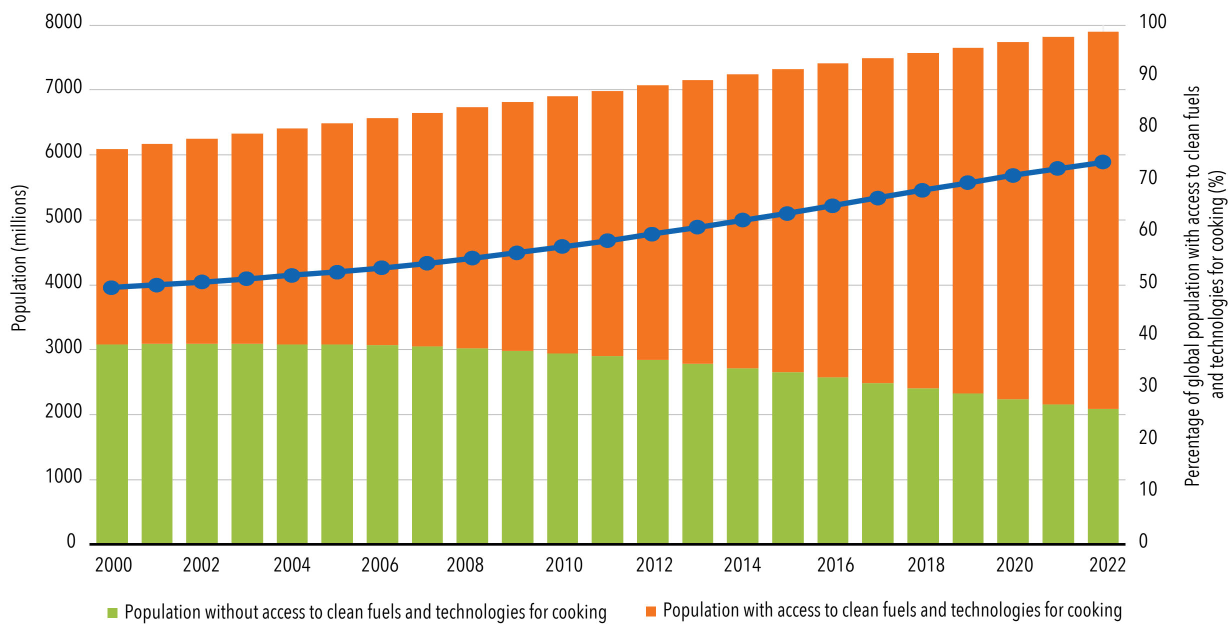
If these trends continue, as per most recent World Health Organization (WHO) estimates, only 408 million people will gain access to clean cooking between 2022 and 2025, while an additional 505 million people will gain access between 2025 and 2030. This indicates a significant and pressing need to ramp up efforts to ensure 1 billion more people obtain access to clean cooking solutions by 2025, as pledged by the Global Roadmap for Accelerated SDG 7 Action in Support of the 2030 Agenda for Sustainable Development and the Paris Agreement on Climate Change (United Nations 2021).

Looking beyond the main indicators

ACCESS AND POPULATION

The global rate of access to clean fuels and technologies for cooking reached 74 percent (70–77) in 2022. Figure 2.4 shows the access rate rising gradually over the past two decades, with gains totaling around 22 percentage points since 2000 and 16 percentage points since 2010.

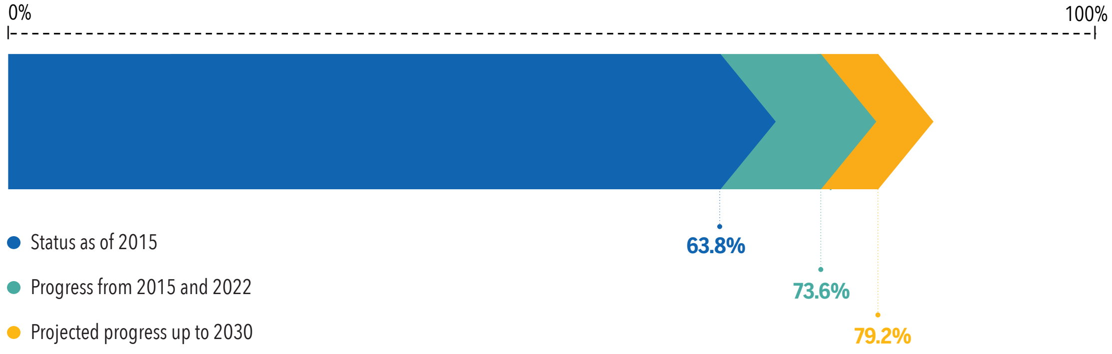
FIGURE 2.4 • CHANGE IN THE ABSOLUTE NUMBER OF PEOPLE (LEFT AXIS, BARS) AND PERCENTAGE OF THE GLOBAL POPULATION (RIGHT AXIS, LINE) WITH ACCESS TO CLEAN COOKING, 2000–22



Source: WHO 2024a.

An assessment of the trajectory toward the 2030 target reveals that progress has been made in some parts of the world. The pace of change remains insufficient, however, to achieve the universal access target within the stipulated timeframe. Urgent action is needed to bridge existing gaps, particularly in regions with entrenched deficits, to ensure equitable access to clean cooking fuels and technologies by 2030 and beyond. Despite global progress, only about 79 percent (75–81) of the population are projected to have gained access to clean cooking fuels and technologies by 2030 (figure 2.5).

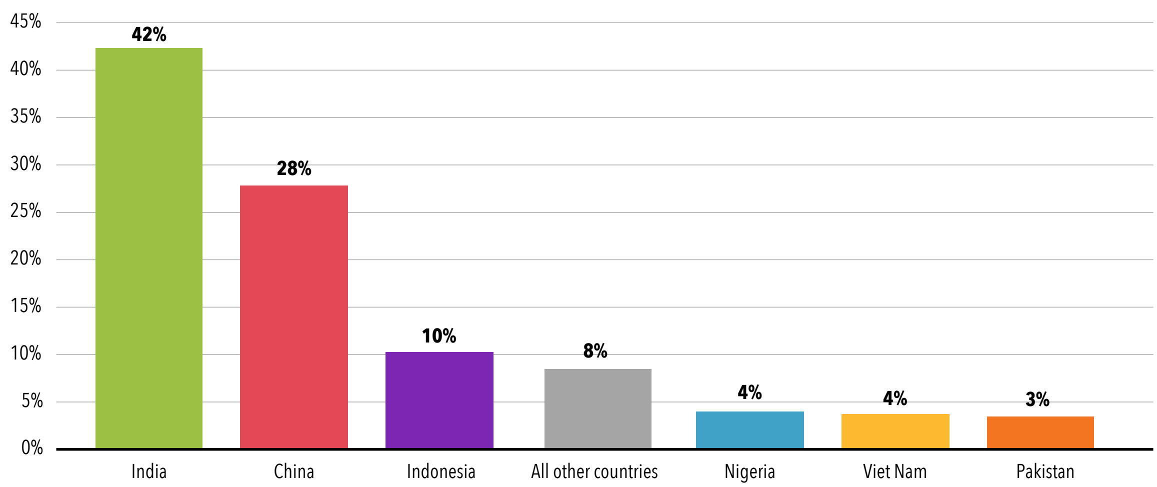
FIGURE 2.5 • PROGRESS TOWARD UNIVERSAL ACCESS TARGET, 2010–30 (IN PERCENTAGES)



Source: WHO 2024a.

Higher global access rates have largely been driven by progress in the most populous LMICs, such as India, China, Indonesia, Nigeria, and Pakistan (United Nations 2018). According to figure 2.6, 92 percent of progress in the global access rate since 2010 can be attributed to progress in only six countries, meaning only 8 percent of global gains were seen in all other countries combined (see the "Changes in Fuel Mix" subsection for breakdowns by fuel). This serves as another reminder that while good progress has been made in a handful of countries (four of which are the most populous globally), a number of less-populous countries have been lagging. If current trends continue, the overall access rate to clean cooking will reach only 61 percent in LMICs, excluding the five most populous LMICs.

FIGURE 2.6 • BREAKDOWN OF GLOBAL PROGRESS TOWARD UNIVERSAL ACCESS TO CLEAN COOKING SINCE 2010



Source: WHO 2024a.
LMICs = low- and middle-income countries.

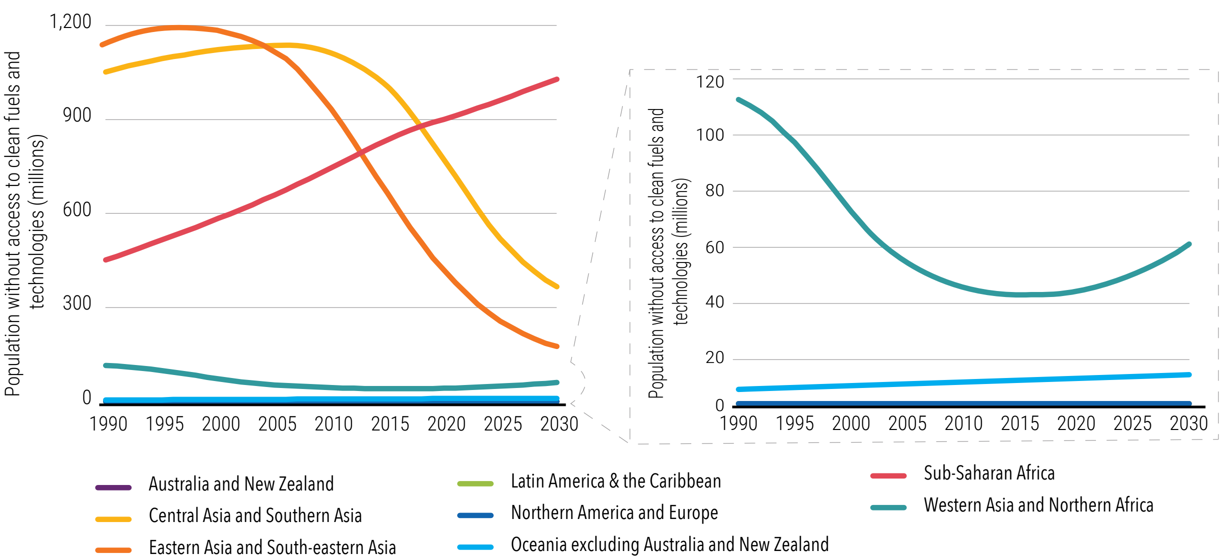
THE ACCESS DEFICIT

While gains have been made toward the 2030 target for universal access, major disparities persist. The slow pace overall highlights shortcomings in efforts to achieve the goal. On a global scale, the number of people with access to clean cooking has risen steadily over the past two decades (figure 2.5). But the total number of people with no access to clean cooking—an indicator of the number exposed to the damaging health and socioeconomic effects of polluting fuels and technologies, referred to here as the "access deficit"—began to drop only recently, from its historic high of around 2.9 billion people (2.7–3.2) in 2010 to 2.1 billion people (1.8–2.4) in 2022.

Countries in Sub-Saharan Africa, Central Asia, and Southern Asia dominate the global access deficit. In 2022, it is estimated that 79 percent (76–82) of the population in Sub-Saharan Africa and 33 percent (22–46) of people living in Central Asia and Southern Asia continue to rely on polluting fuels and cooking technologies. Figure 2.7 depicts how the access deficit has fallen consistently in Eastern Asia and South-eastern Asia since 2000 and in Central Asia and Southern Asia since 2010.

Sub-Saharan Africa remains the only region where the number of people without access continues to climb. The access deficit in Sub-Saharan Africa more than doubled between 1990 and 2022, primarily due to a rapid increase in population size (United Nations 2018), which translates into 923 million (888–954) people without access to clean cooking fuels and technologies in 2022. If no action is taken and current trends continue, the access deficit in Sub-Saharan Africa is projected to exceed 1 billion people by 2030.

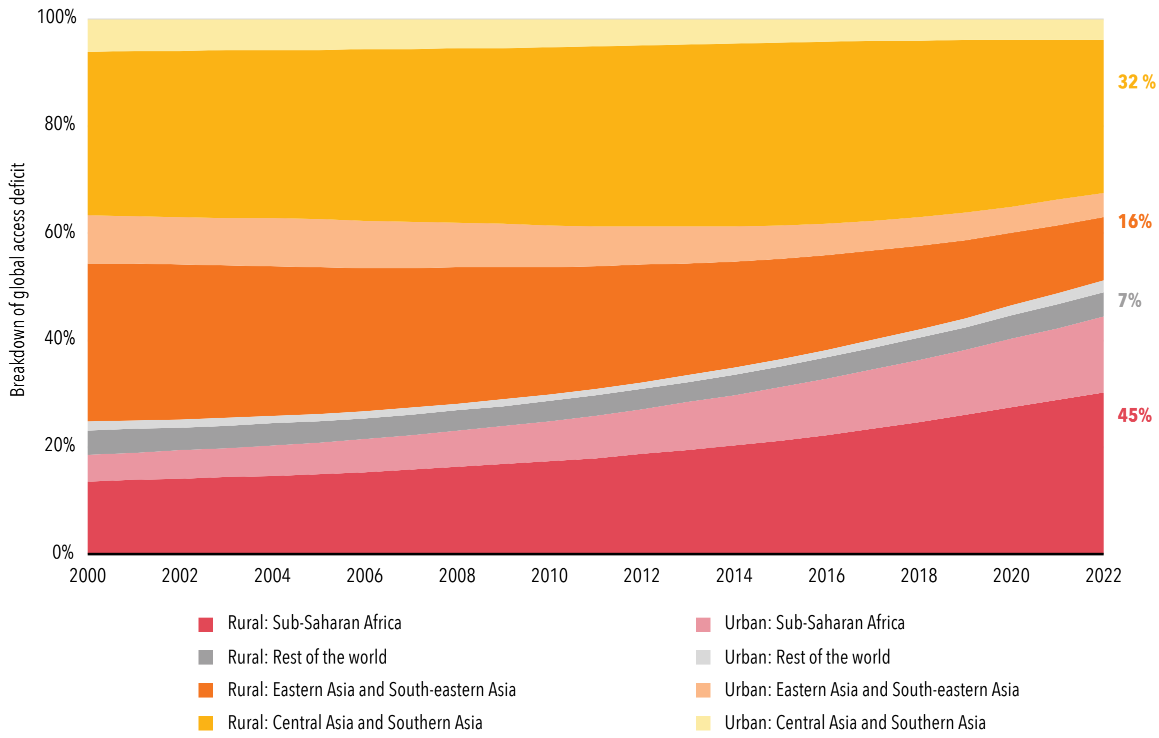
FIGURE 2.7 • NUMBER OF PEOPLE WITHOUT ACCESS TO CLEAN FUELS AND TECHNOLOGIES, BY REGION, 2000–22



Source: WHO 2024a.

Figure 2.8 illustrates the changing regional composition of the global population lacking access to clean fuels for cooking between 2010 and 2022. In 2000, 4 in 10 people lacking access to clean cooking lived in Central Asia and Southern Asia, 4 in 10 in Eastern Asia and South-eastern Asia, and 2 in 10 in Sub-Saharan Africa. By 2022, 5 in 10 people without access lived in Sub-Saharan Africa as a result of decreases in the access deficit in the two Asian regions and a stark rise in the deficit in Sub-Saharan Africa. If these trends persist, almost 6 in 10 people without access will reside in Sub-Saharan Africa by 2030.

FIGURE 2.8 • PROPORTION OF THE TOTAL GLOBAL ACCESS DEFICIT IN THE THREE LARGEST ACCESS-DEFICIT REGIONS AND THE REST OF THE WORLD, 2000–22



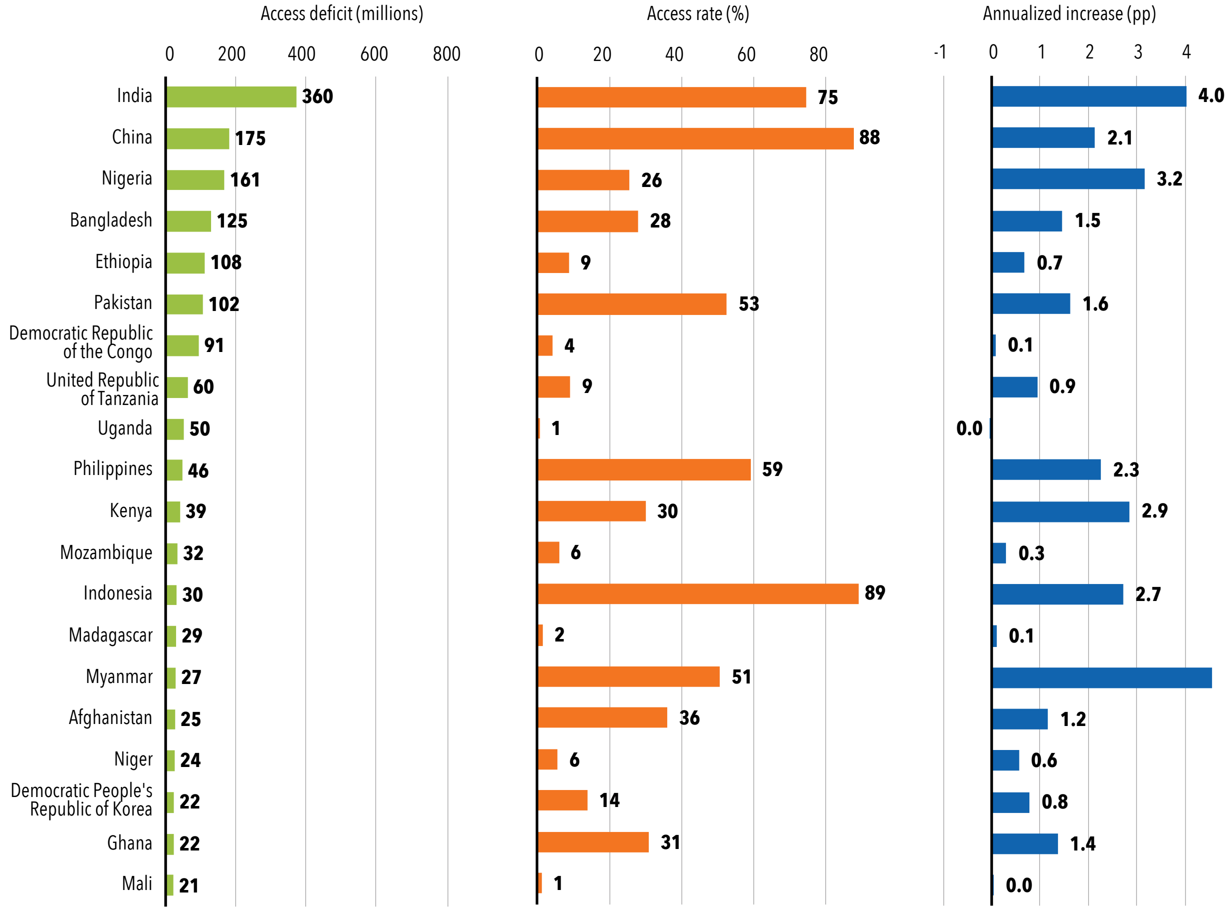
Source: WHO 2024a.

ANALYSIS OF THE TOP 20 ACCESS-DEFICIT COUNTRIES

Around three-quarters (74 percent) of the world's population without access to clean cooking are found in only 20 countries. India has the largest share of the access deficit, with 360 million (157–631) people lacking access, followed by China at 175 million (67–341) (figure 2.9).

In 8 of the 20 countries, less than 10 percent of the population has access to clean fuels and technologies. These countries are the Democratic Republic of Congo, Ethiopia, Madagascar, Mali, Mozambique, Niger, Uganda, and the United Republic of Tanzania. Additionally, 14 of the 20 countries have access rates below 50 percent.

FIGURE 2.9 • THE 20 COUNTRIES WITH THE LARGEST ACCESS DEFICIT BY ABSOLUTE POPULATION (VIOLET), ACCESS RATE (ORANGE), AND ANNUALIZED INCREASE IN ACCESS (GREEN, BASED ON THE 2017–22 AVERAGE)

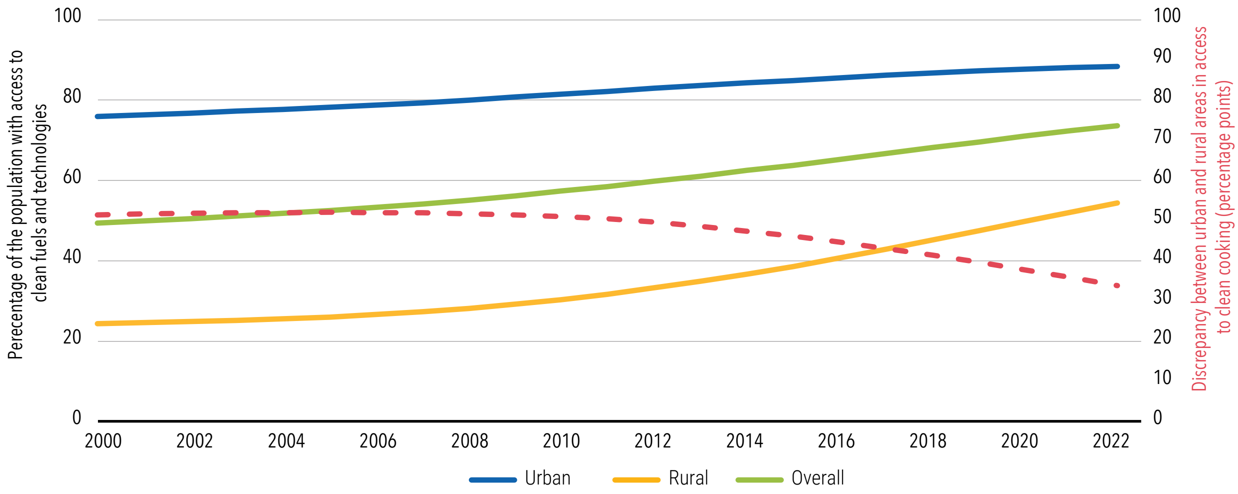


Source: WHO 2024a.
pp = percentage points.

URBAN-RURAL DIVIDE

Urban areas tend to adopt modern cooking fuels and technologies at a higher rate than rural areas. This may be due to better infrastructure (e.g., roads) and greater access to services and more reliable energy supply in urban areas. About 88 percent (85–90) of urban households globally have access to clean cooking, while only 54 percent (49–59) of rural households have access. Between 2010 and 2022, the percentage of people with access to clean cooking in urban areas only inched upward, from 81 percent (78–84) to 88 percent (85–90). On the other hand, the percentage of people with access in rural areas leaped from 30 percent (27–35) to 54 percent (49–59) during the same period, as illustrated in figure 2.10.

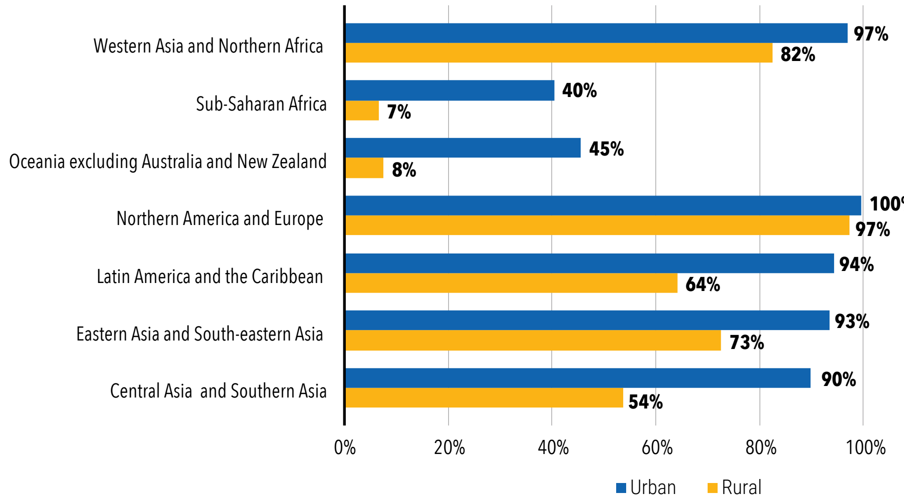
FIGURE 2.10 • PERCENTAGE OF PEOPLE WITH ACCESS TO CLEAN COOKING IN URBAN AREAS, RURAL AREAS, AND OVERALL (SOLID LINES), AND DISCREPANCY IN ACCESS BETWEEN URBAN AND RURAL AREAS (DASHED LINE)



Source: WHO 2024a.

The urban-rural gap across regions has been narrowing in all regions except Sub-Saharan Africa, where it is diverging dramatically. Notably, in Sub-Saharan Africa, only 7 percent (5–9) of rural households have access to clean cooking, while the figure is 40 percent (36–45) in urban areas (figure 2.11). Moreover, in Latin America and the Caribbean, one of the most urbanized regions in the world, 36 percent (29–44) of the rural population still lacks access to clean fuels and technologies for cooking. This discrepancy highlights the pronounced challenges faced by rural communities, where reliance on traditional biomass for cooking remains prevalent, affecting approximately 84 percent (80–87) of rural households in Sub-Saharan Africa. Such disparities disproportionately impacted the rural population and resulted in higher exposure to household air pollution, contributing to adverse health outcomes, particularly among women and children. Addressing this urban-rural gap requires evidence-based interventions that prioritize rural infrastructure development and targeted clean cooking initiatives.

FIGURE 2.11 • POPULATION WITH ACCESS TO CLEAN FUELS AND TECHNOLOGIES FOR COOKING BY SDG REGION (PERCENT)

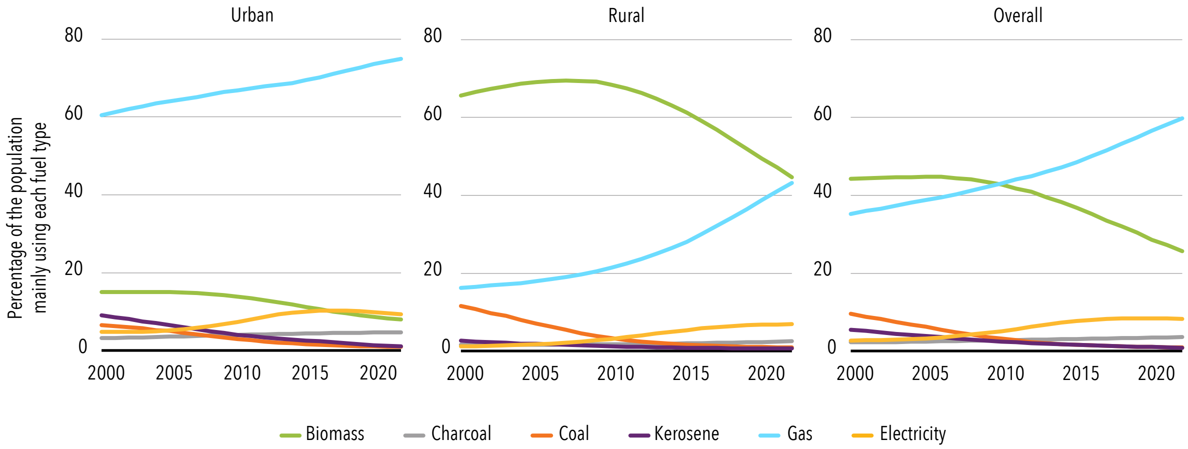


Source: WHO 2024a.
SDG = Sustainable Development Goal.

CHANGES IN THE FUEL MIX

A deeper look at the specific fuels and technologies used by LMICs in 2022 reveals that gaseous fuels (LPG, natural gas, and biogas)[14] remain the main energy source for cooking among 60 percent (55–64) of people (4 billion) (figures 2.12 and 2.14); electricity was the main fuel for 8 percent (6–11) of people (550 million). Unprocessed biomass (wood, crop waste, and dung), a polluting alternative, was the main fuel for 26 percent (22–30) of people (1.7 billion) and charcoal for 4 percent (3–4) (241 million). Coal and kerosene were used as primary cooking fuels by only 1 percent (0–2) (65 million) and 0.8 percent (0.5–1.8) (59 million) of people, respectively.

FIGURE 2.12 • PERCENTAGE OF PEOPLE MAINLY USING EACH TYPE OF COOKING FUEL IN LOW- AND MIDDLE-INCOME COUNTRIES, URBAN, RURAL, AND OVERALL



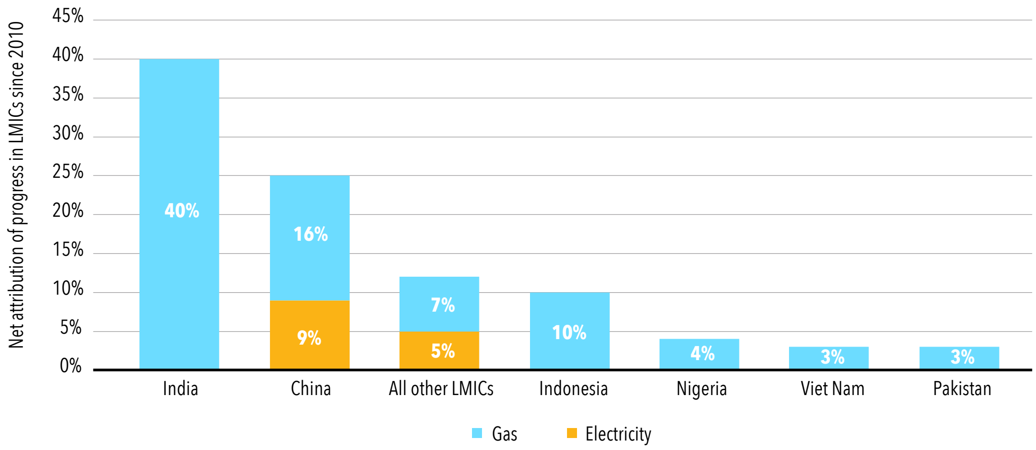
Source: WHO 2024a.

In around 2010, gas surpassed unprocessed biomass as the most commonly used fuel in LMICs owing to the rapid expansion of LPG programs in Ecuador and Bolivia, among other countries. Yet biomass continues to be the main fuel for cooking for 45 percent (40–50) of people (1.4 billion) in rural areas in 2022, more than any other type of fuel. Although the use of unprocessed biomass may be decreasing in both urban and rural areas, the reliance on charcoal is increasing in both areas. This is especially true among those living in LMICs and urban areas of Sub-Saharan Africa, where 30 percent (26–34) of people (146 million) primarily used charcoal for cooking in 2022.

Additionally, while considering the contributions since 2010 of different countries and fuel types toward universal access to clean cooking in LMICs (figure 2.12), we can see gas playing a dominant role; China being the only major contributor where electricity also plays a significant role. India, Indonesia, Nigeria, Viet Nam, and Pakistan rely entirely on gas for their contributions, indicating a lower adoption of electric cooking solutions in these countries (figure 2.13).

14 Gaseous fuels (or gas) refers to LPG, natural gas, and biogas together, as most input surveys do not differentiate among the three.

FIGURE 2.13 • BREAKDOWN OF PROGRESS TOWARD UNIVERSAL ACCESS TO CLEAN COOKING IN LMICS SINCE 2010 BY FUEL

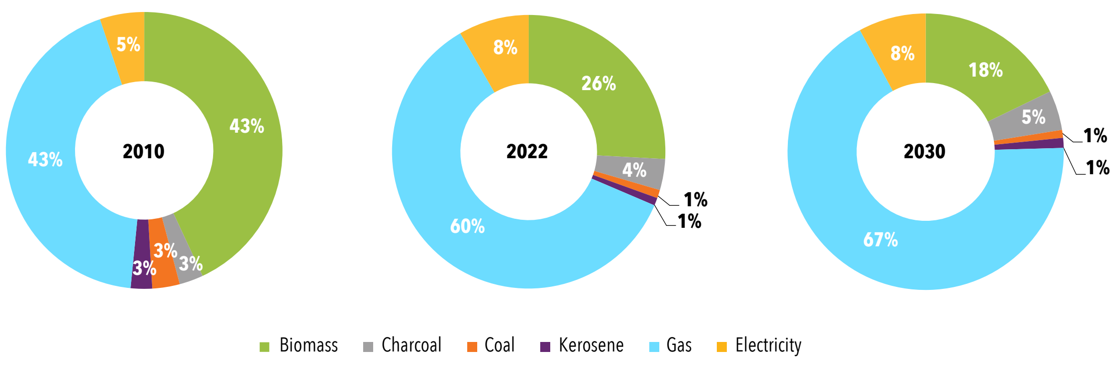


Source: WHO 2024a.
LMICs = low- and middle-income countries.

The use of gas as the primary fuel is increasing more quickly than electricity in rural areas and overall. In urban areas, however, the use of electricity is rising more quickly than gas. In 2022, the use of electricity in LMICs was the highest in Northern America and Europe, at 24 percent (15–35), or about 51.4 million people, followed by Eastern Asia and South-eastern Asia, at 17 percent (10–26), or about 360 million people.

Examining the historical progress in the proportion of people using clean fuels and technologies for cooking shows that it has been accompanied by steep declines in the use of unprocessed coal and kerosene. In 2010, coal was mainly used by 3 percent (1–6) of the population (180 million people) in LMICs, with 80 percent (150 million) residing in Eastern Asia and South-eastern Asia. In 2010, kerosene was the main cooking fuel of 2 percent (2–3) of the population in LMICs (142 million people), including 17 percent (11–25) of those in urban areas of Oceania (excluding Australia and New Zealand) and 16 percent (12–19) of those in urban areas of Sub-Saharan Africa. In 2022, kerosene or coal were the primary fuels for cooking among less than 2 percent of the combined population in LMICs.

FIGURE 2.14 • COMPARISON OF THE PERCENTAGES OF PEOPLE IN LOW- AND MIDDLE-INCOME COUNTRIES USING VARIOUS FUEL TYPES IN 2010 AND 2022, WITH PROJECTIONS FOR 2030



Source: WHO 2024a.

If current trends continue through 2030, 67 percent of the population in LMICs will mainly use gas, while 18 percent will continue to rely on unprocessed biomass. About 8 percent of the population will use electricity for cooking, 5 percent will use charcoal, while 1 percent will use kerosene or coal. It is worth noting that the use of gaseous fuels, rather than electricity, is expected to account for most of the growth in the share of the population using mostly clean fuels and technologies.

"Stove stacking" refers to the simultaneous use of various cooking fuels and technologies. Although this remains a common practice, the statistics consider only the primary cooking fuel (figure 2.15). Survey methodologies tend to overlook stove types as well as secondary fuels, implying that the count of individuals relying exclusively on clean fuels may be considerably lower than what the figures report. This presents challenges for accurately characterizing the exposure to household air pollution from the use of polluting fuels and technologies and the associated health, social, and environmental/climate impacts. A comprehensive analysis of all cooking stoves and fuels used along with household energy use more broadly, including other energy uses (e.g., heating and lighting), requires survey takers to devise and implement survey questions that capture the full range of fuels and technologies employed at home (World Bank and WHO 2021).

FIGURE 2.15. EXAMPLE OF A HOUSEHOLD USING MULTIPLE CLEAN AND TRANSITIONAL/POLLUTING FUELS AND TECHNOLOGIES SIMULTANEOUSLY IN INDIA

Photo credit: Jessica Lewis.

Policy insights

As the world faces compounding crises like pandemics, economic downturns, and climate change, the need to achieve universal access to clean cooking has become more important than ever. In 2022, it was estimated that 74 percent (70–77) of the world's population had access to clean cooking solutions. Despite some progress, many households worldwide still rely on polluting cooking fuels and technologies that disproportionately affect the most vulnerable: women and children. These practices pose health risks and environmental damage and perpetuate cycles of poverty. Moreover, the lack of access to clean household energy exacerbates gender inequalities, as women and children are often tasked with household cooking and fuel collection, which can hinder their educational and economic opportunities. Cooking with polluting fuels and technologies is also a major source of greenhouse gas (GHG) emissions and climate pollutants such as black carbon, which account for over half of human-induced black carbon emissions. The benefits of clean cooking are estimated in box 2.1.

While progress has been made toward the 2030 goal of universal access, the current trajectory indicates that only 79 percent (75–81) of the world's population will have access to clean cooking solutions by then, leaving around 1.8 billion people still without access. The discrepancy in access between urban (88 percent) and rural (54 percent) areas worldwide is stark. In Sub-Saharan Africa, only 7 percent (5–9) of rural households have access to clean fuels and technologies for cooking, compared to 40 percent (36–45) in urban settings. In Latin America and the Caribbean, only 64 percent (56–70) of the rural population has access to clean fuels and technologies for cooking, compared to 94 percent (89–96) in urban areas, despite the region being one of the most urbanized in the world. Urban areas tend to have better access to clean cooking fuels and technologies due to better infrastructure, greater service availability, and more reliable energy supply compared to rural areas.

Across Eastern Asia, South-eastern Asia, Central Asia, and Southern Asia, access to clean cooking has been rising since the early 2000s. Sub-Saharan Africa remains the sole region where the number of people lacking access is still increasing. The number more than doubled between 1990 to 2022 due to population growth. This has resulted in 923 million (888–954) individuals without access to clean cooking technologies in 2022. If the current trend persists, the access deficit in Sub-Saharan Africa could surpass 1 billion by 2030, impeding the achievement of the 2030 target. Immediate and focused interventions are necessary to tackle this growing challenge.

Box 2.1 • Global cost-benefit analysis on clean cooking transitions using the Benefits of Action to Reduce Household Air Pollution tool

Switching from polluting fuels such as wood, dung, and charcoal for cooking to cleaner energy sources like liquefied petroleum gas and electricity can bring substantial gains in health, environment, climate, and gender equity. Quantifying and estimating the value of these benefits and costs of transition can help make a case for investment in policies and programs for promoting widespread adoption of clean household energy. The World Heath Organization Clean Household Energy Solutions Toolkit (CHEST) includes the Benefits of Action to Reduce Household Air Pollution (BAR-HAP) tool, which allows users to model the costs and benefits of transitions to cleaner cooking fuels and technologies with different policy options.

A recent analysis applied the BAR-HAP model to estimate the regional and global costs and benefits of policies that support households in transitioning to cleaner technologies. The analysis considered three types of policy actions—(1) stove subsidies alone, (2) stove and fuel subsidies, or (3) stove subsidies plus financing (e.g., installment)—under three transition scenarios: (1) promotion of clean solutions only; (2) a mix of clean and other improved solutions, one with a larger share of the transition targeted toward clean solutions; and (3) a mix of clean and other improved solutions, one with a smaller share of the transition targeted toward clean solutions.

This analysis provides realistic, evidence-based estimates of the impacts of policy interventions on cleaner cooking transitions while remaining conservative about factors such as stove usage rates, subsidy leakage rates, and exposure levels. Despite these conservative assumptions, the results show that policies promoting a clean cooking transition would generate net benefits of USD 1.4 trillion between 2020 and 2050 across 120 low- and middle-income countries. Policies that include some promotion of improved stoves produce lower net social benefits. Most monetized benefits are from health, particularly reductions in mortality, followed by averted carbon dioxide equivalent emissions.

Specifically, for the clean solution scenario, the most socially beneficial policies can save millions of disability adjusted life years and about 21 billion hours per year associated with fuelwood collection. Additionally, the policies can avoid emissions of 380 million tonnes of carbon dioxide equivalent per year (310 and 70 million, in rural and urban areas, respectively), and the annual unsustainable forest loss avoided is about 80 billion kilograms of wood harvest.

Although substantial investment will be required to achieve these benefits, the economic case for scaling up clean cooking policy action is strong. Identifying the most effective policies to achieve more exclusive clean fuel use would only increase benefits. There is a lot of evidence that shows the need to act to reduce the heavy health, time, and environmental burdens of traditional cooking technology. The results of this policy analysis suggest that even with considering conservative assumptions about the partial transition to clean cooking, there are significant benefits. Greater policy action will also enhance learning on which options are most effective for realizing the full potential of clean cooking energy and make a stronger case for increased investments to tackle global energy poverty.

PATH TO PROGRESS IN SCALING UP CLEAN COOKING: URGENT ACTION REQUIRED FOR UNIVERSAL ACCESS BY 2030

Sizeable gains have been made in certain regions to expand access to clean cooking solutions. China, Ghana, India, and Kenya have all emerged as some exemplars, showcasing advancements propelled by steadfast political endorsement, advocacy, and substantial financial allocations. This momentum underscores a palpable shift toward cleaner cooking practices, establishing a precedent for emulation by others.

Yet it is crucial to sustain the prominence of clean cooking on the global political agenda. With impending milestones such as the voluntary review of SDG 7, which includes clean cooking, at the High-Level Political Forum, along with other pivotal events and initiatives such as the Global Stocktaking for SDG 7 implementation in April 2024, the International Energy Agency's Summit on Clean Cooking in Africa in May 2024, and the World Bank's clean cooking fund, world leaders and governmental bodies have a critical opportunity to emphasize their commitment to clean cooking. Highlighting its vital role in promoting health, climate resilience, and various cross-cutting objectives, prioritizing clean cooking at these forums represents a unified effort to achieve a healthier and more sustainable future for all.

At the country level, integrating clean cooking into the Nationally Determined Contributions (NDCs) under the Paris Agreement provides a structured pathway to strengthen efforts to reduce GHG emissions, improve air quality, benefit ecosystems, and protect health. By setting specific targets for clean cooking in NDCs, countries can demonstrate their commitment to public health and environmental sustainability and leverage resources and climate finance mechanisms to support these efforts and achieve their goals. Access to clean cooking fuels and technologies also has a direct impact on food security. Institutional cooking, such as in schools and hospitals, would greatly benefit from clean cooking solutions. This would ensure that large-scale meal preparation emits less pollution, is more energy-efficient, and provides safe, nutritious meals to vulnerable populations to support better education and health outcomes.

Women and girls are disproportionately affected by household air pollution and the labor-intensive and time-consuming nature of fuel collection. Policies and interventions should prioritize gender-sensitive solutions that recognize and tackle the specific needs and challenges that women face in relation to household energy and empower them through involvement in educational or entrepreneurial activities and decision-making processes.

Governments, international organizations, and partners across sectors should prioritize investments in infrastructure and technology that promote the uptake and adoption of clean cooking solutions. It is crucial to develop comprehensive policy frameworks and subsidies/financial incentives to encourage the shift from traditional and polluting fuels and technologies to clean alternatives. This is particularly important in LMICs where the initial cost of clean fuels and technologies could be the biggest obstacle to the transition toward clean household energy. Moreover, raising public awareness of the health, social, economic, and environmental benefits of clean cooking is crucial to encourage positive behavior changes. Collaborative efforts that focus on scalable and sustainable policies and interventions across governments, nongovernmental organizations, the private sector, and communities are the key to achieving universal access to clean cooking by 2030 and bringing about long-lasting health, social, and climate benefits.

CLEAN AND POLLUTING FUEL USE FOR COOKING IN HIGH-INCOME COUNTRIES

The issue of access to clean cooking is typically associated with LMICs, as many of these places still rely heavily on polluting fuels and technologies for cooking. In high-income countries (HICs), however, clean cooking presents a slightly different set of challenges. While access to modern and efficient cooking fuels and technologies is generally high in these nations, the impacts of cooking still manifest in several ways.

Cooking is a contextualized system with no one-size-fits-all solution. Each country should have a customized approach to the clean cooking transition, taking into account its stage of economic development and progress in access to clean cooking (box 2.2). In HICs, the impacts of cooking also consider the efficiency and sustainability of fuels and technologies. For example, natural gas stoves release methane—a GHG that is 86 times more potent than carbon dioxide—through post-meter leaks and incomplete combustion (Lebel and others 2022; Balmes and others 2023). There has been a growing emphasis on lowering the carbon footprint of household cooking through adoption of technologies that are more energy efficient and the use of sustainable energy, such as stoves powered by electricity from renewable sources. Therefore, for HICs, in addition to ensuring universal access to clean cooking, there should also be a focus on decarbonizing cooking and setting a more ambitious pace for the transition to net zero than LMICs.

HICs play a crucial role in transitioning the cooking sector globally toward clean cooking and achieving net-zero emissions. They can contribute to the research and development of clean cooking technologies and support LMICs in accessing and adopting them. Investments in innovation and implementation can lead to the creation of more efficient, affordable, and user-friendly solutions that can benefit not only HICs but also support global efforts to address clean cooking challenges. Although clean cooking in HICs might not involve the lack of access seen in lower-income settings, it is intertwined with dimensions involving health, environment, and socioeconomic standing. Addressing these challenges requires a holistic approach encompassing policy intervention, consumer education, and technological innovation.

Box 2.2 • Estimating polluting fuel use in high-income countries

A recent analysis conducted by the World Health Organization estimated the percentage of the population relying on clean fuels and technologies for cooking among 59 high-income countries (HICs) in 2022. Using the Global Household Energy Model (Stoner and others 2020, 2021), results were modeled as a function of gross national income per capita and a model error. Preliminary analysis estimated that 98 percent of the population (1.19 billion people) in included HICs used clean fuels and technologies for cooking, while 2 percent of the population (24 million) still lacks access to clean cooking solutions. Although access to modern and efficient cooking fuels and technologies is generally high in HICs, universal access has not yet been reached. Additional efforts are needed to bridge the gap and ensure that no one is left behind.

CHAPTER 3
RENEWABLES

Main messages

- **Global trend.** In 2021, the global share of renewable energy sources in total final energy consumption (TFEC), including traditional uses of biomass, was 18.7 percent as TFEC rebounded after the disruption caused by the pandemic. This share had remained relatively steady over the previous three decades, increasing slowly in 2012–21 (+2.7 percentage points), mainly due to the accelerated deployment of renewables in the electricity sector. Excluding traditional uses of biomass, modern renewable sources had an only 12.5 percent share in TFEC in 2021, despite a doubling of consumption over the preceding 15 years. Trends differ across end uses. The largest increase in renewables' share continues to be in electricity generation, while transport and heat show only limited progress.
- **Target for 2030.** Ensuring access to affordable, reliable, sustainable, and modern energy for all requires rapidly increasing the use of renewable energy in electricity, heat, and transport. Target 7.2 of the Sustainable Development Goals (SDGs) is to "increase substantially the share of renewable energy in the global energy mix" by 2030.[15] The main indicator used to assess progress is the share of renewable energy in TFEC. While no quantitative milestone has been set, current trends indicate that progress is not sufficient to meet the target or accomplish international climate objectives. Significant action to boost energy efficiency and expand the adoption of renewable energy is needed, especially in heat and transport.
- **Recent trends.** Global renewables-based power capacity is growing faster than at any time in the past three decades and is expected to further increase two and a half times by 2030 under current policies and market conditions. This would, however, not be sufficient to triple renewables' share by 2030—an objective that more than 130 national governments committed to at the United Nations Climate Change Conference (COP28) in 2023. Appropriate tools and metrics will be key to track and monitor progress and support countries in achieving this objective in the electricity, heat, and transport sectors.
- **Electricity.** The use of renewables-based electricity grew more than 6 percent from 2020 to 2021, and by 23 percent from 2015. As of 2021, renewables made up 28.2 percent of global electricity consumption—the largest share among all end uses of renewable energy. Renewables-based electricity represented one-third of global renewable energy consumption, and half of modern uses of renewable energy. Continuous new capacity addition—mainly in wind and solar photovoltaics (PV), which together represented a 2.3 times larger share of electricity generation in 2021 than in 2015—is rapidly increasing renewables' share in electricity. Hydropower remains the predominant source of renewables-based electricity in the world, meeting 16 percent of global electricity demand.
- **Heat.** In 2021, renewable sources accounted for 23.5 percent of the world's use of energy for heat. Notably, over half of this renewables-based heat was via traditional uses of biomass (24 exajoules [EJ]), of which 95 percent was concentrated in Africa and Asia. The share of modern renewable energy use in global heat consumption increased marginally, reaching 10.4 percent in 2021, just 2.1 percentage points higher than a decade earlier owing to a simultaneous increase in global annual heat demand.

15 Detailed datasets with country data for the SDG 7 indicator discussed in this chapter can be accessed at no charge at https://trackingsdg7.esmap.org/downloads.

- **Transport.** While remaining below 2019 levels, global final energy consumption for transport rebounded and grew 8 percent (+8.1 EJ) in 2021. The share of renewable energy in transport TFEC rose to 4.4 percent in 2021, up from 3.5 percent in 2015. Biofuels, primarily crop-based ethanol and biodiesel, continued to dominate renewable energy use in transport, registering 7 percent year-on-year growth in 2021. Remarkably, renewables-based electricity used in vehicles and trains grew 34 percent from 2015; this growth was driven by the rise of electric vehicle (EV) sales and a higher share of renewables in electricity for transport.
- **Regional highlights.** Sub-Saharan Africa leads among the regions where renewables constitute the largest share of energy supply because of widespread uses of traditional biomass for heating and cooking. When considering only modern uses of renewable energy, Latin America and the Caribbean lead, with the highest share of renewables in TFEC, owing to hydropower generation and to the consumption of bioenergy in industrial processes and biofuels for transport. In 2021, more than half of the global year-on-year increase in modern uses of renewable energy was in Eastern Asia—essentially China—where wind and solar PV dominated growth. Europe was the second market for renewable capacity in 2021. It accounted for more than 17 percent of the year-on-year increase in modern uses of renewable energy, led by solar PV.
- **Top 20 energy-consuming countries.** The share of renewable energy in TFEC varies widely across countries. Among the top 20 energy-consuming countries, Brazil and Canada continued to have the highest shares of modern uses of renewables in 2021 (respectively, 43 percent and 24 percent of TFEC), due to their considerable reliance on hydro for electricity, biofuels for transport, and biomass for extracting heat, specifically, in industry. In 2021, Australia, Mexico, and China recorded the largest year-on-year increase in the share of modern uses of renewables (+1.1, +0.7, and +0.5 percentage points, respectively). China alone accounted for more than a fifth of the global modern uses of renewable energy. Between 2010 and 2021, the United Kingdom and Indonesia showed the largest growth in the share of modern uses of renewables in TFEC (+9 and +7 percentage points, respectively); they were followed by China, India, and Germany. This growth was mostly possible thanks to the development of wind and solar PV, as well as a significant shift from traditional to modern uses of biomass in China, India, and Indonesia.
- **Installed renewable energy generating capacity in developing countries.** In 2022, the global share of installed renewable energy generating capacity[16] on a per capita basis peaked at 40.3 percent; 424 watts per capita of renewable capacity were installed. While renewables' share of installed capacity is almost the same in developed and developing countries, renewable wattage per capita differs vastly. Whereas developing countries had 293 renewable watts per capita installed in 2022 (almost double the figure of 2015), in developed countries, the amount was 3.7 times larger, at 1,073 watts per capita. These variations suggest considerable disparities in how renewables-based electricity serves the population in developing countries. This is particularly evident in the case of small island developing states (SIDS), where the renewable watts installed per capita grew from 93 in 2021 to 101 in 2022; in landlocked developing countries (LLDCs), where 102 renewable watts were installed per capita in 2022, from 98 in 2021; and least-developed countries (LDCs), where growth was more modest, from 37 watts per capita in 2021 to 39 watts in 2022. Greater efforts are thus needed to meet SDG indicator 7.b.1 to "expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing states and landlocked developing countries."

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16 Installed renewable energy generating capacity corresponds to indicator 7.b.1/12.a.1 and means the installed capacity to generate electricity from renewable sources in net terms, divided by the population of an individual country/territory. This chapter uses various terms to refer to the above indicator, including "renewable capacity installed per capita."

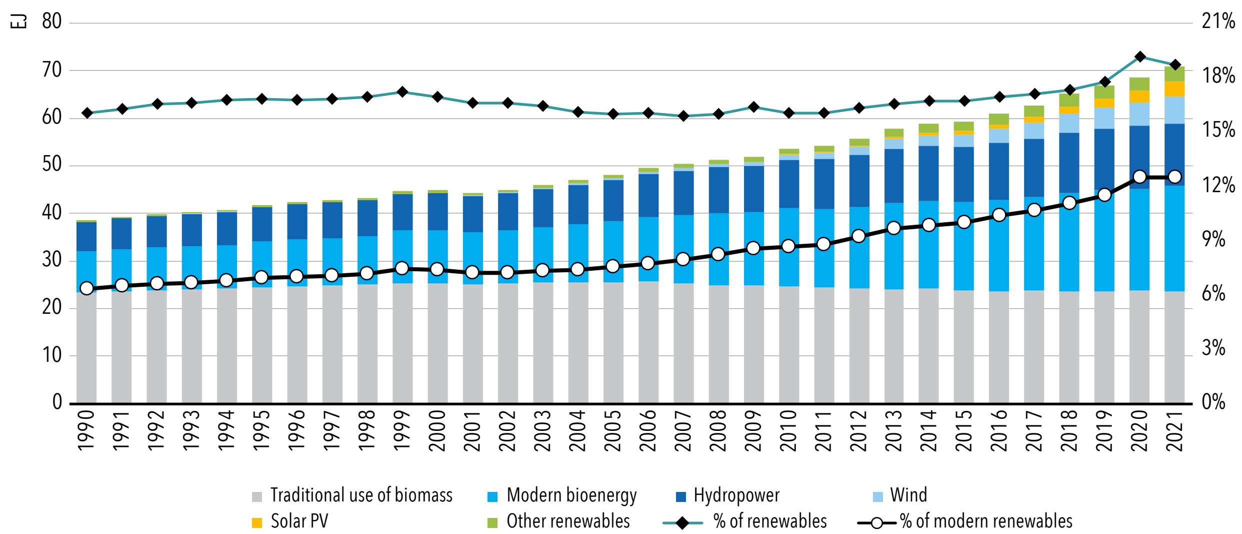
Are we on track?

INDICATOR 7.2.1 • RENEWABLE ENERGY'S SHARE IN TOTAL FINAL ENERGY CONSUMPTION

Globally, renewables have had a relatively steady share in TFEC over the past three decades; the share grew slowly in the most recent decade (+2.7 percentage points), mainly due to the accelerated deployment of renewables in the electricity sector.

In 2021, the recovery of social and economic activities, transport, industrial production, and services from the worldwide disruptions caused by COVID-19 led demand to rebound significantly; global final energy consumption grew 5.1 percent year-on-year. Global renewable energy consumption, including traditional uses of biomass,[17] reached 70.8 EJ, allowing renewables to reach 18.7 percent of TFEC in 2021; this share was, however, slightly lower than that of the year before (figure 3.1).[18]

FIGURE 3.1 • RENEWABLE ENERGY CONSUMPTION AND SHARE IN TFEC BY TECHNOLOGY—MODERN AND TOTAL RENEWABLES—1990–2021



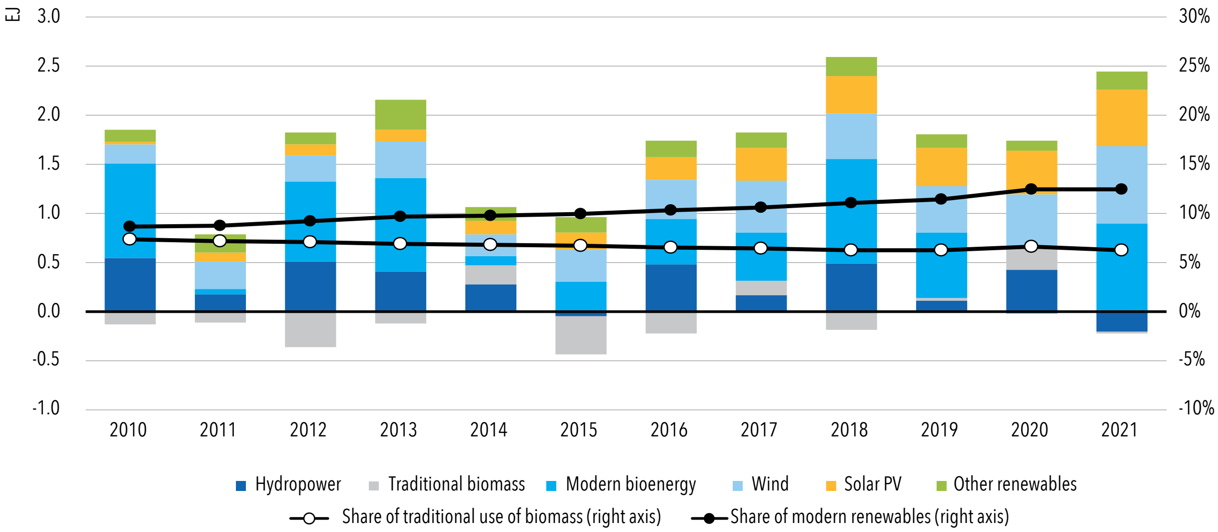
Source: International Energy Agency and United Nations Statistics Division.
EJ = exajoule; PV = photovoltaics.

17 The term "traditional uses of biomass" refers to the use of local solid biofuels (wood, charcoal, agricultural residues, and animal dung), burned using basic techniques and solutions, for example, traditional open cookstoves and fireplaces. The low conversion efficiency of such solutions can generate adverse environmental effects, besides indoor pollution, which poses health hazards. Because of their informal and noncommercial nature, it is difficult to estimate the energy consumed in such practices and with such solutions, which remain widespread in households in parts of the developing world. For the purposes of this report, "traditional uses of biomass" refers to the residential consumption of primary solid biofuels and charcoal in countries outside the Organisation for Economic Co-operation and Development (OECD). Although biomass is used with low efficiency in OECD countries, as well (e.g., in fireplaces burning split logs), such use is not included in the traditional uses of biomass cited in this report; instead, it is being reported here under modern use. Modern bioenergy—along with solar PV, solar thermal, geothermal, wind, hydropower, and tidal energy—is one of the "modern renewable" sources analyzed in this report.

18 The data in this report reflect revisions from last year's edition. Final consumption of renewable energy in transport was revised down 0.16 EJ (4 percent) globally for 2020, mainly due to changes in the United States (-0.12 EJ, -9 percent) and China (-0.05 EJ, -16 percent). Global final renewable electricity consumption was revised up 0.10 EJ (+0.4 percent), with China (+0.04 EJ, +0.6 percent) and Mexico (+0.03 EJ, +15 percent) being the main contributors to this change.
The regional groupings discussed in this section follow the United Nations' M49 regional classification (https://unstats.un.org/unsd/methodology/m49/ https://unstats.un.org/unsd/methodology/m49/).

From 2020 to 2021, modern uses of bioenergy, wind, and solar PV made the largest contributions to the growth of renewable energy use, followed by geothermal and solar thermal, whereas traditional uses of biomass and hydropower had declining contributions (figure 3.2). The global decrease in hydropower in 2021 (coming mostly from North America and Latin America) was the largest since 2001.

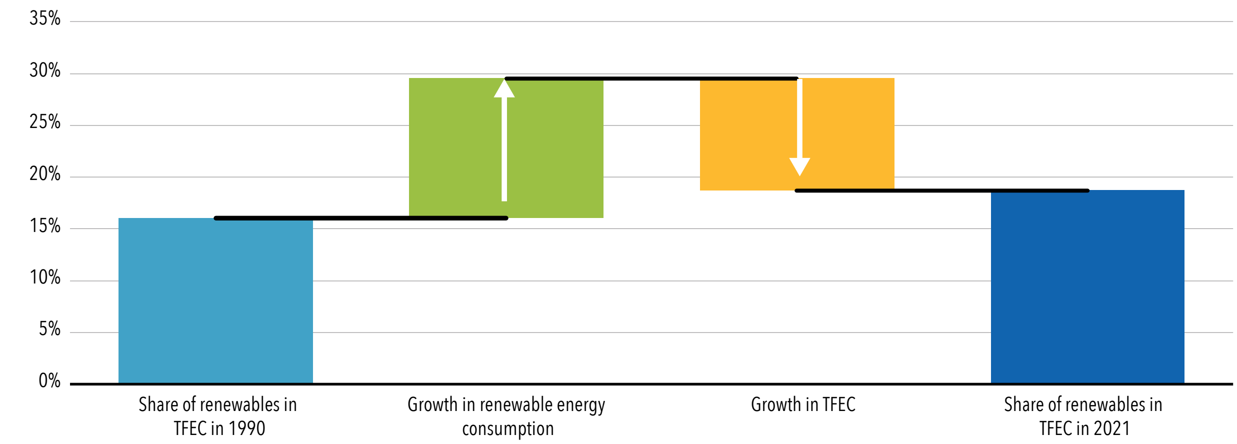
FIGURE 3.2 • GROWTH IN RENEWABLE ENERGY CONSUMPTION BY TECHNOLOGY, AND SHARE OF MODERN USES OF RENEWABLE ENERGY AND TRADITIONAL USES OF BIOMASS IN TFEC, 2011–21



Source: International Energy Agency and United Nations Statistics Division.
Note: In 2021, the share of modern uses of bioenergy remained stable as declining consumption in the residential and transport sectors offset increasing consumption in the electricity and industry sectors.
EJ = exajoule; PV = photovoltaics.

From 1990 to 2021, global renewable energy consumption grew 84 percent while TFEC grew 58 percent. As a result, the share of renewable energy in TFEC remained relatively steady (figure 3.3). Two trends coexisted in that time period. The share of modern uses of renewables—excluding traditional uses of biomass—in TFEC progressively increased, from 8.8 percent in 2011 to 12.5 percent in 2021, with the strongest growth in the electricity sector. Meanwhile, traditional uses of biomass declined to 6 percent from their highest point in 2006, albeit stabilizing in 2016.

FIGURE 3.3 • IMPACT OF TFEC GROWTH ON THE EXPANDING SHARE OF RENEWABLES IN TFEC GLOBALLY, 1990–2021



Source: International Energy Agency and United Nations Statistics Division.
TFEC = total final energy consumption.

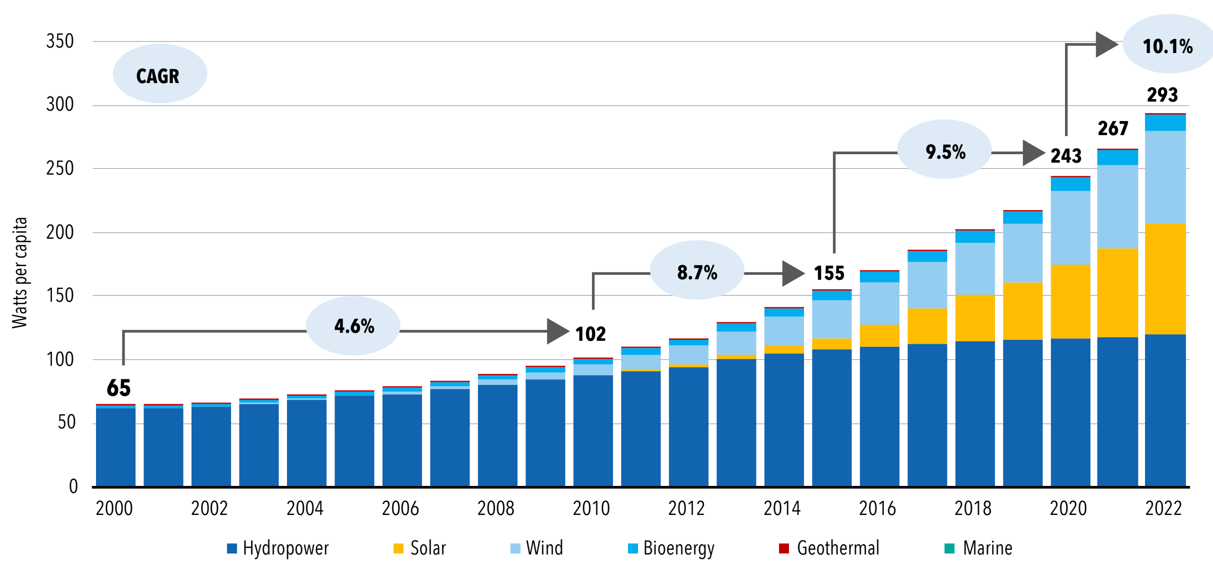
In 2012–21, modern uses of bioenergy accounted for almost one-third (+5.8 EJ) of the increase in modern uses of renewable energy—the largest absolute increase among renewable sources. Solar PV and wind, although starting from a smaller base, recorded the fastest growth rates, averaging 32 percent and 16 percent, respectively. Overall, bioenergy, including traditional uses of biomass, remained the largest renewable source of energy, representing 12 percent of global final energy consumption, and almost two-thirds of the renewable portion in 2021, followed by hydropower, wind, and solar PV.

INDICATOR 7.B.1 • INSTALLED CAPACITY FOR GENERATING ELECTRICITY FROM RENEWABLE SOURCES IN DEVELOPED AND DEVELOPING COUNTRIES

Installed renewable capacity per capita is progressing and continues to grow. In 2022, it reached 424 watts per capita globally; it had more than doubled over the previous 10 years, with 1,073 watts per capita installed in developed countries and 293 watts per capita installed in developing countries, as highlighted in table 3.1 and figure 3.4.

The global average is close to the figure for developing countries, as these countries are home to more than two-thirds of the global population. Renewable energy generating capacity grew 8.5 percent, from 391 watts in 2021, outgrowing the compound average growth rate (CAGR) of 7.8 percent between 2017 and 2021. This showcases that not only are the watts per capita increasing every year, but they are also increasing faster; watts per capita presented a trend of 8.1 percent CAGR over the five-year period (2018–22). Nonetheless, much larger growth rates are needed, and there are significant disparities among development groups. Developed countries experienced lower annual growth, of 7.2 percent from 1,001 watts per capita in 2021, with a five-year CAGR of 6.9 percent. Developing countries drove global growth in 2022, rising 10.1 percent from 2021, and saw a five-year CAGR of 9.5 percent.

FIGURE 3.4 • GLOBAL INSTALLED RENEWABLE ENERGY GENERATING CAPACITY PER CAPITA, 2000–22; AND CAGR FOR SELECTED PERIODS



Source: International Renewable Energy Agency.
CAGR = compound annual growth rate.

Developing countries accounted for most of the growth in renewable capacity per capita in 2010–22, given the proliferation of solar and wind energy deployment in the 2010s (table 3.1).

TABLE 3.1 • GLOBAL INSTALLED RENEWABLE ENERGY GENERATING CAPACITY PER CAPITA, ANNUAL GROWTH AND CAGR, 2010–22

YEAR	GLOBAL			DEVELOPED			DEVELOPING		
Year	Renewables per capita	Annual growth (%)	Five-year CAGR (%)	Renewables per capita	Annual growth (%)	Five-year CAGR (%)	Renewables per capita	Annual growth (%)	Five-year CAGR (%)
2010	175	6.3	5.0	500	6.5	4.7	102	7.0	6.2
2011	188	7.4	5.8	539	7.9	5.7	109	7.7	6.8
2012	202	7.2	6.4	582	7.9	6.6	117	7.1	7.1
2013	216	7.1	6.8	613	5.3	6.7	129	9.9	7.8
2014	232	7.1	7.0	647	5.5	6.6	141	9.5	8.2
2015	250	7.8	7.3	691	6.8	6.7	155	9.5	8.7
2016	268	7.5	7.3	732	5.9	6.3	169	9.7	9.1
2017	288	7.3	7.4	769	5.1	5.7	186	9.9	9.7
2018	308	6.8	7.3	809	5.2	5.7	202	8.7	9.5
2019	329	6.8	7.2	864	6.9	6.0	217	7.3	9.0
2020	360	9.7	7.6	929	7.5	6.1	243	12.1	9.5
2021	391	8.4	7.8	1,001	7.8	6.5	267	9.5	9.5
2022	424	8.5	8.1	1,073	7.2	6.9	293	10.1	9.5

Source: International Renewable Energy Agency.
CAGR = compound annual growth rate.

Looking beyond the main indicators

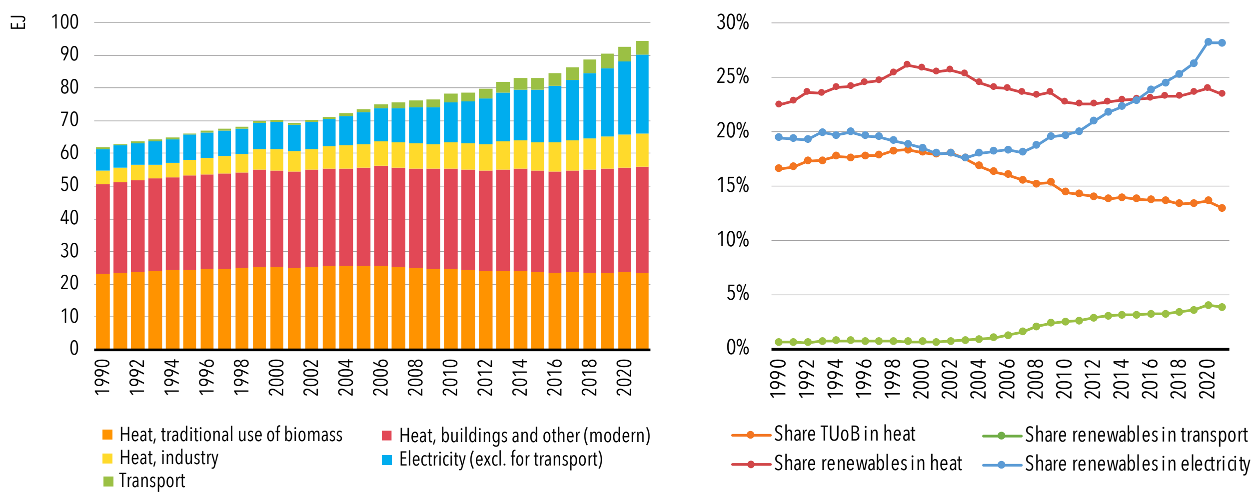
Ensuring access to affordable, reliable, sustainable, and modern energy for all implies a substantial increase in the share of renewable energy in all three main end-use categories. In 2021, heat, transport, and electricity made up 48, 30, and 22 percent, respectively, of TFEC (figure 3.5).

Electricity has had the largest and the most dynamic share of renewables in final consumption; its share grew from 23 percent in 2015 to 28.2 percent in 2021. Renewables-based electricity represented one-third of global renewable energy consumption, and half of modern uses of renewable energy. Hydropower remained the predominant source of renewables-based electricity globally. Continuous new capacity addition—especially of wind and solar PV, which together represented a share 2.3 times larger in 2021 than in 2015—is boosting renewables' share in electricity.

In the **heating** sector, renewable sources accounted for 23.5 percent of energy used; more than half of this corresponded to traditional uses of biomass, which decreased 0.1 percent in 2021. Excluding traditional uses of biomass, modern uses of renewables for heat grew 3.7 percent year-on-year, and the global heat demand grew 3.2 percent year-on-year, due to the recovery of social and economic activities following the disruptions of COVID-19 in 2020. This also caused a 5 percent growth in the use of nonrenewable energy for heat in 2021.

Including the use of renewables-based electricity, the **transport** sector consumes only 9 percent of global modern uses of renewable energy. It is the end-use sector with the lowest renewable energy penetration, at only 4 percent of final energy consumption in 2021. Biofuels (90 percent) dominated renewable energy use in transport. Remarkably, renewable electricity used in vehicles and trains grew 34 percent over 2015, due to a rise in EV sales and a higher share of renewables in electricity for transport.

FIGURE 3.5 • RENEWABLE ENERGY CONSUMPTION AND SHARE BY END USE, 1990–2021

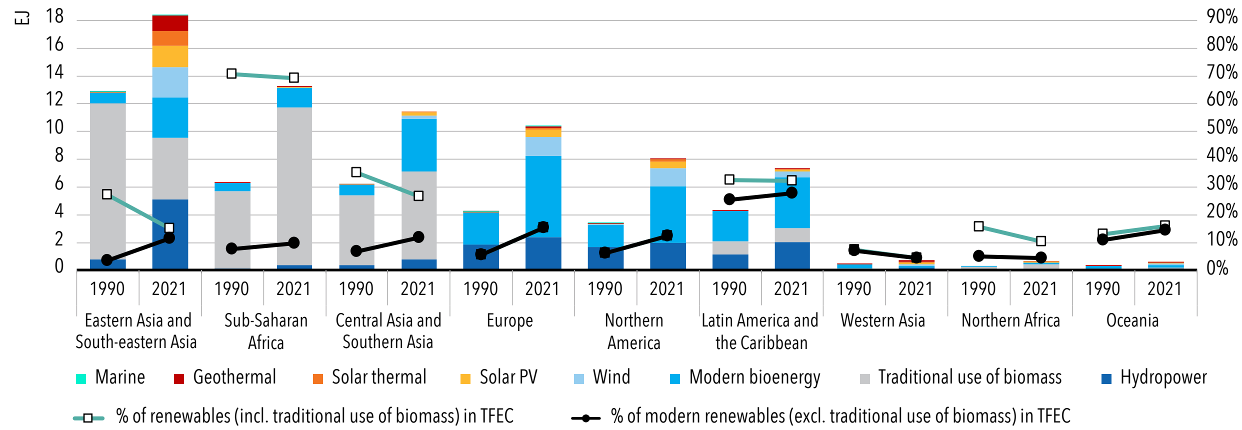


Source: International Energy Agency and United Nations Statistics Division.
Note: Electricity used for transport is included under transport.
EJ = exajoule; TUoB = traditional uses of biomass.

REGIONAL TRENDS

Progress across regions varies widely. For instance, while renewable energy constitutes more than two-thirds of TFEC in Sub-Saharan Africa, excluding traditional uses of biomass, modern uses of renewables represent only 10 percent of TFEC in the region (figure 3.6). The share of modern uses of renewable energy is the largest in Latin America and the Caribbean (28 percent of TFEC in 2021), due mostly to the consumption of bioenergy for industrial processes (especially in the sugar and ethanol industry), biofuels for transport, and sizeable hydropower generation.

FIGURE 3.6 • RENEWABLE ENERGY CONSUMPTION AND SHARE IN TFEC BY REGION, 1990 AND 2021

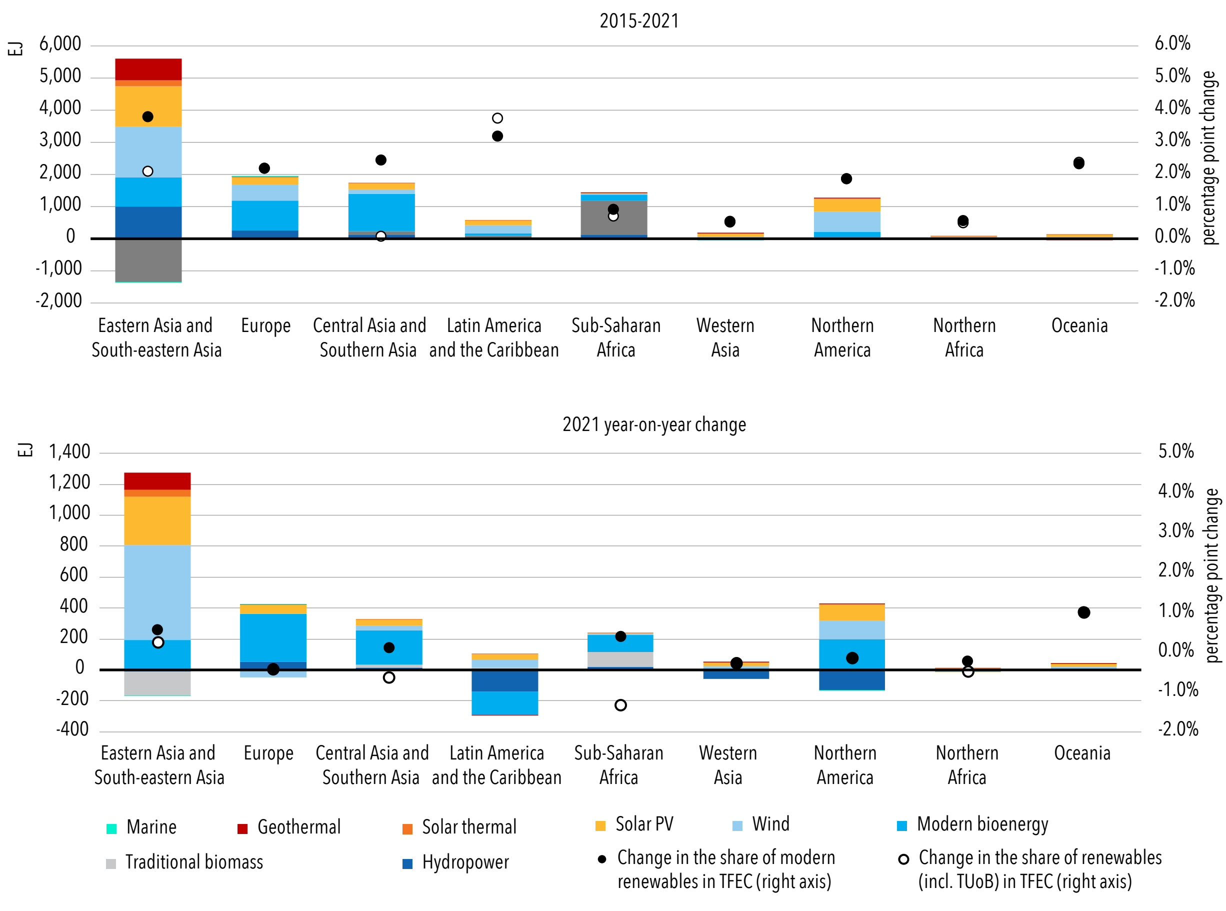


Source: International Energy Agency and United Nations Statistics Division.
EJ = exajoule; PV = photovoltaics; TFEC = total final energy consumption.

In 2021, significant additions of wind, solar PV, and, to a lesser extent, geothermal capacity in Eastern Asia led the region to account for more than half of the global year-on-year increase in modern uses of renewable energy, while traditional uses of biomass declined significantly (figure 3.7). Europe was the second-largest market (IEA 2022a) in terms of solar PV and wind capacity additions in 2021 and accounted for 17 percent of the global year-on-year growth in modern uses of renewable energy.

The rebound in TFEC after COVID-19's impact in 2020 (+5.1 percent in 2021 year-on-year) made increases in the use of renewable energy less noticeable as a share of TFEC. Eastern and South-eastern Asia and Oceania were the only regions where renewables' share in TFEC grew in 2021 (at +0.26 and +1 percentage point year-on-year, respectively). Modern uses of bioenergy showed the same trend as renewables' share in TFEC in Eastern and South-eastern Asia and Oceania (growing by +0.56 and +1 percentage points in 2021 year-on-year, respectively). In other regions, the share of renewables fell, with the largest decline observed in Latin America and the Caribbean (-2.2 percentage points in 2021 year-on-year). Globally, traditional uses of biomass declined owing to a strong drop in Eastern and South-eastern Asia; this trend was offset by increased consumption in Sub-Saharan Africa.

FIGURE 3.7 • CHANGE IN RENEWABLE ENERGY CONSUMPTION AND IN RENEWABLES' SHARE IN TFEC BY REGION, 2015–21; AND YEAR-ON-YEAR CHANGE, 2021



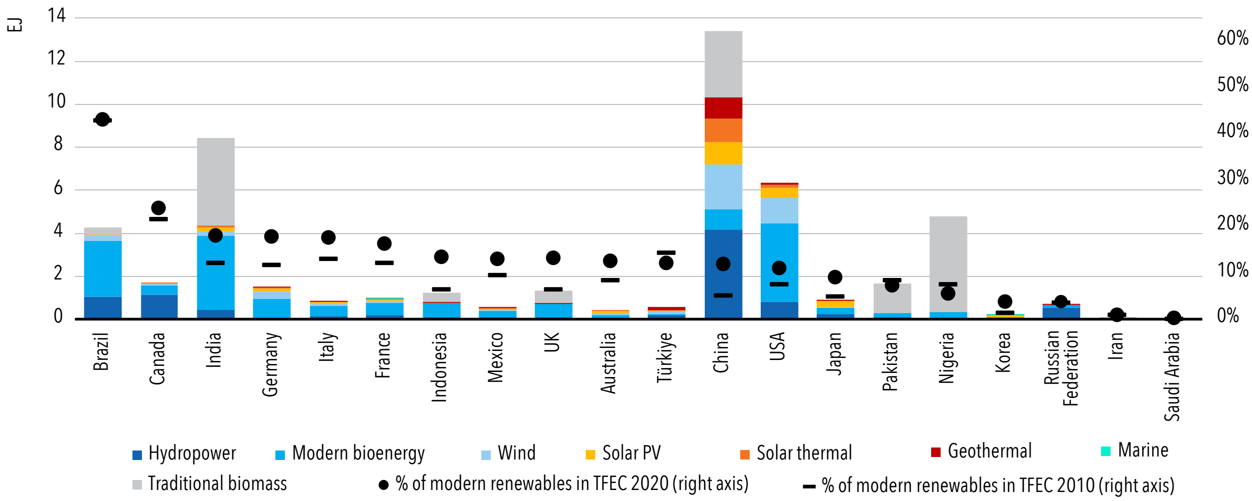
Source: International Energy Agency and United Nations Statistics Division.
EJ = exajoule; PV = photovoltaic; TFEC = total final energy consumption; TUoB = traditional uses of biomass.

At a national level, the share of renewable sources in energy consumption varies widely depending on resource availability, policy support, and the total energy demand resulting from consumption patterns and energy efficiency performance. In 2021, final energy consumption rebounded strongly due to a gradual recovery of social and economic activities following the pandemic-triggered global disruptions in 2020. Nineteen countries among the top 20 energy consumers recorded a higher TFEC in 2021 than 2020, with the exception of Mexico (-3.2 percentage points in TFEC year-on-year).

In 2021, Australia, Mexico, and China recorded the largest year-on-year increase in the share of modern uses of renewables (+1.1, +0.7, and +0.5 percentage points, respectively). Among the top 20 energy-consuming countries, Brazil and Canada continued to lead in the share of modern uses of renewables in 2021 (respectively, 43 and 24 percent of TFEC), due to their considerable reliance on hydro for electricity, biofuels for transport, and biomass for extracting heat, specifically, in industry (figure 3.8). China alone accounted for more than a fifth of global modern uses of renewable energy, even though renewables represented less than 12 percent of its TFEC.

Between 2010 and 2021, the United Kingdom and Indonesia achieved the largest progression in the share of modern uses of renewables in TFEC (+9 and +7 percentage points, respectively); they were followed by China, India, and Germany (with shares ranging between +6 and +7 percentage points). This growth was mostly possible thanks to the development of wind and solar PV, as well as a significant shift from traditional to modern uses of biomass in China, India, and Indonesia.

FIGURE 3.8 • RENEWABLE ENERGY CONSUMPTION, 2021; AND SHARE OF MODERN USES OF RENEWABLES IN TFEC, 2010 AND 2021, FOR THE TOP 20 ENERGY-CONSUMING COUNTRIES

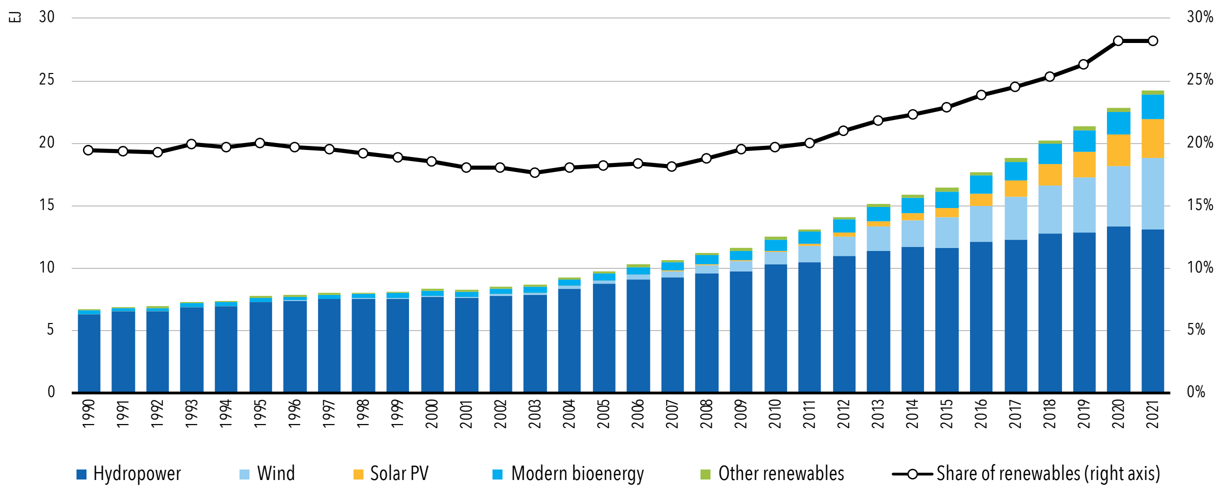


Source: International Energy Agency and United Nations Statistics Division.
EJ = exajoule; PV = photovoltaic; TFEC = total final energy consumption.

ELECTRICITY

Electricity accounted for 22 percent of TFEC globally in 2021. It is the fastest-growing end use: electricity consumption doubled over the past 22 years, and grew 35 percent since 2010.[19] Although global annual electricity consumption remained steady, at 85 EJ in 2021, global renewable electricity consumption increased in 2021 by more than 6 percent (+1.3 EJ) year-on-year. The share of renewables in electricity generation increased to 28.2 percent in 2021—the highest share among all end uses (figure 3.9).

FIGURE 3.9 • GLOBAL RENEWABLE ELECTRICITY CONSUMPTION BY TECHNOLOGY, 1990–2021



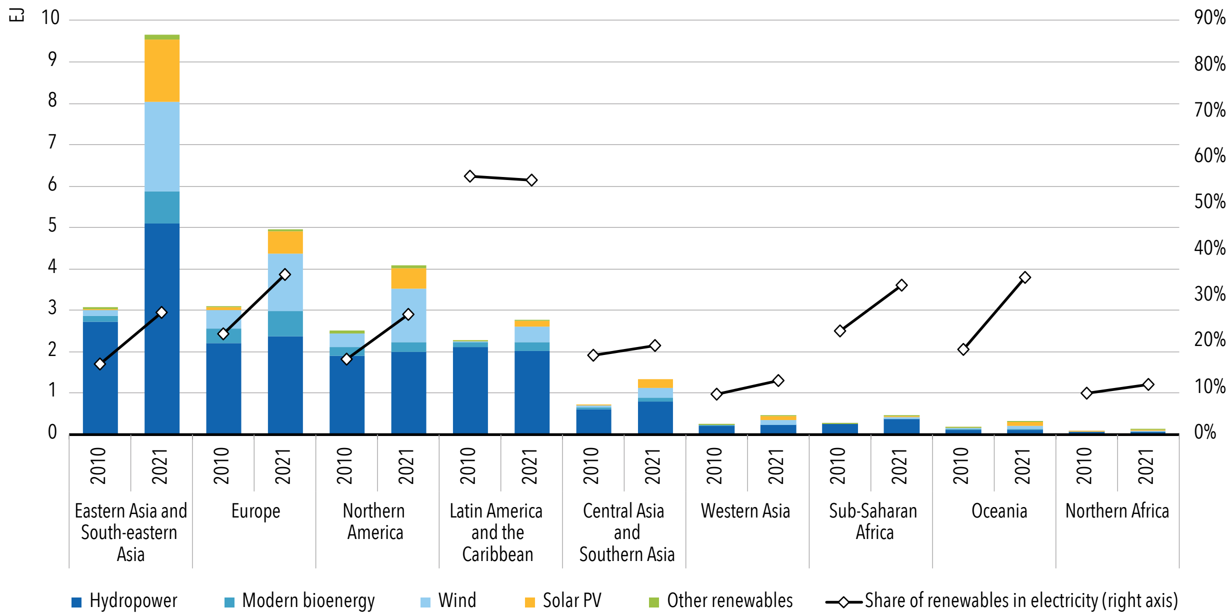
Source: International Energy Agency and United Nations Statistics Division.
EJ = exajoule; PV = photovoltaics.

In 2021, wind and solar PV made the largest contributions to the annual increase in renewable electricity consumption. The remaining growth came from modern uses of bioenergy. Hydropower remained the largest renewable source of electricity globally and for each region, representing more than half of renewable electricity consumption in 2021. However, consumption of hydroelectricity decreased 16 percent annually in 2021 due mostly to extreme drought conditions (IEA 2022c) in Latin America and North America.

Eastern Asia and South-eastern Asia recorded the largest absolute year-on-year increase of renewables in electricity consumption in 2021. More than four-fifths of the growth in global renewable electricity consumption came from this region. This growth was led mainly by rapid developments of wind and solar PV in this region. Latin America and the Caribbean recorded the largest share of renewable sources in electricity consumption; hydropower alone represented two-fifths of the region's electricity consumption in 2021. Europe and Oceania ranked second and third for their shares of renewable sources in electricity consumption. Thanks to rapidly declining costs and policy support, wind and solar PV together represented more than two-thirds of the increase in global renewable electricity consumption from 2010 (figure 3.10).

19 Among the most important factors driving this trend is the rapidly growing use of electricity for space cooling; air conditioners and electric cooling fans accounted for about 10 percent of global electricity consumption in 2018 (IEA 2018).

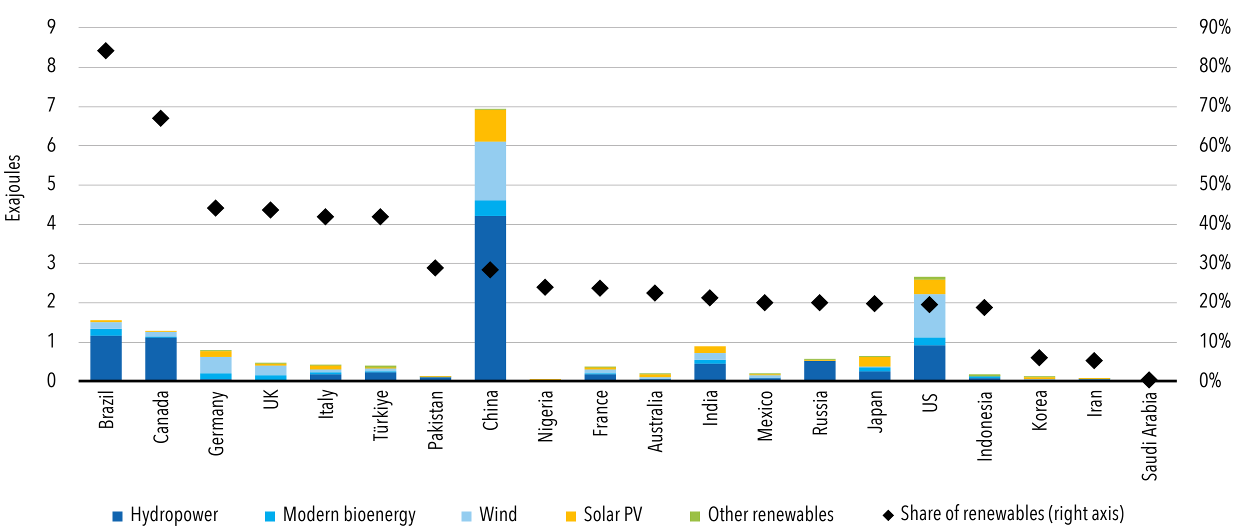
FIGURE 3.10 • RENEWABLE ELECTRICITY CONSUMPTION AND RENEWABLES' SHARE IN ELECTRICITY BY REGION, 2010 AND 2021



Source: International Energy Agency and United Nations Statistics Division.
EJ = exajoule; PV = photovoltaic.

The top 20 energy-consuming countries show strikingly varied trends in renewables' share in electricity consumption, ranging from near 0 percent to over 75 percent. Brazil and Canada are the countries with by far the highest shares, due to large hydropower capacities (figure 3.11). Wind and solar PV together—that is, nondispatchable renewables—are the largest renewable electricity sources in Australia, Germany, the Republic of Korea, the United Kingdom of Great Britain and Northern Ireland, and the United States of America, and they supply more than three-fifths of the total renewable electricity consumed in these countries. Between 2020 and 2021, China contributed 67 percent of the global annual increase in renewable electricity consumption, most of it from wind, solar PV, and modern uses of bioenergy.

FIGURE 3.11 • RENEWABLE-BASED ELECTRICITY CONSUMPTION IN THE TOP 20 FINAL ENERGY USERS, BY SOURCE AND COUNTRY, 2021



Source: International Energy Agency and United Nations Statistics Division.
EJ = exajoule; PV = photovoltaics.

Box 3.1 • COP 28's global renewables tripling agreement

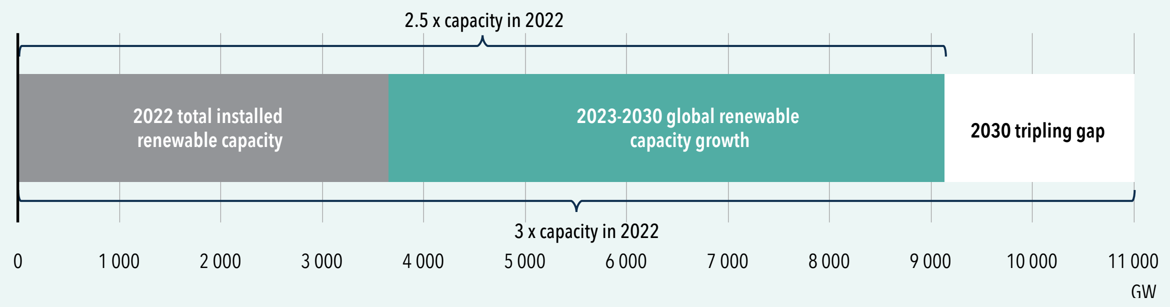
The electricity sector is leading progress toward SDG target 7.2, with renewables accounting for 28.2 percent of total final electricity consumption in 2021. Global annual additions to electricity-generating capacity powered by renewable sources grew by 50 percent in 2023, according to IEA (IEA 2024a). Total annual power additions from renewable sources reached 473 gigawatts (GW) in 2023 (IRENA 2024a). Three-quarters of that capacity is located in China, the United States, and the European Union. Solar photovoltaic accounted for three-quarters of additions worldwide (IEA 2024a; IRENA 2024a).

Yet the current rate of progress is not fast enough to realize the COP 28 agreement on renewable energy, under which over 130 countries committed "to work together to triple the world's installed renewable energy generation capacity to at least 11,000 GW by 2030, taking into consideration different starting points and national circumstances" (UNFCCC 2023).

According to IEA forecasts, under current policies and market conditions, global renewable electric capacity would grow to 7,300 GW by 2028. This would put the world on course to increase renewable capacity two-and-a-half times by 2030—below, but still close to, the objective of a global tripling global (IEA 2024a). The latest IEA Renewable Energy Market Update (IEA 2024a) finds that accelerating policy implementation could drive growth in renewable power capacity 21 percent higher than forecasted and help meet the global tripling agreement.

IRENA similarly finds that tripling renewable power capacity by 2030 is both technically feasible and economically viable, provided sufficient commitment, policy support, and investments are in place. However, commitments based on Nationally Determined Contributions under the Paris Agreement as of October 2023 fall short of what is required to limit global temperature rise to 1.5°C by the end of the century (IRENA 2023a). The Agency estimates that the Group of 20 countries alone would need to increase their collective renewable power capacity from less than 3 terawatts (TW) in 2022 to 9.4 TW by 2030. This would account for more than 80 percent of the global total (IRENA 2024b). For more on the outlook and the progress needed to achieve SDG 7 by 2030, see chapter 6.

FIGURE B3.1.1 • RENEWABLE CAPACITY GROWTH, 2022–30—AND THE REMAINING DISTANCE TO THE GLOBAL TRIPLING OF RENEWABLES



Source: International Energy Agency.

IEA and IRENA maintain that substantial action is required to triple renewable power capacity by 2030, tailored to the specific contexts of different countries, regions, and technologies. Monitoring and reporting country progress against key commitments, identifying barriers, and providing governments and the global community with recommendations on how to accelerate energy transitions will be essential to progress toward SDG target 7.2. In this regard, both IEA and IRENA are committed to tracking annual progress toward the COP28 tripling agreement and supporting countries in realizing their renewable energy and energy efficiency ambitions. UNFCCC and IEA have joined forces to track COP28 energy outcomes, build consensus on transitions aligned with 1.5 °C, and support the next round of Nationally Determined Contributions (IEA 2024c). IEA's Renewable Energy Progress Tracker (IEA 2024b) allows users to explore historical data and forecasts at the regional and country level, and to track progress toward the tripling goal.

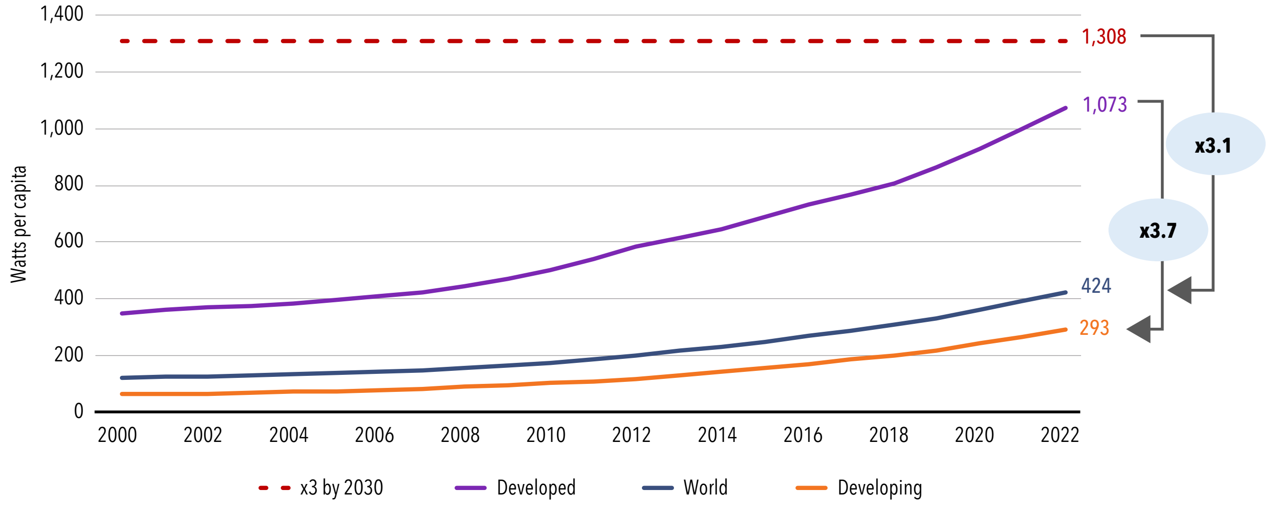
The COP28 presidency has appointed IRENA as the official custodian of a dedicated annual report tracking progress towards the tripling target. IRENA will also continue to monitor global progress towards the tripling target through its annual *World Energy Transitions Outlook*.

INSTALLED RENEWABLE ENERGY GENERATING CAPACITY PER CAPITA

SDG 7 includes a target to “expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least-developed countries, small island developing states and landlocked developing countries, in accordance with their respective programs of support” by 2030. Progress in SDG indicator 7.b.1, which measures the increase in renewable energy generating capacity (in watts per capita), is tracked in this chapter for the fourth consecutive year.

The share of installed renewable energy generating capacity in developing countries and developed countries has been on the rise at least since the beginning of the 2000s, when it stood at 21.4 percent (figure 3.13). In 2022, this share reached its peak, at 40.3 percent, with 424 watts per capita of installed renewable energy generating capacity (see figure 3.12). This value has reached parity across categories of development status, with developed countries reaching 40.1 percent and developing countries, 40.4 percent. While the share of renewables is equal across these groups, the story for renewable wattage per capita is vastly different.

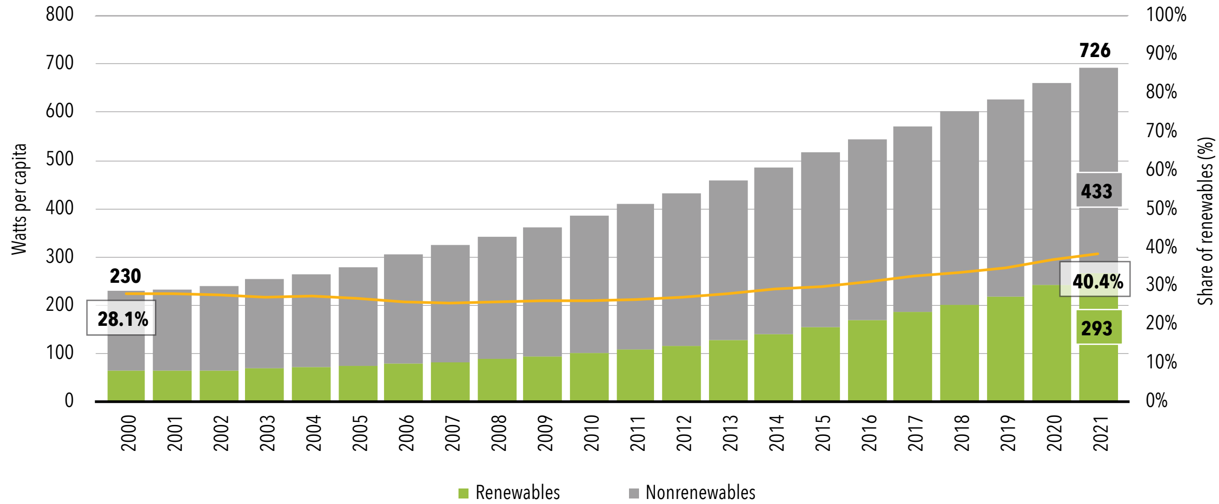
FIGURE 3.12 • ANNUAL GROWTH OF RENEWABLE ENERGY GENERATING CAPACITY PER CAPITA IN DEVELOPING AND DEVELOPED COUNTRIES, AND THE WORLD, 2000–22



Source: International Renewable Energy Agency.

A large gap remains in the deployment of renewable energy per capita between developed and developing countries, as shown in figure 3.12. In 2022, developing countries had 293 renewable watts per capita installed, while developed countries had 1,073 watts per capita, or 3.7 times more. Installation in developing countries accelerated rapidly in recent years, nearly doubling from 155 watts per capita in 2015 to 293 in 2022. Yet lack of financing, market-related and economic challenges, along with technical and capacity limitations, have limited the ability of developing countries to benefit from their renewable energy opportunities.

FIGURE 3.13 • ANNUAL GROWTH OF RENEWABLE ENERGY GENERATING CAPACITY IN DEVELOPING COUNTRIES, AND SHARE OF RENEWABLES, 2000–22

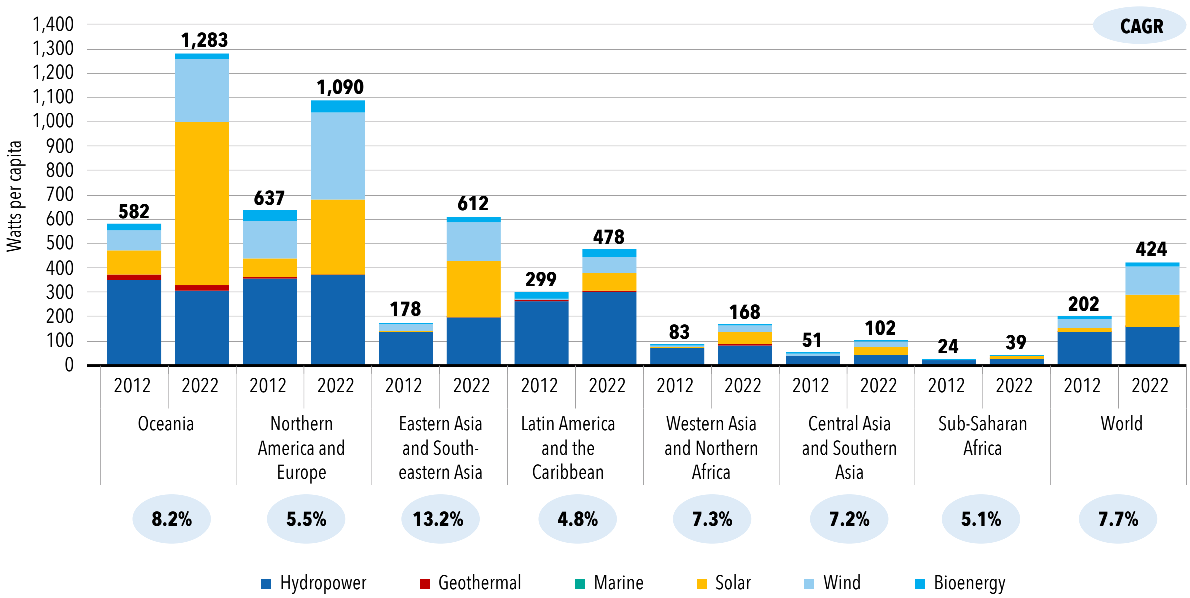


Source: International Renewable Energy Agency.

In 2022, the total electricity capacity per capita in developing countries was 726 watts, combining both renewables and nonrenewables (figure 3.13). Meanwhile, developed countries had 1,073 watts per capita of only renewables. In other words, people in developed countries had more renewable electricity capacity per capita than the total electricity per capita (from all sources) available to people in developing countries.

Between 2012 and 2022, growth in renewable energy generating capacity per capita varied across regions. The greatest capacity growth was 13.2 percent CAGR (from 178 to 612 watts per capita) in Eastern and South-eastern Asia, primarily due to additions of wind and solar power.

FIGURE 3.14 • GROWTH IN RENEWABLE ENERGY GENERATING CAPACITY PER CAPITA BY TECHNOLOGY ACROSS REGIONS, 2012–22

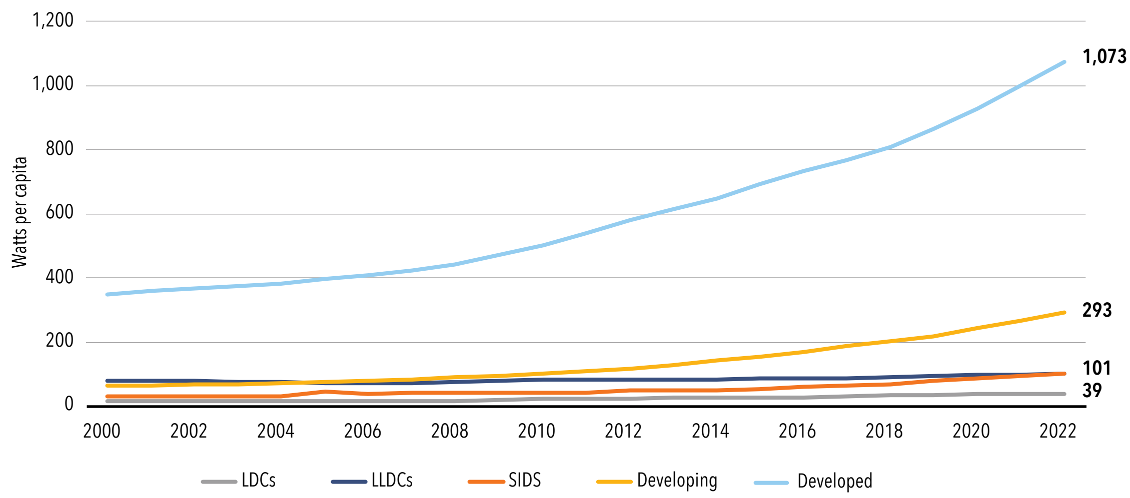


Source: International Renewable Energy Agency.
CAGR = compound annual growth rate.

The second-largest growth rate was Oceania's at 8.2 percent, expanding from 582 to 1,283 watts per capita—values surpassing the developed world average in 2022 and making Oceania the best-performing region. Other regions remained below the global average of 7.7 percent CAGR over the decade. By 2022, Latin America and the Caribbean had the slowest growth rate, at 4.8 percent CAGR, and Sub-Saharan Africa had the lowest average values of 39 watts per capita and the second-lowest CAGR of 5.1 percent (figure 3.14).

Meanwhile, growth rates across country groups reveal concerning disparities, with small island developing states (SIDS), least-developed countries (LDCs), and landlocked developing countries (LLDCs) lagging even developing countries as a group (figure 3.15).

FIGURE 3.15 • RENEWABLE ENERGY GENERATING CAPACITY PER CAPITA BY COUNTRY GROUP, 2000–22



Source: International Renewable Energy Agency.
LDC = least-developed country; LLDC = landlocked developing country; SIDS = small island developing states.

In 2022, LLDCs reached 102 watts per capita and SIDS 101 watts per capita, while LDCs stayed behind at 39 watts per capita of renewable electricity. These country categories represent a widening gap compared with the rest of the world. At CAGRs, LDCs would need almost 41 years, LLDCs would need 38 years, and SIDS would need 11 years to reach a level of deployment similar to the average levels in developing countries in 2022 (293 watts per capita).

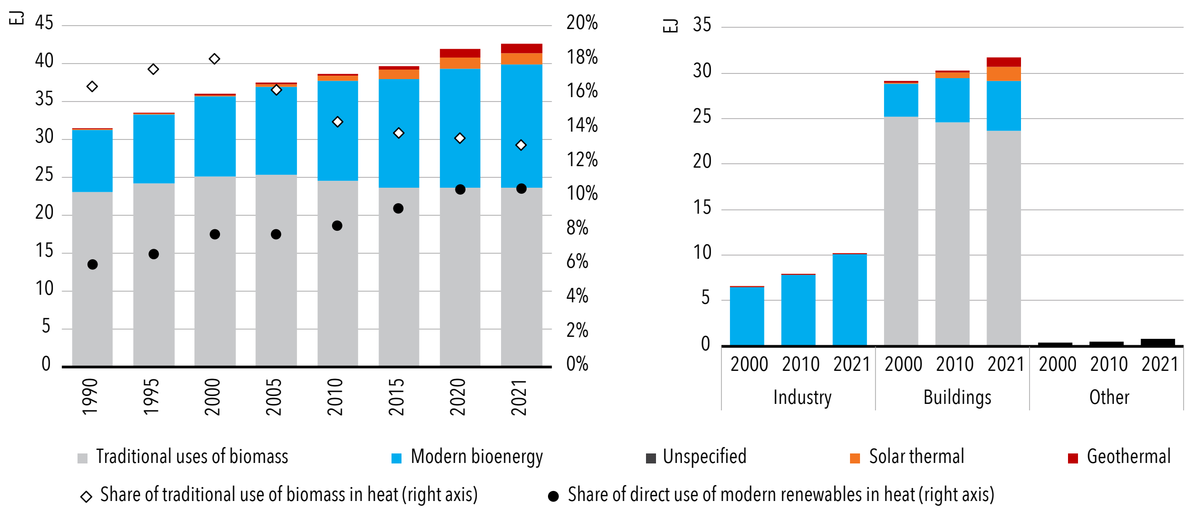
HEAT

Heat is the largest energy end use worldwide, accounting for almost half of global TFEC (182 EJ). Total energy consumption for heat increased by an estimated 3.2 percent in 2021 compared with 2020. With coal, gas, and oil meeting more than three-quarters of global heat demand, the sector remains heavily dependent on fossil fuel. Traditional uses of biomass declined slightly by 0.1 percent in 2021 year-on-year, accounting for nearly 13 percent (24 EJ) of global energy consumption for heat. Excluding traditional uses of biomass, as well as ambient heat harnessed by heat pumps[20] (for which data availability is limited), direct uses of modern renewables for heat increased 1.6 percent year-on-year to reach 19 EJ in 2021. This represented 10.5 percent of total energy consumed for heat, only 2.2 percentage points higher than in 2010 (figure 3.16).

20 The rapid spread of heat pumps over the past decade is making ambient heat an increasingly important heat source, although its prevalence globally is difficult to estimate because data are unavailable for some markets. Because of this lack of data, this report does not account for ambient heat (in excess of any nonrenewable electricity used to run the pumps), although it can be credited as a renewable source, and electric heat pumps are expected to play a key role in the decarbonization of the heating sector.

Despite its dominant share in final energy consumption, the heating sector has received limited policy attention and support until recently. While the last couple of years have seen a number of supporting policy updates for renewable heat based on energy security considerations, greater ambition and stronger policy support are needed to progress toward SDG target 7.1 ("ensure universal access to affordable, reliable and modern energy services"—for instance, for cooking and space and water heating) and SDG target 7.2 ("increase substantially the share of renewable energy in the global energy mix"). Doing so requires combining strong improvements in energy efficiency, conservation, and material efficiency—especially for energy-intensive materials such as cement and steel, which come from hard-to-decarbonize sectors—with fast deployment of renewable heat technologies in order to transition away from fossil fuels and inefficient and unsustainable uses of biomass.

FIGURE 3.16 • RENEWABLE HEAT CONSUMPTION BY SOURCE AND SECTOR, 1990–2021



Source: International Energy Agency and United Nations Statistics Division.
Note: Indirect consumption of renewable heat through renewable electricity and district heating is not represented in this figure.
EJ = exajoule.

Bioenergy accounts for about 82 percent (15.6 EJ) of direct[21] modern use of renewables for heat globally. Bioenergy accounts for about one-tenth (IEA 2021) of energy consumed for heat in the industry and one-twentieth in the buildings sector (IEA 2024b). Industry is responsible for two-thirds of modern use of bioenergy, most of which is concentrated in subsectors producing biomass residues on site such as wood, pulp, and paper industries, as well as the sugar and ethanol industries. In 2021, modern use of bioenergy for heat expanded 1.6 percent year-on-year in industry—mostly due to increasing use in Brazil's and India's sugar and ethanol industries—and increased 6.8 percent in the buildings sector, as heat demand increased.

Global **solar thermal** consumption remained relatively steady in 2021 compared to 2020, accounting for 8 percent (1.54 EJ) of modern use of renewables for heat; yet it still met less than 1 percent of total final heat demand. China continued to dominate solar thermal developments, accounting for around 70 percent of both newly installed capacity and global solar thermal capacity in operation in 2021 (IEA-SHC 2023). However, despite positive development in many European markets, the global market declined by 9.3 percent in 2022 compared to 2021, due to COVID-19 lockdown measures disrupting construction and installation activities in China, but also due to increasing competition

21 Renewables also contribute to heat supply indirectly through renewable electricity used for heating and district heat networks. Accounting for these indirect uses, and excluding ambient heat harnessed by air-source heat pumps, renewable electricity is actually the second-largest modern use of renewable heat source after bioenergy, and the fastest-growing one. It accounted for almost half of the increase in total (direct and indirect) modern use of renewable energy used for heat in 2018, owing to the combination of increasing penetration of renewables in the power sector and heat electrification through the use of electric heat pumps and boilers. The buildings sector is responsible for the majority of electricity consumption for heat.

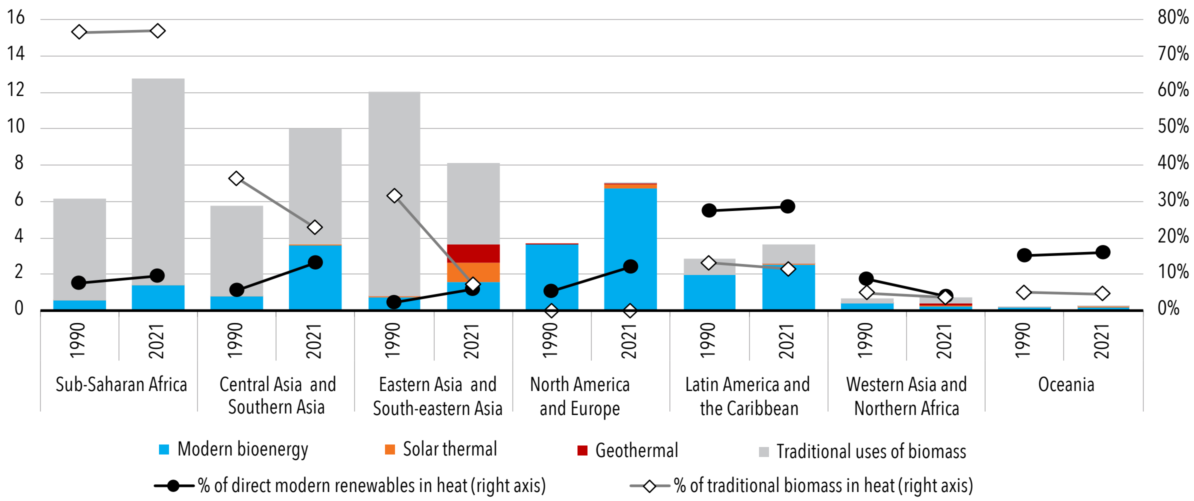
from rooftop PV systems in some important markets like India. From this perspective, hybrid photovoltaic thermal (PVT) systems offer enormous potential.[22] The global installed capacity for these systems reached 0.79 GW of thermal capacity and 0.28 GW of electric capacity in 2022, although new installations slowed down significantly that year due to competition with solar PV systems and changes in funding schemes collapsing the leading PVT market of France (IEA-SHC 2023).

While domestic solar water heaters still represent the large majority of installations—85 percent of newly installed capacity in 2021 (IEA-SHC 2023)—there is also growing interest in large-scale solar thermal systems for industrial applications or connected to district heating networks, which continue to develop as a niche market while significant potential remains untapped. Solar thermal cooling offers great potential to decarbonize space cooling, especially since the greatest demand coincides with the highest solar potential, reducing the load of electric air conditioners at peak times during summer months. However, technology deployment is currently very limited.

Global **geothermal** heat consumption grew 10.4 percent in 2021, driven almost exclusively by China, and represented 6 percent (1.2 EJ) of modern use of renewables for heat. About 60 percent of geothermal heat is harnessed by ground-source heat pumps worldwide (Lund and Toth 2020). The large majority of applications are in the buildings sector, with bathing, swimming, and space heating (primarily via district heating) being the most prevalent end uses globally. China is responsible for more than four-fifths of global geothermal heat consumption, followed by Türkiye and the United States, which together account for almost one-tenth.

Traditional uses of biomass are primarily concentrated in Sub-Saharan Africa and Asia (figure 3.17), with—in descending order—Nigeria, India, China, Ethiopia, Pakistan, the Democratic Republic of the Congo, and the United Republic of Tanzania together accounting for two-thirds of global consumption. Despite a slightly declining trend since 2006, traditional uses of biomass in 2021 were still at a level similar to that of 1990 at a global scale. Contrasting trends were observed across regions and countries in 2012–21, with significant declines in Eastern Asia—especially in China—as well as in Indonesia and Viet Nam, partly compensated by strong population-driven increases in Sub-Saharan Africa (especially in Nigeria, Ethiopia, Uganda, and the Democratic Republic of the Congo).

FIGURE 3.17 • RENEWABLES' CONSUMPTION FOR HEATING, BY REGION, 1990 AND 2021

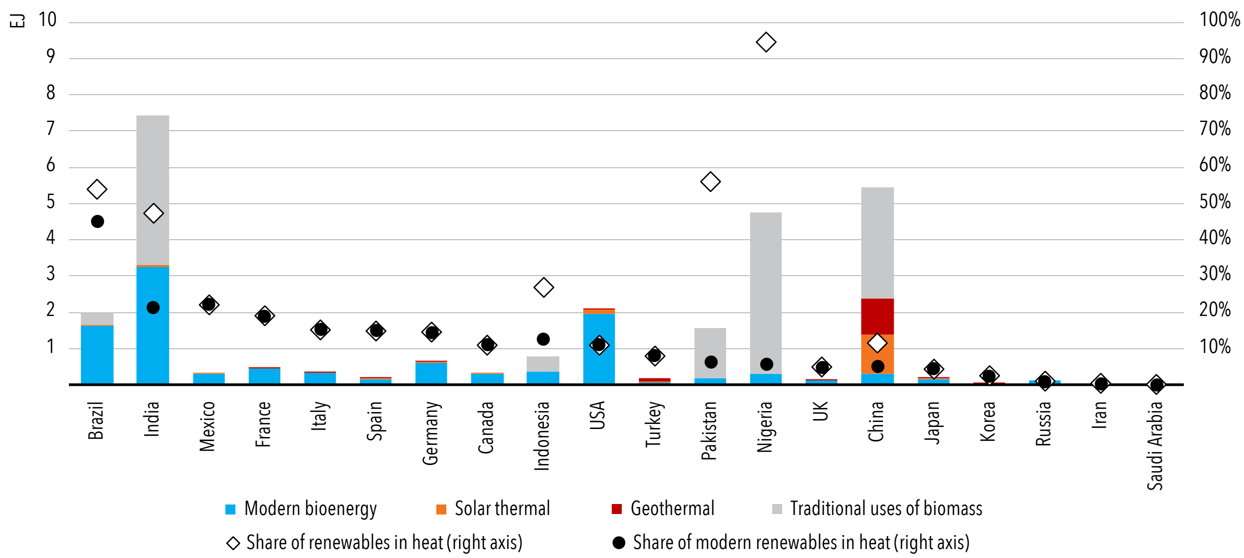


Source: International Energy Agency and United Nations Statistics Division.
Note: Indirect consumption of renewable heat through renewable electricity and district heating is not represented in this figure.
EJ = exajoule.

22 PVT systems combine PV cells with thermal collectors, which allows them to convert solar radiation into both usable thermal and electrical energy.

China and India together represented more than two-thirds of the global increase in modern use of renewable energy for heat from 2010 to 2021. Together with the United States and Brazil, they were responsible for 47 percent of global heat demand and accounted for half of modern use of renewable heat globally in 2021 (figure 3.18). This results from large consumption of bioenergy in the "pulp and paper" industry and for residential heating in the United States; extensive use of bagasse in the sugar and ethanol industry in Brazil and India; and notable deployment of solar thermal water heaters and geothermal heat in China. Europe is responsible for another quarter of global modern use of renewable heat, owing to the use of residential wood and pellet stoves and boilers (e.g., in France, Germany, and Italy) and of biomass in district heating (e.g., Nordic and Baltic countries, Germany, France, and Austria). Although not quantified in this report, the growing consumption of renewable electricity through electric heaters and heat pumps, as well as ambient heat harnessed by heat pumps in China, the United States, and the European Union, contributed indirectly to renewable heat consumption (IEA 2024b).

FIGURE 3.18 • RENEWABLE HEAT CONSUMPTION AND SHARE OF RENEWABLES IN TOTAL HEAT CONSUMPTION, BY COUNTRY, TOP 20 ENERGY-CONSUMING COUNTRIES, 2021



Source: International Energy Agency and United Nations Statistics Division.
Note: Indirect consumption of renewable heat through renewable electricity and district heating is not represented in this figure.
EJ = exajoule.

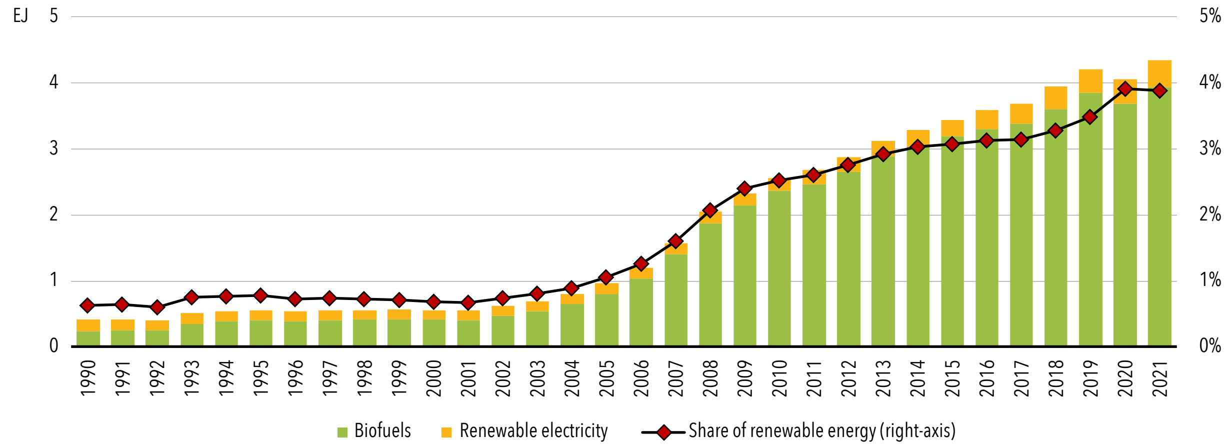
TRANSPORT

The share of renewable energy in transport TFEC rose to 4.4 percent in 2021, up from 3.5 percent in 2015. Global final energy consumption for transport rebounded and increased 8 percent (+8.1 EJ) in 2021, as social and economic activities began to recover from the disruptions caused worldwide by the COVID-19 pandemic in 2020. Accounting for 90 percent of renewable supplies, biofuels continued to dominate renewable energy use in transport, which increased 7 percent year-on-year in 2021 (+0.24 EJ). While overall biofuel demand returned to 2019 levels, the recovery was uneven across countries and fuels, and biofuels' share remained steady at 3.5 percent of final energy consumption in transport in 2021. Bio gasoline and other liquid biofuels (mostly ethanol) demand remained 5 percent below 2019 levels in 2021. This was mainly because high ethanol prices in large markets like Brazil and lower gasoline demand in the United States relative to 2019 levels drove down ethanol volumes in 2021. By comparison, in 2021, biodiesel, renewable diesel, and bio jet kerosene expanded well beyond 2019 levels, albeit from a low base for bio jet kerosene. The combined demand for these fuels in 2021 was 15 percent, or 7 billion liters, more than in 2019.

Liquid biofuels, mainly crop-based ethanol and biodiesel blended with fossil transport fuels, represented 90 percent of renewable energy consumed for transport, with most of the remainder coming from renewable electricity used in vehicles and trains, which grew to 0.42 EJ in 2021, or 2.5 times that of 1990.

Part of this growth is driven by an expanding EV fleet. The number of EVs on the road increased from 7.1 million in 2019 to 11.3 million in 2020 to more than 16.5 million in 2021 (IEA 2022d). The electricity powering these vehicles increasingly came from renewable sources. The renewable share of total electricity use in transport climbed from 20 percent in 2010 to 28 percent in 2021 (figure 3.19).

FIGURE 3.19 • GLOBAL RENEWABLE FUEL SHARE IN TRANSPORT AND TOTALS FOR RENEWABLE ELECTRICITY AND BIOFUELS, 1990–2021



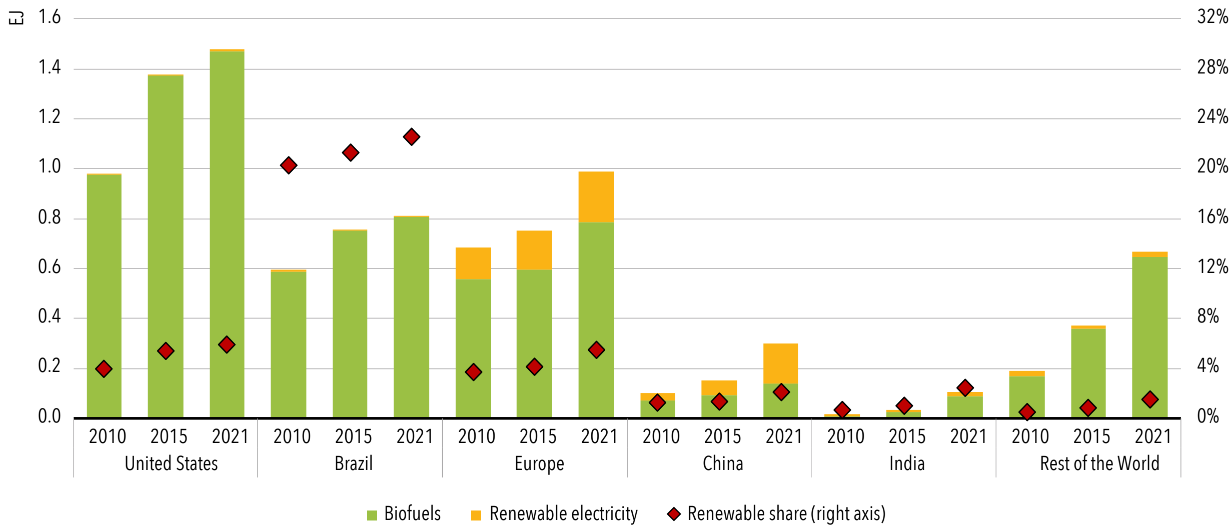
Source: International Energy Agency and United Nations Statistics Division.
EJ = exajoule.

In 1990–2021, renewable energy in transport grew 60 percent, but its share of total consumption increased by only 1.5 percentage points. The growth is thanks to country-level policies to expand biofuels, electrify transport, and increase renewable energy generation. Biofuel policies are the primary driver while renewable electricity played a smaller, but growing, role. Despite many successes at the country level, supportive policies have only marginally kept ahead of growing fossil fuel demand, leading to only a small share increase overall.

While the United States, Brazil, and Europe account for three-quarters of renewable energy used in transport, other countries and regions are also increasing their share (figure 3.20). In the United States and Brazil, 99 percent of renewable energy in transport comes from biofuels (mainly ethanol and biodiesel). In Europe, 20 percent of the renewable energy consumed in transport comes from renewables-based electricity. China's use of renewable energy in transport grew by almost 96 percent between 2015 and 2021, with renewable electricity consumption increasing 2.6 times over the same period. By 2021, renewable electricity represented more than half of all renewable energy used in transport, thanks to increasing shares of renewables in power generation and efforts to electrify transport; biofuel policy support remained limited. Also by 2021, EV sales in China had more than doubled, reaching 3.3 million (IEA 2022d). Together, China and Europe represented more than 85 percent of global electric car sales in 2021. In India, biofuel support policies doubled renewable energy use in transport between 2015 and 2021.

To increase the share of renewable energy in transport will require a combination of policies. Priorities include supporting biofuels (while ensuring that feedstock meets stringent sustainability criteria), transport electrification, renewable electricity generation, as well as active mobility, transit efficiency (by design), and the phaseout of fossil fuels for transport. Such policies must be steadily strengthened where they exist and introduced where they do not.

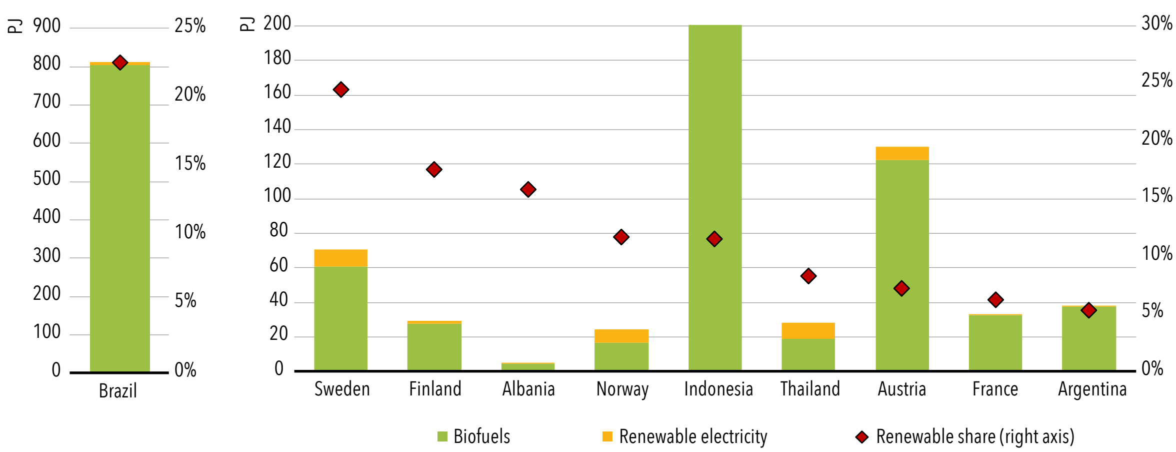
FIGURE 3.20 • RENEWABLE ENERGY SHARE AND TOTAL RENEWABLE ENERGY IN TRANSPORT ACROSS SELECTED COUNTRIES AND REGIONS, 2010, 2015, AND 2021



Source: International Energy Agency and United Nations Statistics Division.
EJ = exajoule.

The United States, Brazil, Europe, China, and India account for 85 percent of renewable energy use in transport, driven by policy support for biofuels and electrification across these countries and regions. In 2021, Brazil, Sweden, Finland, Albania, Norway, and Indonesia recorded the highest shares of renewables in their transport energy consumption, and all achieved renewable energy shares above 10 percent (figure 3.21).

FIGURE 3.21 • TOP 10 COUNTRIES BY RENEWABLE ENERGY SHARE IN TRANSPORT, 2021



Source: International Energy Agency and United Nations Statistics Division.
PJ = petajoule.

Policy insights

Despite significant progress on the renewables targets under SDG 7, achievements in recent years lag far behind ambitions. The agreement by over 130 countries to triple the world's renewable power capacity by 2030 as well as a global consensus on the need to transition away from fossil fuels at COP28 in Dubai in 2023 have significant implications for accelerated renewable energy deployment (UNFCCC 2023). The international, top-level agreement sends an important signal that needs to be incorporated into national renewable energy targeting and planning across countries and regions, including in their nationally determined contributions. Yet the agreement is contingent on far stronger action to reduce policy uncertainty, along with sufficient financing, to help achieve global energy and climate ambitions and reduce inequalities (COP28, IRENA, and GRA 2023).

Multiple policy tools are required to speed up the necessary transition of energy systems across developed and developing countries in line with the tripling target (IEA 2024a; IRENA 2023b). These tools include setting realistic, yet ambitious targets for deployment that reflect national potential and capacity, and embedding net-zero commitments in legislation. Targets need to be accompanied by effective policy planning and implementation, including through regulatory reform, price-based mechanisms, market incentives, fiscal policy, power market design, and streamlined permitting procedures. Forward-looking planning is also needed to modernize and expand supporting infrastructure, such as storage, electricity transmission, and distribution in the energy sector to accommodate greater shares of renewables, as well as infrastructure facilitating end-user electrification in the agriculture, industry, and transport sectors.

Achieving the tripling target as well as the broader SDGs further hinges on accelerated renewable energy deployment—both in developing and developed countries—integrated with relevant socioeconomic policies. Policy makers need to create economic opportunities for people across the globe through the energy transition. This involves investing in local supply chains, skills, and capacities, as well as creating job opportunities within the renewable energy sector. Dedicated planning, consultation, and policy making are needed to address socioeconomic and environmental impacts of transitioning energy systems. Key areas of focus include the affordability of sustainable energy; job transfers; as well as impacts on land, gender equality, indigenous peoples, and local communities (IRENA 2023b).

While the agreement to triple renewable energy capacity is a global goal, the chapter highlights significant disparities in per capita renewable capacity deployment, with installed capacity in developed countries 3.7 times higher than in developing countries. This underscores the need to support deployment efforts in developing countries through international collaboration. That collaboration must extend to ensuring access to affordable finance, as well as putting in place strong governance mechanisms and robust regulatory frameworks that help reduce real and perceived risks and so attract investment. The facilitation of necessary finance through the mobilization of public and private funds, and collaboration with development financial institutions, are thus fundamental (see also chapter 5).

Photo: © Unsplash

CHAPTER 4
ENERGY EFFICIENCY

Main messages

- **Global trend.** Primary energy intensity[23] (defined as the ratio of total energy supply to gross domestic product) improved—that is, decreased—by only 0.8 percent in 2021. This is well below the decade's average rate of improvement and marks the second year in a row of rates under 1 percent. Also in 2021, global energy intensity stood at 4.59 megajoules (MJ) per 2017 US dollar. The year's slow progress in energy efficiency coincided with a robust economic recovery from the onset of the COVID-19 pandemic, a recovery that saw the largest annual increase in energy consumption in 50 years. This increase—of over 5 percent—reflected a shift toward energy-intensive industries and the recovery of other demand sectors amid the easing of lockdowns.
- **2030 target.** Energy intensity improvements continue to fall short of the United Nations' Sustainable Development Goals (SDGs), which aims to double the global rate of improvement in energy efficiency between 2010 and 2030 compared with the 1990–2010 baseline. From 2010 to 2021, global energy intensity improved by an annual average rate of 1.6 percent—better than the 1.2 percent rate from 1990 to 2010, but below the 2.6 percent set out in SDG target 7.3. The particularly low rates of 2020 (0.6 percent) and 2021 (0.8 percent) played a significant part in the decade's low average. To meet SDG target 7.3 by 2030, annual improvements through 2030 must now accelerate to over 3.8 percent. Prioritizing energy efficiency in policy and investment can help the world achieve this target, promote economic development, improve health and well-being, and ensure access to clean energy.
- **Regional highlights.** No region achieved the 2.6 percent improvement rate set by SDG target 7.3 between 2010 and 2021. Eastern and South-eastern Asia came closest, at 2.2 percent. Oceania reached 2.0 percent, in part thanks to its exceptional progress in 2021, when energy intensity decreased 7 percent. Average annual improvement rates of 1.8 percent in both Northern America and Europe, and Central and Southern Asia were also above the global average and historical trends. In contrast, Western Asia and Northern Africa (0.8 percent), Latin America and the Caribbean (0.7 percent), and Sub-Saharan Africa (1.1 percent) performed below historical averages.
- **Trends in the top 20 countries with the largest total energy supply.** Between 2010 and 2021, 13 of the 20 countries with the largest total energy supply[24] saw their average annual rate of improvement in energy intensity accelerate compared with the 1990–2010 baseline. However, only the United Kingdom (3.4 percent), China (3.2 percent), and Indonesia (3.0 percent) exceeded SDG target 7.3. The improvement rates in Japan and Germany fell slightly short of 2.6 percent, after an increase in their energy intensity in 2021.

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23 Hereafter referred to as *energy intensity*. See note to figure 4.9 for a definition of energy intensity by sector.

24 At the country level, total energy supply is made up of production + imports - exports - international marine bunkers - international aviation bunkers ± stock changes. It represents the total energy used within a country, taking into account losses in transformation and other processes.

- **End-use trends.** Improvement in energy intensity quickened in all but one sector in 2010–21 compared with the previous decade. The exception was the residential buildings sector, where the improvement rate fell by half, to less than 1 percent a year on average. Passenger transport sustained nearly the same annual rate as that of the previous decade, while freight transport's rate declined slightly. Progress was also evident in industry, at over 1.6 percent.
- **Electricity supply trends.** Since 2010, the efficiency of generating electricity from fossil fuels has steadily improved, despite a slowdown in 2021 following a record increase in energy demand. The growing share of renewables in electricity generation is also contributing to efficiency gains on the supply side, as they do not incur the thermal losses of converting fossil fuels into electricity. This link between renewable energy[25] and a lower energy intensity highlights the synergies between SDG targets 7.2 (increasing renewable energy) and 7.3 (improving energy efficiency).

Are we on track?

SDG 7 commits the world to ensure universal access to affordable, reliable, sustainable, and modern energy. Target 7.3 calls for doubling the global rate of energy intensity improvement relative to the 1990–2010 average. This means improving energy intensity on average by 2.6 percent per year from 2010 to 2030.[26]

Energy intensity is the ratio of total energy supply to gross domestic product, revealing the energy used per unit of wealth created. It helps track changes in energy use and the factors influencing these rates, such as economic structure, weather, and behavior changes. All these being equal, as energy efficiency improves, energy intensity decreases.

Progress toward SDG target 7.3 is measured by the year-on-year percentage change in energy intensity. Initially, the United Nations recommended an annual improvement of 2.6 percent between 2010 and 2030 to achieve the target. But because global progress has been slower in all years except 2015, the rate required from 2021 forward is on average 3.8 percent. This figure is in line with the Net Zero Emissions by 2050 Scenario of the International Energy Agency (IEA), which requires average rates of improvement of slightly over 4 percent until 2030, and with the goal of doubling the global average annual rate of energy efficiency improvement by 2030 agreed during the 2023 United Nations Climate Change Conference (COP28).[27]

25 Primary renewable electricity is captured directly from natural resources. Electricity from geothermal, solar thermal, and biomass sources is renewable, but it is not treated as 100 percent efficient in energy statistics because of conversion losses.

26 Revisions of underlying statistical data and methodological improvements explain the slight changes in growth rates in the base period (1990–2010) from previous editions. The SDG target 7.3 of improving energy intensity by 2.6 percent per year in 2010–30 remains the same, however. Detailed datasets with country data for the SDG 7 indicator discussed in this chapter can be accessed at no charge at https://trackingsdg7.esmap.org/downloads.

27 The Net Zero Emissions by 2050 Scenario maps a way to achieve a 1.5°C stabilization in the rise in global average temperatures alongside universal access to modern energy by 2030.

Recent numbers[28] show that global energy intensity improved by only 0.8 percent in 2021, to 4.59 MJ/USD (2017 PPP [purchasing power parity]), in a context of a strong economic rebound after the COVID-19 crisis and the largest annual increase in total energy supply in the past 50 years (figure 4.1). For the second year in a row, the improvement rate was well below long-term averages (figure 4.2).

FIGURE 4.1 • AVERAGE ANNUAL CHANGES IN GLOBAL PRIMARY ENERGY INTENSITY BY PERIOD, 1990–2030

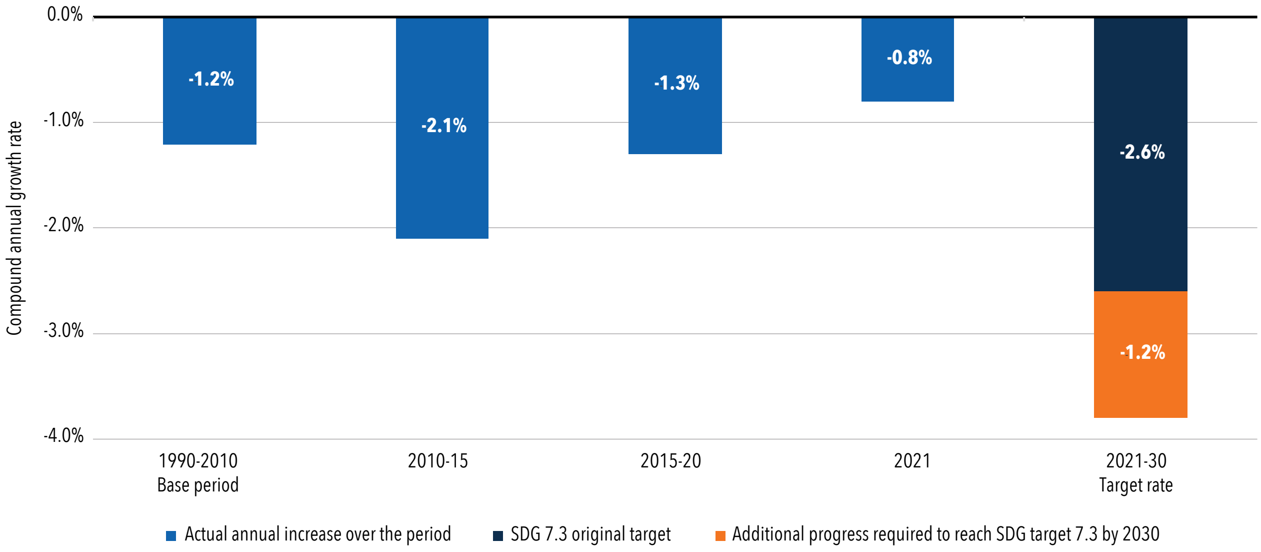
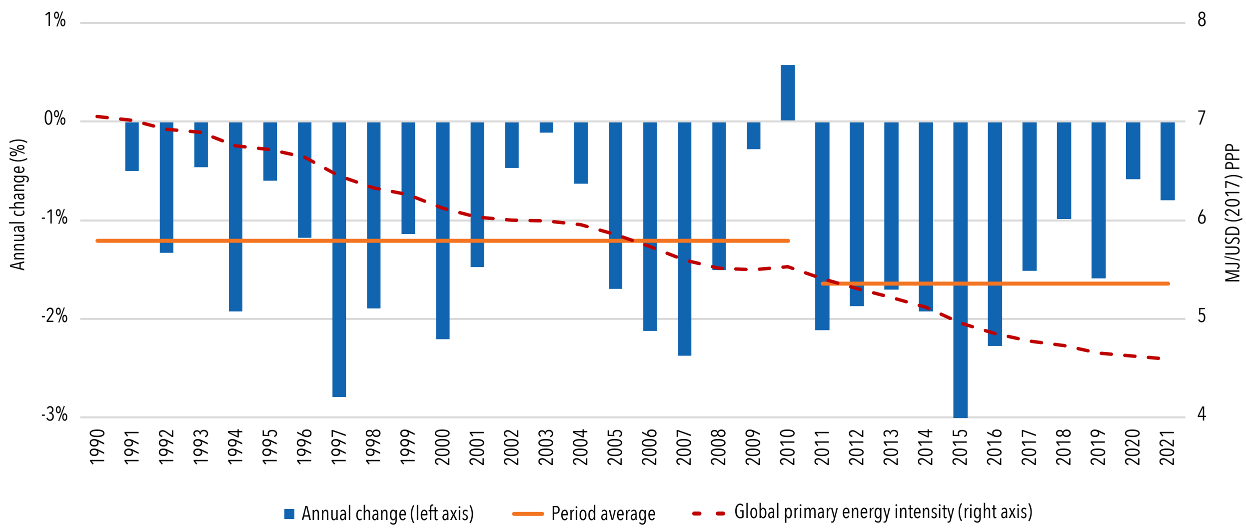


FIGURE 4.2 • GLOBAL PRIMARY ENERGY INTENSITY AND ANNUAL CHANGE, 1990–2021



MJ = megajoule; PPP = purchasing power parity.

28 The majority of the energy data in this chapter (including the data used in nearly all of the figures) comes from a joint data set built by the International Energy Agency (https://www.iea.org/data-and-statistics/) and the United Nations Statistics Division (https://unstats.un.org/unsd/energystats/). GDP data are primarily sourced from the International Monetary Fund's World Economic Outlook database (https://www.imf.org/en/Publications/SPROLLs/world-economic-outlook-databases), complemented by data from the World Bank's World Development Indicators (https://databank.worldbank.org/source/world-development-indicators) and the CEPII's CHELEM database (http://www.cepii.fr/CEPII/en/bdd_modele/bdd_modele_item.asp?id=17).

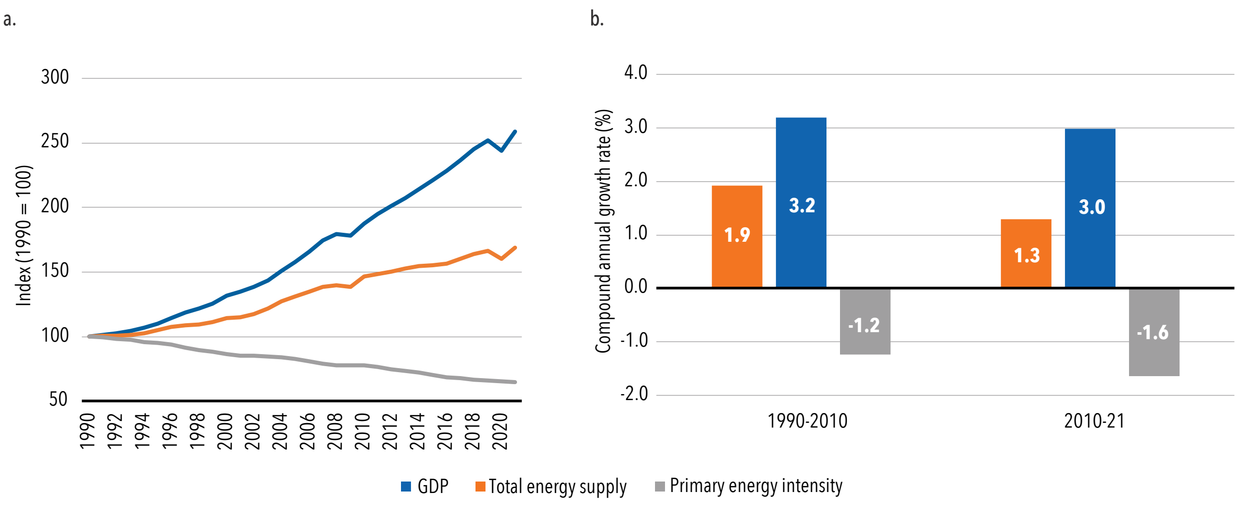
Looking beyond the main indicators

COMPONENT TRENDS

The year 2021 was marked by a strong economic rebound following the COVID-19 crisis. Globally, economic growth reached almost 6.2 percent, and total energy supply increased 5.4 percent. As GDP increased slightly more than energy supply, energy intensity improved (decreased), but this improvement was similar to that of the previous year, because of a larger share of energy-intensive industry in energy demand and the recovery of other demand sectors that had been affected by lockdowns the previous year.

Over the longer term, the impact of improvements in energy intensity is revealed by trends in its underlying components (figure 4.3). Between 1990 and 2021, global GDP increased by a factor of 2.6, and global total energy supply grew by 69 percent (or a factor of 1.69).[29] This decoupling of energy use from economic growth yielded a consistent improvement in global energy intensity, which fell by more than a third between 1990 and 2021.

FIGURE 4.3 • CHANGES IN COMPONENTS OF GLOBAL PRIMARY ENERGY INTENSITY, 1990–2021



GDP = gross domestic product.

At 3.0 percent a year, average economic growth in 2010–21 was slightly lower than growth in 1990–2010 (3.2 percent). Energy demand increased only 1.3 percent a year, revealing how the decoupling of the two is accelerating and that similar levels of GDP growth can be achieved with a smaller increase energy consumption.

The fastest improvement rate was 2.1 percent between 2010 and 2015. Progress slowed to 1.2 percent in 2015–21, in large part because of the pandemic's impact in 2020 and 2021. For 2022, values are expected to have returned to earlier levels, but more effort is needed to reach the required 3.8 percent.

29 *Total primary energy supply was renamed total energy supply*, in accordance with the International Recommendations for Energy Statistics (UN 2018).

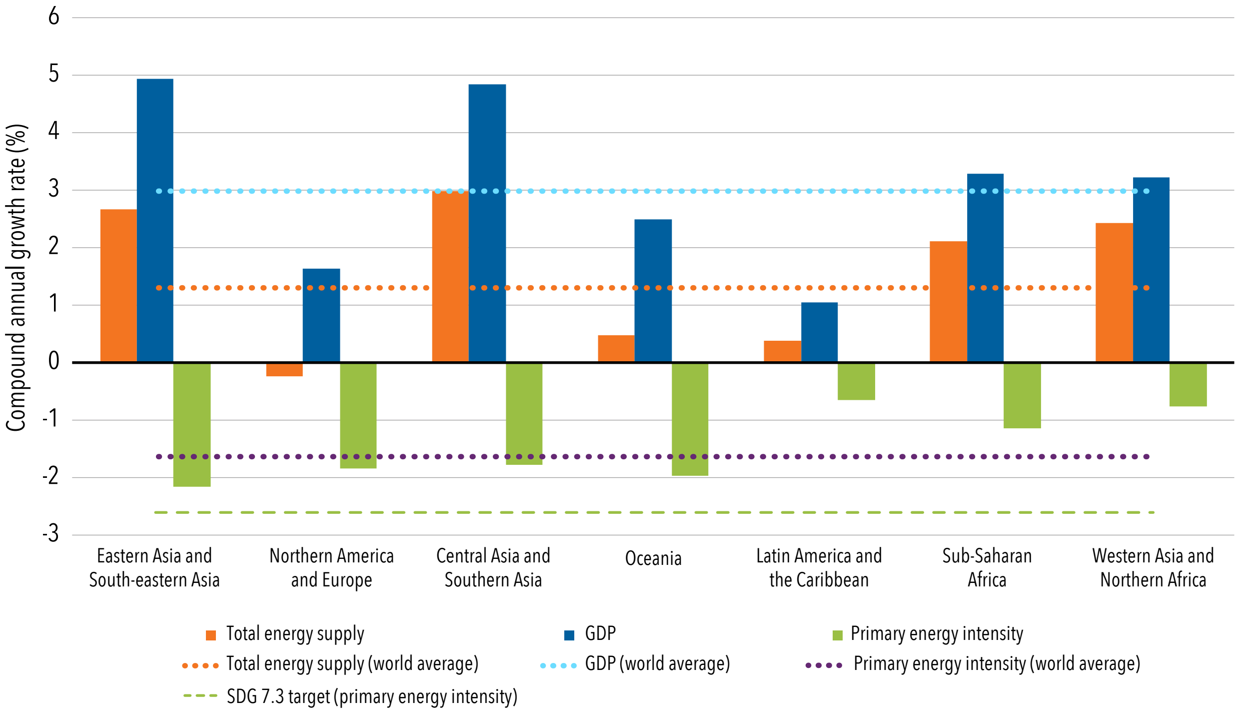
REGIONAL TRENDS

The COVID-19 crisis affected energy consumption and GDP across the world. All regions saw weaker or declining GDP in 2020, followed by a rebound in 2021, with variations depending on the timing and length of pandemic-related restrictions. In 2021, the economic recovery led to GDP growth of at least 4.5 percent in every region, with Central and Southern Asia growing at 7.6 percent. At the same time, energy consumption increased significantly in all regions, except Oceania, limiting reductions in energy intensity.

Despite the large increase in energy consumption, all regions reduced their energy intensity. Oceania achieved the greatest improvement, at almost 7 percent. Northern America and Europe lowered their energy intensity by a mere 0.2 percent, putting downward pressure on global progress.

Energy intensity has improved across the world since 2010, with significant differences across regions (figure 4.4). Economies in Asia, excluding the Middle East, saw a rapid increase in economic activity and a slower rise in total energy supply, thanks to substantial improvements in energy efficiency. Given Asia's large population, the effect on the global average was significant.

FIGURE 4.4 • AVERAGE ANNUAL CHANGES IN TOTAL ENERGY SUPPLY, GDP, AND PRIMARY ENERGY INTENSITY, BY REGION, 2010–21

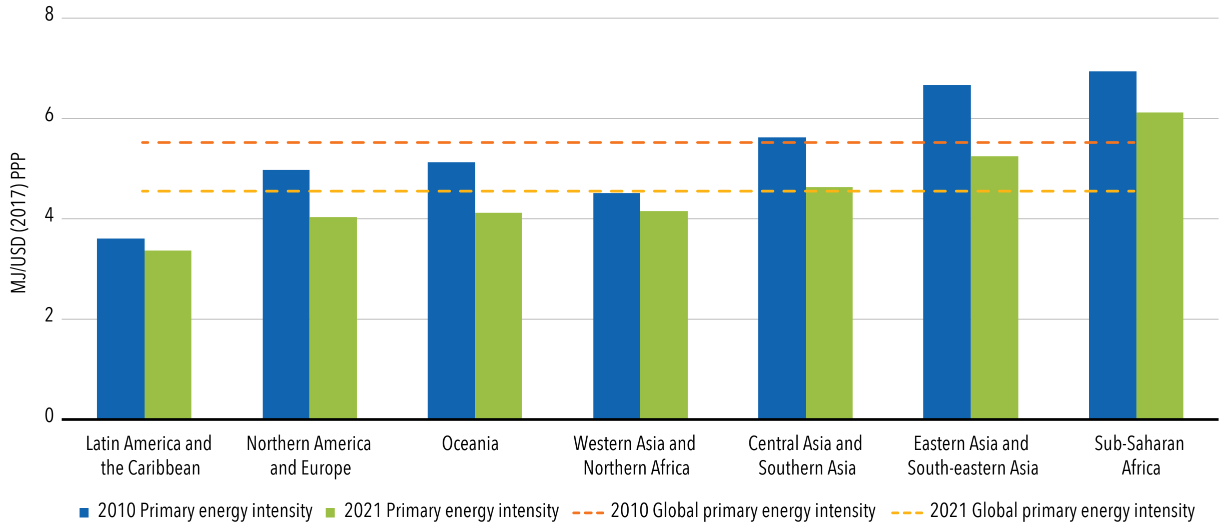


GDP = gross domestic product; SDG = Sustainable Development Goal.

Over the same period, countries in Northern America and Europe experienced much slower economic growth but also a decrease in their total energy supply, thanks to a decoupling of the economy from energy usage. This trend was enabled by a continued shift toward less-energy-intensive activities (such as services) and the impacts of long-standing energy efficiency policies, first implemented during the 1970s. Also in these regions, energy intensity improved at a rate slightly above global trends, and their energy intensity level stayed below the global average (figure 4.5). Similar trends are evident in Oceania, where total energy supply increased modestly while GDP grew more rapidly than in Northern America and Europe.

Latin America and the Caribbean, Western Asia and Northern Africa, and Sub-Saharan Africa recorded the smallest average improvements in energy intensity from 2010 to 2021 (1 percent per year or less). In Latin America and the Caribbean, total energy supply slightly increased and GDP growth was among the lowest worldwide, but the region was also the least energy intensive in the world, at 3.36 MJ/USD (2017 PPP) (figure 4.5). In contrast, in Western Asia and Northern Africa, and in Sub-Saharan Africa, growth in total energy supply and GDP exceeded the global average. Economic output in Sub-Saharan Africa was highly energy intensive, at 6.12 MJ/USD (2017 PPP); the intensity for Western Asia and Northern Africa was much lower, at 4.15 MJ/USD (2017 PPP).

FIGURE 4.5 • PRIMARY ENERGY INTENSITY, BY REGION, 2010 AND 2021



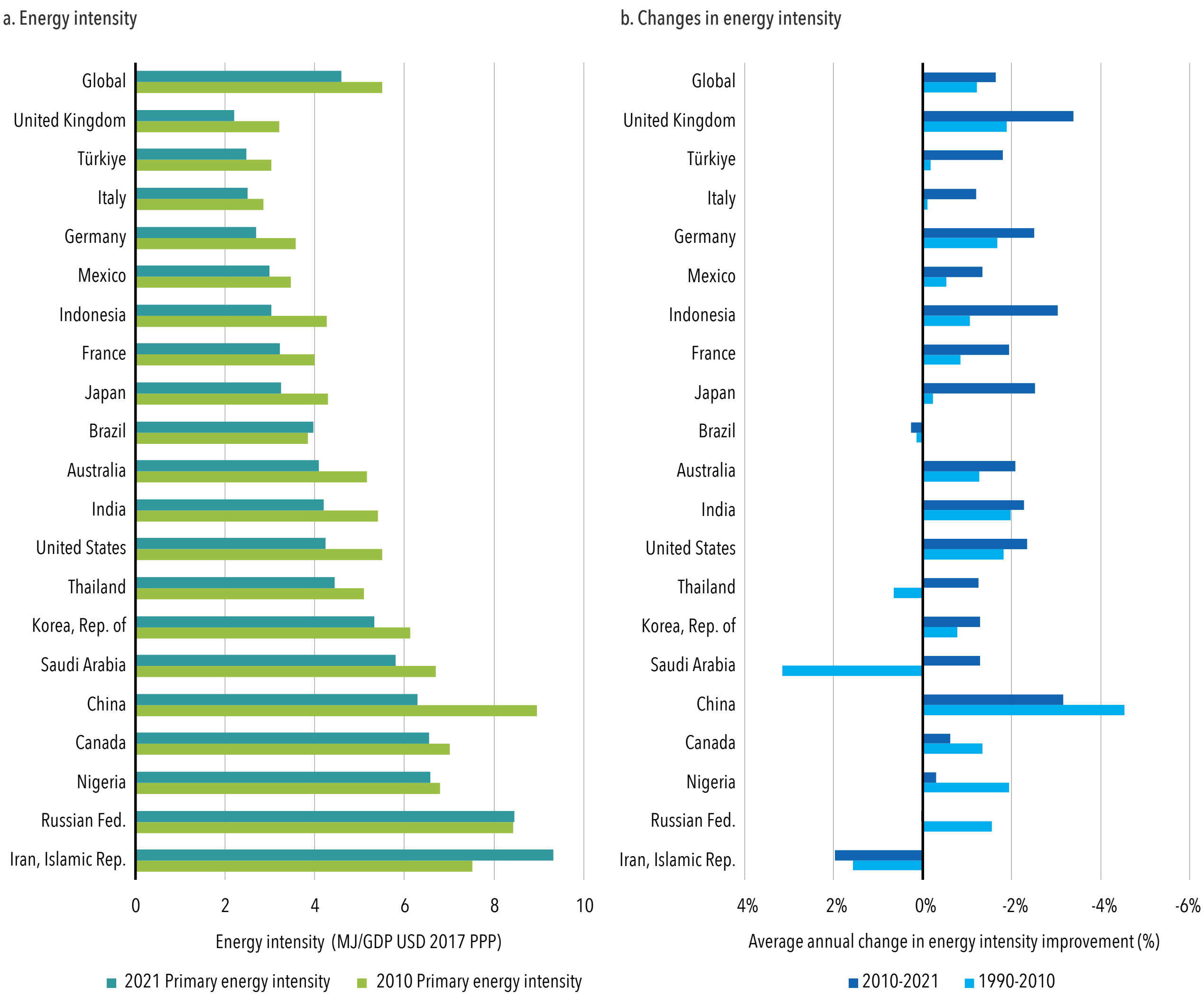
MJ = megajoule; PPP = purchasing power parity.

Three regions—Eastern Asia and South-eastern Asia, Latin America and the Caribbean, and Western Asia and Northern Africa—doubled the rate of improvement of energy efficiency in 2010–21 compared with 1990–2010. However, for the latter two, these rates remained low, at 0.7 and 0.8 percent, respectively.

TRENDS IN TOP 20 COUNTRIES WITH LARGEST TOTAL ENERGY SUPPLY

The 20 countries with the largest total energy supply are central to achieving SDG target 7.3, as they represent three-quarters of global GDP and energy consumption. Between 2010 and 2021, 13 of these countries improved their energy intensity rates relative to the previous decade. However, only China, the United Kingdom, and Indonesia exceeded the 2.6 percent improvement required (figure 4.6). This group included two others, Japan and Germany, until a slowdown in 2021 pulled their average below the threshold. Six countries (Mexico, France, Indonesia, Japan, Türkiye, and Italy) more than doubled their improvement rates in 2010–21 compared with 1990–2010.

FIGURE 4.6 • LEVEL OF AND CHANGES IN PRIMARY ENERGY INTENSITY IN THE 20 COUNTRIES WITH LARGEST TOTAL ENERGY SUPPLY



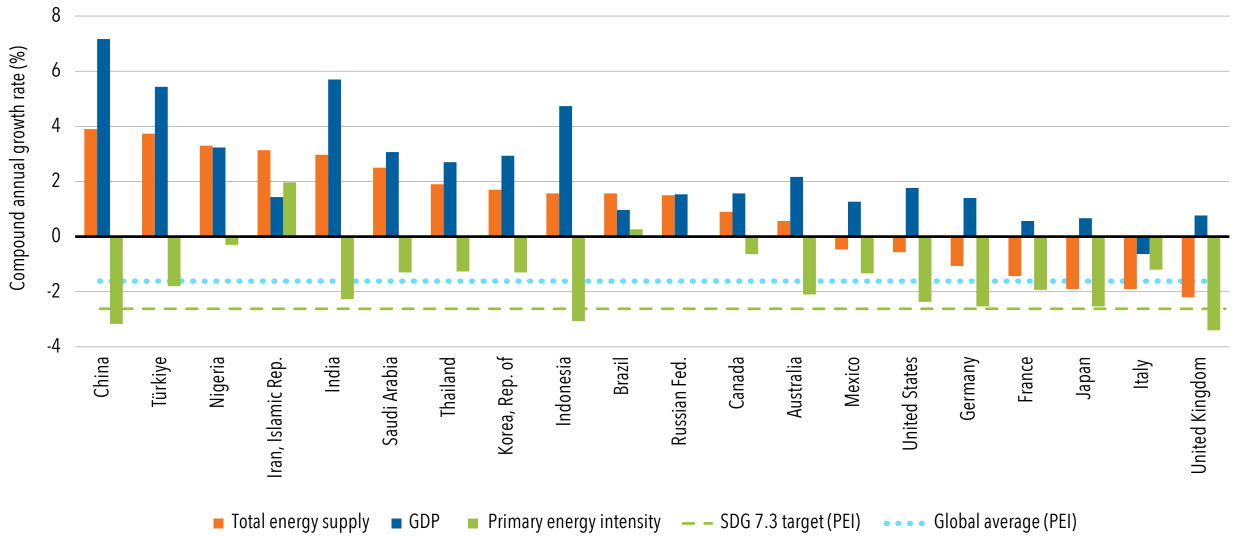
GDP = gross domestic product; MJ = megajoule; PPP = purchasing power parity.

However, in more than half of the top 20 countries, the COVID crisis reversed the trend. In 2020, four of them—China and the United Kingdom (which had significantly reduced their energy intensity over the decade), Mexico, and Australia—saw energy intensity improvement fall to its lowest level in a decade. Most of the 20 major countries improved their energy intensity levels in 2021, but 6 became more energy intensive, lowering the global average.

In absolute terms, the energy intensity of the 20 countries with the largest total energy supply ranges from slightly over 2 MJ/USD to more than 9 MJ/USD. Economies that rely heavily on extractive industries, such as fossil fuel producers, or energy-intensive industries tend to have much higher energy intensity due to their economic structure, not necessarily because of lower efficiency.

Countries where fossil fuel extraction is a major part of GDP—namely, the Islamic Republic of Iran, Brazil, Nigeria, Saudi Arabia, the Russian Federation, and Canada—are among those with the slowest progress. High energy intensity indicates the potential for a transition toward the use of cleaner and more efficient energy sources to achieve significant progress. The annual rate of change in energy intensity is an important indicator and policy target for tracking both diversification and energy efficiency goals.

FIGURE 4.7 • AVERAGE ANNUAL CHANGES IN TOTAL ENERGY SUPPLY, GDP, AND PRIMARY ENERGY INTENSITY IN THE 20 COUNTRIES WITH THE LARGEST TOTAL ENERGY SUPPLY



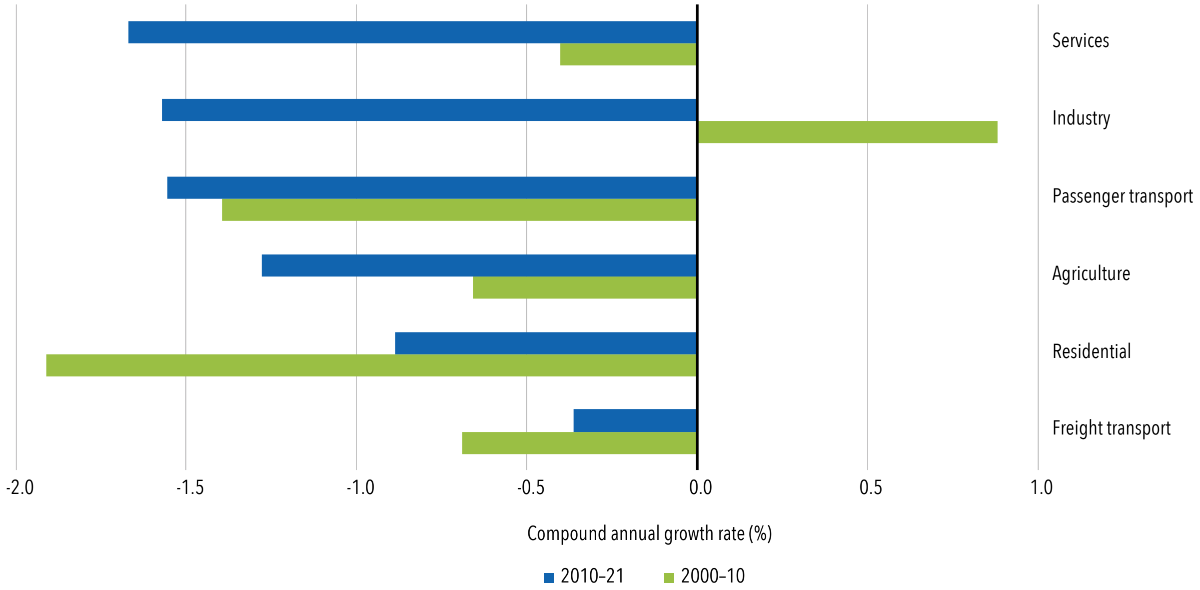
Note: Figures show changes between 2010 and 2021. Countries are set in decreasing order of total energy supply growth.
GDP = gross domestic product; SDG = Sustainable Development Goal, PEI = primary energy intensity.

Between 2010 and 2021, the United Kingdom, Japan, France, Germany, the United States, and Mexico grew their economies while reducing their energy use, indicating a decoupling of economic growth from energy consumption. These countries have decades-long records of policy action on energy efficiency and, except Mexico, increasingly service-based economies, which are less energy intensive than manufacturing. In contrast, countries with higher energy demand (see the left side of figure 4.7) are building new infrastructure with energy-intensive industrial products, such as steel and cement. Economic growth in emerging markets and developing economies also results in increased access to energy services, driving up energy demand.

END-USE TRENDS

Sectoral energy intensity is calculated as the ratio of final energy consumption to a sectoral activity indicator, such as industrial gross value added or surface area. Between 2010 and 2021, sectoral energy intensity improvement accelerated across all but the residential buildings sector, where it nearly halved from its value in the 2000–10 period (figure 4.8).

FIGURE 4.8 • AVERAGE ANNUAL CHANGE IN ENERGY INTENSITY, BY SECTOR, 2000–10 AND 2010–21



Note: The measures for energy intensity in this figure differ from those applied to global primary energy intensity. Here, energy intensity for freight transport is defined as final energy use per tonne-kilometer (including road and rail transport only, obtained from IEA's Global Energy and Climate Model); for passenger transport, it is final energy use per passenger-kilometer (including only road and rail transport, obtained from the Global Energy and Climate Model); for residential use, it is final energy use per square meter of floor area; in the services, industry, and agriculture sectors, energy intensity is defined as final energy use per unit of gross value-added (in 2017 USD purchasing power parity).

In industry—which comprises highly energy-intensive economic activities such as the manufacturing of cement, iron, and steel—energy intensity improved by an average of 1.6 percent per year between 2010 and 2021. This rate represents a major achievement, reversing the trend of the previous decade (2000–10), when the sector's energy use per unit of value added increased. Amid the economic recovery following the onset of the COVID-19 pandemic, industrial demand for energy surged to record levels, mainly due to an increase in energy-intensive industrial processes.

Between 2010 and 2021, the energy intensity of passenger transport improved at a slightly faster rate (1.6 percent a year) than in the previous decade (1.4 percent). Freight transport's improvement slowed after 2010, dropping from 0.7 percent to 0.4 percent. After being one of the hardest-hit sectors, passenger transport experienced rapid recovery in 2021 as lockdowns were lifted and people resumed travelling. However, demand had not returned to pre-pandemic levels by 2021.

Electrification is playing a key role in increasing efficiency and limiting growth in demand for passenger transport. In 2021, 6.5 million electric vehicles (EVs) were sold, more than doubling 2020 sales and representing about 10 percent of car sales worldwide. At the same time, however, the average size of cars increased, with SUVs accounting for almost half of global sales (IEA 2023c). SUVs are typically heavier and less fuel-efficient, consuming on average 20 percent more energy than medium-size vehicles to travel the same distance (IEA 2024a).

The residential sector, which includes final residential uses such as heating, cooling, and cooking, saw a slowdown in the annual rate of energy intensity improvement, from 1.9 percent in the first decade of this century to 0.9 percent in the second. Final energy demand in the residential sector was the least affected by COVID-19 restrictions in 2020 and saw only a small increase in 2021.

In the services sector, energy intensity improved by 1.7 percent a year between 2010 and 2021, returning to pre-pandemic levels in 2021. This is a notable shift from the previous decade's average of just 0.4 percent.

Annual improvement rates also accelerated in agriculture, rising from 0.7 percent in 2000–10 to 1.3 percent in 2010–21, as the sector's economic output outpaced growth in its energy demand.

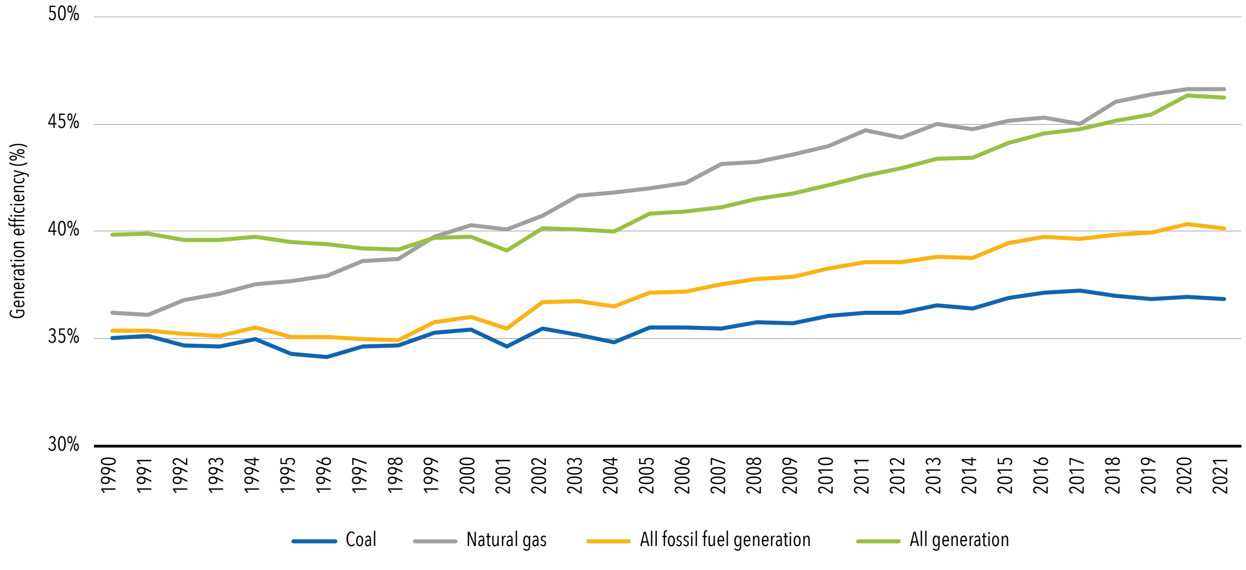
TRENDS IN THE EFFICIENCY OF ELECTRICITY GENERATION

Improving the efficiency of electricity generation[30] can also lower energy intensity by reducing primary energy use. Measures include modernizing infrastructure to reduce transmission and distribution losses, improving the efficiency of fossil fuel generation, phasing out inefficient power plants, and adding renewable energy sources to the electricity mix.

Analyzing the two major fossil fuels used for electricity generation, coal and natural gas, average efficiency increased between 2000 and 2021, after showing flat rates of improvement during the 1990s. Efficiency improvements from natural gas balanced out slower improvements from coal generation (figure 4.9).

An important factor affecting supply efficiency is the share of renewable energy sources in the mix. By convention, most renewable energy technologies are treated as 100 percent efficient, even though minor losses occur in the conversion of resources such as sunlight and wind into electricity. Thus, adding more renewable energy in the electricity mix has a direct impact on the efficiency of electricity generation. The rapid deployment of renewable energies, particularly in the past 15 years, has contributed to an upward trend in overall efficiency.

FIGURE 4.9 • GLOBAL EFFICIENCY OF ELECTRICITY GENERATION, BY TYPE OF FUEL AND TOTAL, 1990–2021



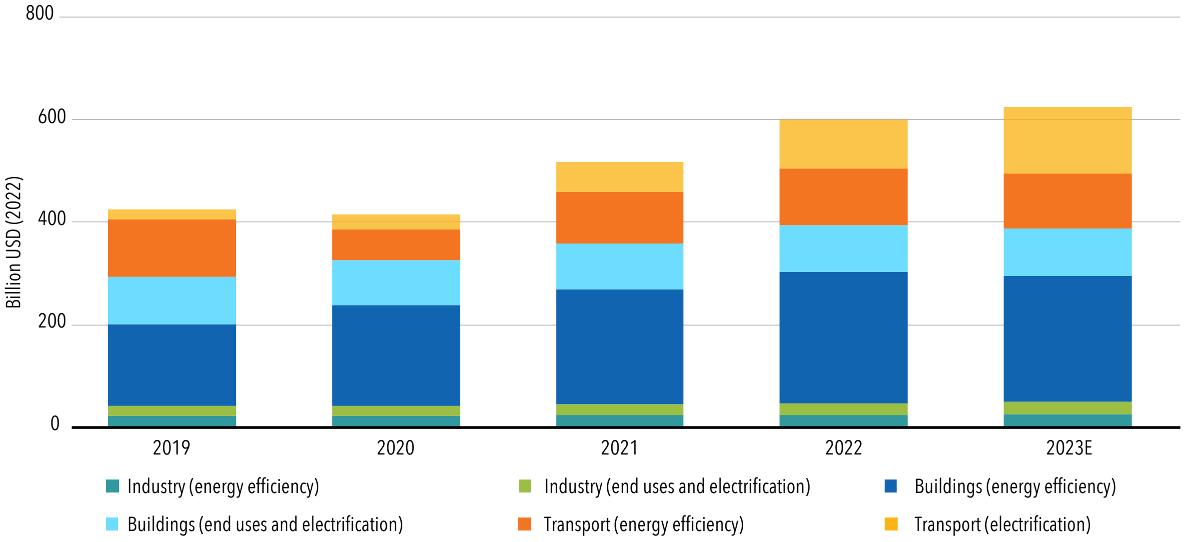
Adding renewables to the electricity mix and electrifying final uses can significantly improve progress in energy intensity, as efficiency improves on both the supply and demand sides. The implementation of targeted energy efficiency measures can also help phase out or limit the use of inefficient generation equipment, highlighting the synergies between SDG targets 7.2 and 7.3.

30 The efficiency of electricity generation is calculated as the energy output (electricity) over the energy input (such as fossil fuels or other energy sources) on a global scale.

INVESTMENT IN ENERGY EFFICIENCY

In 2020, annual investment in energy-efficient equipment and electrification of end uses decreased only slightly, to about USD 415 billion (figure 4.10). Europe, China, and Northern America accounted for nearly 80 percent of this spending. Unprecedented growth in Europe's buildings sector offset the decline of investment in transport efficiency, while industry spending remained largely unchanged. Investment in building efficiency measures made up two-thirds of total efficiency spending in 2020.

FIGURE 4.10 • INVESTMENT IN ENERGY EFFICIENCY, BY SECTOR, 2015–23



Source: IEA 2023a.
E = estimate.

In 2021, after weak or no growth in the second half of the previous decade, energy efficiency–related investment began to increase, reaching almost USD 520 billion, driven by government stimulus programs in the buildings sector and a recovery in transport investment. Investment in buildings' energy efficiency rose to over USD 220 billion. Investment in transport efficiency reached USD 100 billion (or almost pre-pandemic levels), while investment in transport electrification doubled, following the accelerated adoption of EVs. Investment in industry remained steady, at slightly above USD 40 billion.

The 2022 energy crisis led to a rapid increase in energy efficiency investments, with governments, industry, and households investing nearly USD 600 billion, a new record. At least 16 high-profile national plans are driving increases in efficiency, including the US Inflation Reduction Act, the REPowerEU Plan, the European Union's recast Energy Efficiency Directive, and Japan's Green Transformation (GX) Initiative. Most of this spending is by high-income countries. Low- and middle-income countries could use recovery packages to boost spending, which would create jobs and promote economic growth (IEA 2022).

Inflation and high interest rates are expected to have slowed investment growth in 2023 to 4 percent a year. With investment in other sectors stalling, the increase was driven mainly by investments in transport electrification, which continues to grow at a rapid rate of 35 percent year-on-year. Total energy efficiency–related investment is estimated to have reached a record level of just over USD 620 billion, about USD 200 billion above pre-pandemic levels.

Policy recommendations

Energy intensity is expected to improve at a more rapid pace in 2022 and 2023 but still fall short of meeting SDG target 7.3. Stronger government policies and regulations are needed to accelerate improvements and reach an annual average of 3.8 percent through 2030, in line with the target.

The 2022 energy crisis brought home the fact that well-designed and well-implemented energy efficiency policies can deliver multiple benefits beyond savings in energy and emissions. These benefits include stronger energy security; reduced exposure to global shifts in energy prices; lower energy prices; lower energy bills for households and businesses; new jobs in energy efficiency retrofits; and improved health and well-being.

IEA has identified milestones to achieve 4 percent annual progress in energy intensity for the remainder of the decade, aligned with the doubling target agreed at COP28. These include electrifying final uses, increasing productivity in the industrial sector, reaching higher annual retrofit rates, adopting more efficient appliances and lighting equipment, continued adoption of EVs, and behavioral changes that help reduce energy demand (IEA 2023b).

Governments have a range of policy instruments at hand to increase energy efficiency, such as those introduced in IEA's Energy Efficiency Policy Toolkit. These include information programs to help energy users make informed decisions, regulations mandating higher efficiency levels in buildings, appliances, vehicles, and industry, and fiscal or financial incentives for installing energy-efficient equipment and carrying out retrofits (IEA 2024b). The following sections describe policies that can lead to significant energy efficiency improvements, classified by sector.

POLICIES FOR THE APPLIANCES SECTOR

Energy efficiency labeling. Labeling programs help consumers select more energy-efficient products and appliances. Comparative labels, typically mandatory, include a classification scale for comparing energy performance across all products of the same type. Endorsement labels, usually voluntary, recognize best-in-class models and are affixed only to the most efficient options. Both types of labels help move consumers toward more efficient models.

Label designs vary worldwide, with no universal standard design. It is essential that a label be easily understood by the target consumer, and thus reflect cultural and other local norms. Implementation may require a variety of regulations, institutions, and types of infrastructure. Access to testing facilities can be challenging, for example. International cooperation and regional harmonization play an important role in aligning regulations, reducing compliance costs, and facilitating implementation in new markets.

Comparative energy efficiency labeling is also important for market analysis, by providing a source of standardized data on all models offered in the market. It is also a driver for the implementation of other policies, such as Minimum Energy Performance Standards and rebates and discounts for high-efficiency models. More than 110 countries have labeling schemes. Examples of regional cooperation and harmonization include the Equipment Energy Efficiency Programme in Australia and New Zealand, the EU Energy Label, and most recently, the CARICOM Energy Efficiency Labelling Programme.

Minimum energy performance standards. Minimum Energy Performance Standards (MEPS) help remove inefficient products from the market. The levels set should align with international best practices but be adapted to local circumstances and market conditions. MEPS require active market surveillance and regular updates to match market and technological improvements, while being implemented in a way that allows manufacturers and importers to adapt in a timely way.

Initially adopted in Europe and Northern America, MEPS now cover a large share of key energy-consuming end uses in these regions and are expanding their reach across the world. Over 80 percent of global energy used for air conditioners and refrigerators is covered by MEPS (IEA 2023a); coverage is lower for other appliances and final uses. More than 110 countries have implemented MEPS. Countries that have relatively new programs have the potential to leapfrog to the most efficient and competitive technologies (IEA 2021a).

The stringency of MEPS programs varies widely across countries. Enhanced international cooperation would help governments introduce new standards, learn from others' experiences, and adopt best practices. Regional harmonization is essential to ensure compliance, lower costs of implementation, and mitigate cross-border dumping of inefficient products, while expanding markets for more efficient models.

Economic incentives for high-efficiency appliances. Purchase rebates and financing tools targeting models in the highest energy efficiency classes can encourage manufacturers and importers to offer more efficient products, and consumers to choose them. Several countries have implemented such rebates. Singapore, for example, offers climate vouchers worth around USD 220 for purchasing high-efficiency models of selected appliances, including refrigerators, air conditioners, and washing machines.

To reduce the burden of high up-front costs, some countries offer low- or zero-interest credit. In areas with limited access to credit, governments work with banks and utilities to simplify requirements. For example, "on-bill finance" models involve utilities providing credit to their customers and adding monthly loan payments to utility bills, such as in the Ecofridges program in Senegal. In Ghana, an "on-wage financing" model was used. In that model, loans are paid back through salary deductions, with employers acting as guarantors.

POLICIES FOR THE BUILDINGS SECTOR

Building energy codes. Building energy codes are regulations that set minimum requirements for energy use in buildings. They may specify overall building efficiency (performance-based codes) or the efficiency of individual components such as insulation, lighting systems, or heating and cooling systems (prescriptive codes). Requirements should take into account local climate conditions and include provisions for on-site renewable energy production, energy management systems, electrification of end uses, and demand-response readiness.

Building energy codes should be applied to both new buildings and to those undergoing major renovations, and set deadlines for efficiency upgrades. Energy efficiency requirements should be updated every three to five years, with increasing stringency. Ideally, regulations include a plan for the evolution of these codes with timelines and milestones for updates, in order to help the industry prepare for, and adapt to, new requirements. Codes should specify a clear compliance path for architects, builders, and property developers to follow. As of 2023, around 80 countries had adopted mandatory national energy codes for residential buildings (IEA 2023a).

Energy performance certificates for buildings. Energy performance certificates (EPCs) provide information on a building's energy performance and demand, indicating its efficiency. EPCs typically include an energy efficiency rating (usually from A to G), recommended measures for improving the rating, and estimates of annual energy use based on standard usage patterns.

EPCs can be used to assess the overall energy performance of the real estate market, guiding specific policies for different building types. Residents of low-performing buildings can be eligible to receive targeted retrofit grants, while high-performing buildings can qualify for tax benefits and favorable financing terms for their purchase.

Incentives for building retrofits. In some countries, the buildings of today are expected to account for up to 80 percent of the total building stock in 2030. Retrofits are therefore critical to improving energy efficiency. The most effective retrofits enhance the building envelope (e.g., by adding insulation and improving glazing), involve a switch to more efficient equipment (such as heat pumps or renewables-based heat solutions), and incorporate digital energy management.

Incentives include subsidies, rebates, and low interest rates, among others. They can target simple retrofit measures or aim for deep renovations that substantially improve building performance. The MaPrimeRénov' program in France includes various measures with a focus on low- and middle-income households.

POLICIES FOR TRANSPORT

Energy labels for vehicles. Labels inform consumers about a vehicle's fuel (or electricity) consumption, helping them identify the most efficient models. Labels cover both new and used vehicles, and can be displayed in car showrooms and online. Increasingly, EV labels include metrics for driving range.

In addition to information on energy consumption (e.g., liters/100 kilometers, miles per gallon, watt-hours/kilometer), labels can include information on carbon dioxide and other air pollutants, as well as on fuel cost savings—helping people choose vehicles that cost less to run. More than 35 countries across the world have vehicle efficiency labels in place.

Fuel economy standards. Fuel economy standards regulate the fuel efficiency of new vehicles and promote advanced technologies. When well monitored and enforced, they can greatly reduce fuel use. These standards are most effective in countries with large markets and vehicle manufacturing facilities. Typically, standards for passenger cars require manufacturers to maintain the average efficiency of their sold cars below a certain threshold that is regularly updated based on market trends.

Fuel economy or emissions standards for new cars and trucks can be found in more than 40 countries, covering over 80 percent of new vehicle sales worldwide. These standards increasingly include provisions for zero-emissions vehicles. Most recently, Chile set standards for light-duty vehicles.

Incentives to buy electric vehicles. Several countries offer EV rebates and tax benefits to reduce the price gap between EVs and internal combustion engine vehicles. These incentives usually combine vehicle tax reductions and subsidies, such as purchase rebates or tax credits. Purchase rebates are common in many European countries, Japan, the Republic of Korea, and some Canadian provinces and US states, among others. The United States provides a vehicle tax credit at the national level.

Countries also offer tax exemptions to reduce the costs of acquiring and owning EVs, often as complements to subsidies. Many countries exempt EVs from value-added tax, registration taxes, and excise duties, or reduce these amounts for EV buyers. Additional benefits can include reduced tolls and parking charges. Norway, for example, combines tax exemptions and fee reductions to significantly lower the costs of buying and owning an EV.

POLICIES FOR INDUSTRY

Industrial energy efficiency networks. Energy efficiency networks consist of energy managers from different industrial sites who meet regularly to share knowledge and experiences relevant to improving energy efficiency. These networks may operate solely to facilitate the sharing of information among peers, or may include elements such as energy reporting and the setting of energy-saving targets. They guide industries to become more efficient, align with government policies, and offer insights to inform more effective policy development.

There are more than a thousand industrial energy efficiency networks worldwide and this number is growing as governments seek to expand their policies and industries seek to reduce costs, energy use, and emissions. Efficiency networks were first introduced in Switzerland and have expanded across the world, with successful examples in Germany, Ireland, China, and Argentina, among others.

Minimum energy performance standards for motors. Electric motors and motor systems in industrial and infrastructure applications, such as pumps, fans, and compressors, consume about half of the world's electricity. Electric motors are categorized by energy efficiency under IEC Standard 60034-30 series, ranging from IE1 (lowest efficiency) to IE5 (highest efficiency). Many motors sold around the world do not even meet IE1 efficiency requirements.

By 2023, 62 countries had MEPS for industrial electric motors, covering 57 percent of motors' energy consumption worldwide (IEA 2023a). Some countries—including Switzerland, Türkiye, the United Kingdom, and countries in the European Economic Area—recently adopted IE4 levels for motors in the 75–200 kW range. Efficiency gains can also be achieved by implementing digital technologies and systemwide measures, such as using variable speed drives, which many regulations include when setting MEPS (4E IEA 2022).

Energy management systems. Energy management systems involve practices that improve energy efficiency on an ongoing basis. The process of implementing a system begins with an energy audit to identify opportunities for improvement, followed by the setting of measurable targets and objectives, and the implementation of associated measures. Elements of the process are verified and improved over time.

One of the key frameworks for energy management systems is the international standard known as ISO 50001. This framework centers on monitoring, targeting, and implementing energy-saving measures in a cycle of continuous improvement. In 2022, the number of ISO 50001 certificates issued worldwide grew by almost 30 percent, to 28,000 (IEA 2023a).

Policies and initiatives to promote energy management systems include mandating their implementation by large energy consumers, organizing national awards and acknowledgments, and offering preferred energy tariffs to users with certified energy management systems.

CROSS-CUTTING MEASURES AND POLICIES

Digitalization and system-level efficiency. Digital technologies and data hold great potential to accelerate the clean energy transition across the energy sector. Advances in digital technologies and services, declining costs, and increasing connectivity have accelerated the digital transformation of energy in recent years, particularly in electricity networks. Grid-related investment in digital technologies has grown by over 50 percent since 2015 and was expected to reach 19 percent of total grid investment in 2023 (IEA 2023d).

Digitalization can improve efficiency across all demand sectors, introducing technologies and creating new sources of detailed data to support new business models and revenue streams. It enables smart energy management systems in buildings, increases automation and the optimization of industrial processes, and facilitates the implementation and upgrading of intelligent transport systems. In electricity systems, technologies like machine learning, smart meters, and other digital technologies help integrate greater shares of variable renewables and better match supply and demand from decentralized sources such as EVs and connected appliances.

Several countries and regions have recently put forward strategies and action plans to facilitate the digital transformation of their energy systems, while others are beginning to mandate the use of digital technologies to support the clean energy transition. Many of them incentivize and support the rollout of smart meters and the adoption of digital devices across sectors (IEA 2021b).

Energy efficiency obligation schemes. Energy efficiency obligation (EEO) schemes are market-based programs that specify an outcome (energy savings or cost-effectiveness) to be delivered by a utility or other market participant (such as an energy services company). Auctions allow market actors to bid for funds to deliver specific energy savings. As of 2022, there were 48 EEO programs in 23 jurisdictions. Sixteen countries in the European Union and 24 US states operate EEOs (in the United States, they are called Energy Efficiency Resource Standards).

Some EEO schemes issue "white certificates" (also called energy savings certificates), which certify a certain reduction in energy or emissions. White certificates are generally tradable and come with an obligation to achieve an energy or emissions savings target. They can be obtained by implementing efficiency measures in various sectors. Uruguay, France, and Italy are among the countries to use them.

Conclusions

The rate of energy intensity improvement remains below the annual 2.6 percent necessary to reach SDG target 7.3. The COVID-19 crisis worsened an already slowing trend, with energy intensity improvement dropping to 0.6 percent in 2020 and 0.8 percent in 2021, down from an average rate of 1.3 percent over 2015–20, and 2.1 percent in 2010–15.

To meet the SDG target 7.3 of doubling the global rate of energy intensity improvement by 2030, the average rate must now be at least 3.8 percent per year through 2030, to make up for slow progress in the past. This rate would need to be slightly higher—consistently over 4 percent for the rest of this decade—to put the world on track for IEA's Net Zero Emissions by 2050 Scenario.

Preliminary analysis of 2022 data indicates an above-average improvement rate, reaching about 2 percent, as the energy crisis curbed energy consumption and prompted the rapid implementation of new policies and an increase in energy efficiency investments. This remains under the SDG 7.3 target values. A return to long-term trends is expected in 2023, with energy intensity improvement dropping to around 1.3 percent (IEA 2023a).

Energy efficiency policies and investment in cost-effective measures need to be scaled up significantly. Given the multiple benefits of energy efficiency, doing so is a smart choice for governments. Many countries recognize as much: energy efficiency–related spending accounted for about two-thirds of the USD 1 trillion mobilized by governments for post-pandemic economic recovery between 2020 and 2022 (IEA 2022).

Improving efficiency at scale is key to achieving affordable, sustainable energy access for all. Low levels of intensity improvement, significant investment opportunities, the potential for economic recovery, and the pressing need to expand energy access highlight the importance of enacting policies that foster rapid progress.

Universal access to electricity and clean cooking, increased electrification, and the incorporation of renewable energies improve energy intensity by significantly increasing the efficiency of energy end-uses and reducing inefficiencies on the supply side. More joint efforts are needed to leverage the synergies between the various SDG 7 targets.

National and subnational governments use an array of policies to help meet their energy efficiency goals. Policy packages combine regulations, information, and incentive mechanisms. Successful examples of implementation have the potential to be replicated to enhance energy efficiency at the global level. IEA has published an Energy Efficiency Policy Toolkit summarizing the main tools to be used across various sectors (IEA 2024b).

Both the technologies and resources to double energy efficiency improvement by 2030 are available (UN 2021). Weak improvement rates and inadequate investments indicate a major missed opportunity for the global community. Prioritizing energy efficiency in policies and investments over the coming years can help achieve SDG target 7.3, promote economic development, improve health and well-being, and ensure universal access to clean energy.

CHAPTER 5
INTERNATIONAL PUBLIC FINANCIAL FLOWS TO DEVELOPING COUNTRIES IN SUPPORT OF CLEAN ENERGY

Main messages

Global trends. Tracking of Sustainable Development Goal (SDG) indicator 7.a.1 reveals that international public financial flows in support of clean energy in developing countries rebounded in 2022. However, the rebound did not correct a declining five-year trend that may delay the achievement of SDG 7 by least-developed countries (LDCs), landlocked developing countries (LLDCs), and small island developing states (SIDS). While flows increased to USD 15.4 billion, a 25 percent increase over 2021, the level is still around half the 2016 peak of USD 28.5 billion. The global average for the five years ending in 2022 amounted to USD 14.1 billion, down by USD 1.5 billion from the five-year average ending in 2021.[31]

Target for 2030. There is no quantitative target for international public financial flows under indicator 7.a.1. However, the declining trend shows that the world is not on track to meet the goal of enhancing international cooperation to facilitate access to clean energy research and technologies for countries in need. Given the role of financing in delivering progress toward SDG 7 (as outlined in chapter 6), international public flows must increase substantially and target those countries most in need of financial aid.

Technology highlights. Almost half (47 percent) of financial commitments in 2022 flowed to renewable programs that are not technology specific. Donors increasingly bundle their support for a range of renewable energy solutions, such as electrification programs. The remaining flows are distributed between solar energy (35 percent), wind energy (11 percent), hydropower (7 percent), and geothermal energy (0.4 percent). These trends are likely to continue, since donors are increasing the number of their investments, while decreasing the project size (except in the case of hydropower and other multi-billion-dollar technologies).

Regional highlights. International public investment flows changed substantially in all developing regions except Sub-Saharan Africa between 2021 and 2022. Flows increased in six regions and decreased in two, but remained unevenly distributed across regions and the countries within them.[32] Oceania enjoyed the largest relative increase: 662 percent (USD 85.9 million). Flows to Western Asia and Northern Africa followed, rising 135 percent (USD 990.5 million). Flows to Latin America and the Caribbean were up 114 percent (USD 1.994 billion), while those to Northern America and Europe climbed by 24 percent (USD 90 million). Flows to Sub-Saharan Africa, by contrast, showed only a modest 2.5 percent increase (USD 112.5 million). Flows to Central Asia and Southern Asia fell by 39 percent (USD 1.166.7 billion); those to Eastern Asia and South-eastern Asia dropped by 9 percent (USD 135.4 million). Meanwhile, commitments not directed to a specific region or country (e.g., regional bonds and funds, umbrella loans for multiple projects) climbed 193 percent (USD 1.076.7 billion).

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31 Public investment flows fluctuate widely, with hundreds of commitments, including multi-billion-dollar ones, in some years and fewer and smaller commitments in others. For this reason, a five-year moving average provides a more meaningful analysis of the trend over time. Detailed datasets with country data for the SDG 7 indicator discussed in this chapter can be accessed at no charge at https://trackingsdg7.esmap.org/downloads.

32 The most recent increases are highlighted here. More detailed analysis of longer trends appears in the regional section of this chapter.

Commitment distribution highlights. International public financial flows remain concentrated in a few countries. In 2021, 80 percent of commitments were distributed among 19 countries, while 25 countries accounted for 80 percent of commitments in 2022, which is lower than the average for 2010–22. The number of countries receiving no commitments fell from 28 to 27 in 2022. Forty-three LDCs received some sort of financing in 2022, leaving only Guinea-Bissau and Burundi without inflows. Between 2010 and 2022, LLDCs attracted more finance than LDCs. Flows to SIDS reflect the most even distribution relative to their population, with 80 percent of flows going to countries in which 86 percent of the population lives.

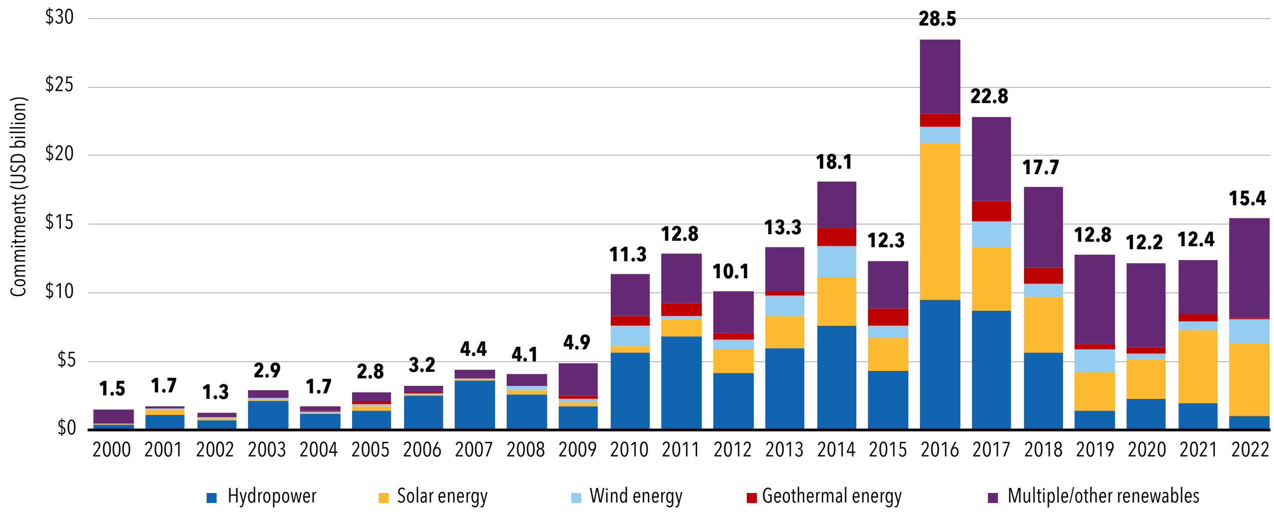
Financing instruments. Debt instruments accounted for two-thirds of flows in 2022, down from more than 90 percent in 2010, while the share of grants, equity, and guarantees increased. Standard loans totaling USD 7.1 billion accounted for 46 percent of flows in 2022, making them the most-used financial instrument. Grants reached an all-time high of USD 3.6 billion, up 50 percent over 2021, to become the second-most frequently used financial instrument, at 23 percent. A larger share of grants helps countries receiving them avoid increasing their debt burdens. Concessional loans reached USD 3.2 billion and equity investments USD 1.2 billion. Mezzanine finance reached USD 136 million, less than 1 percent of total flows in 2022.[33] Guarantees and credit lines reached just USD 16 million.

33 Mezzanine finance includes subordinated loans, preferred equity, and other hybrid instruments, including convertible debt or equity. In case of default, subordinated loans are repaid only after all senior obligations have been satisfied. For the increased risk, mezzanine debtholders require a higher return on their investment than do secured or more senior lenders. In the event of a default, preferred equity is repaid after all senior obligations and subordinated loans have been satisfied and before common equity holders are paid. Mezzanine finance is a more expensive source of finance than senior debt but less expensive than equity.

Are we on track?

The volume of public international financial flows to developing countries in support of clean energy research and development and renewable energy production has fallen over time. Even in the absence of a quantified SDG 7.a.1 target for enhanced international cooperation, data show that these flows have declined since their 2016 peak of USD 28.5 billion. While flows were 25 percent higher in 2022 (USD 15.4 billion) than in 2021 (USD 12.4 billion)—see figure 5.1[34]—a relatively small group of funders is responsible for most flows, as discussed in detail in last year's edition.

FIGURE 5.1 • ANNUAL INTERNATIONAL PUBLIC FINANCIAL FLOWS FOR RENEWABLES IN DEVELOPING COUNTRIES, BY TECHNOLOGY, 2000–22



Source: IRENA and OECD 2024.
Note: The "multiple/other renewables" category is explained in the methodology section.

The uptake in international public flows in 2022 was driven by flows toward multiple renewables (or renewables other than the most common technologies identified in the figure) and from European sources. This potentially reflects a change in portfolio management, with the European Union as the top investor; the European Union accounted for USD 2.3 billion (15 percent) of the year's total—an increase of USD 883 million over 2021.

The largest shift among donors was the USD 912 million invested by the European Bank for Reconstruction and Development (EBRD), which made it the fourth-largest donor in 2022. On the other hand, the International Finance Corporation had the largest year-on-year drop in investment (USD 457 million), followed by the Green Climate Fund (USD 396 million).

In contrast with previous years, the last two years showed no international investments in energy projects from the two Chinese development banks considered for this indicator: the China Development Bank and the Export-Import Bank of China. China accounted for 20 percent of all international public investment in renewable energy between 2000 and 2022—more than twice that of Germany, the second-largest donor.

34 Unless stated otherwise, all commitment amounts are expressed in US dollars at 2021 constant prices and exchange rates. Constant amounts are adjusted for inflation rates and changes in exchange rates. The methodology section of this chapter provides more information.

China's hydropower investment significantly affected flows, making hydropower the largest renewable energy technology attracting donor support. China directed 96 percent of its financial flows for renewable energy in 2000–22 to hydropower. Its investments accounted for more than half of total hydropower investments by donors over the period.

Looking beyond the main indicators

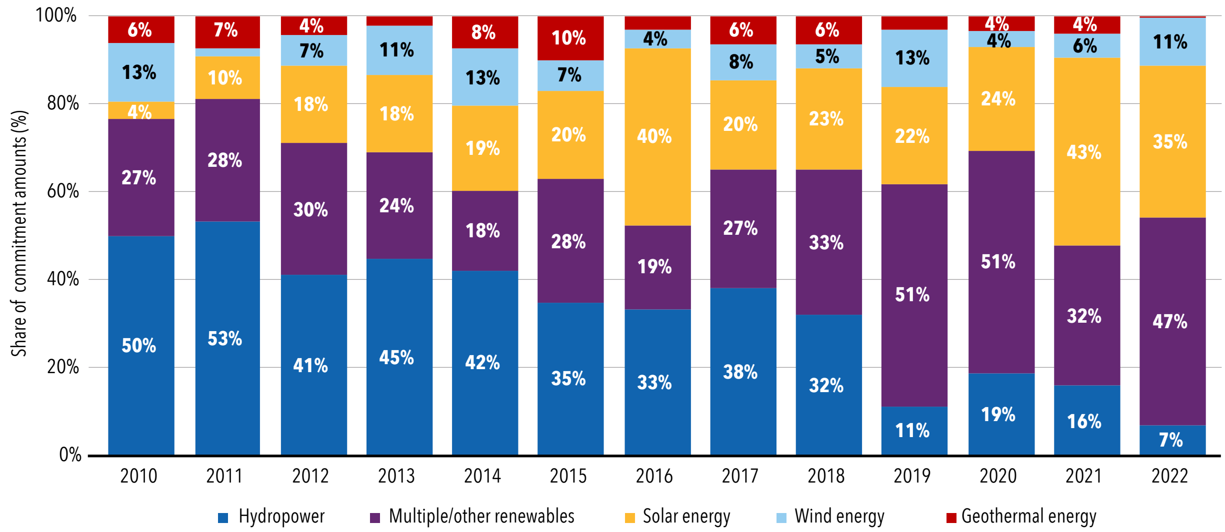
This section studies trends in international public flows from the perspective of technologies, geographic regions, countries, and financing mechanisms.[35]

TECHNOLOGY TRENDS

International public investors categorize flows to clean energy by the type of renewable energy involved: hydropower, solar, wind, geothermal, and multiple/other[36] (figure 5.2).

Over the past decade, the share of energy investments in hydropower fell and that of solar and multiple/other energy investments rose. This trend is likely to continue, though it may occasionally be disrupted by multi-billion-dollar investments in single hydropower projects. The reduction in hydropower is linked to the absence of such large investments. The data show donors opting for an increased number of loans and grants but reduced commitment amounts for individual projects.

FIGURE 5.2 • SHARE OF INTERNATIONAL PUBLIC FINANCIAL FLOWS TO RENEWABLES, BY TYPE OF ENERGY, 2010–22



Source: IRENA and OECD 2024.

35 The word country refers to a territory, area, or other unspecified location within the scope of SDG indicator 7.a.1.

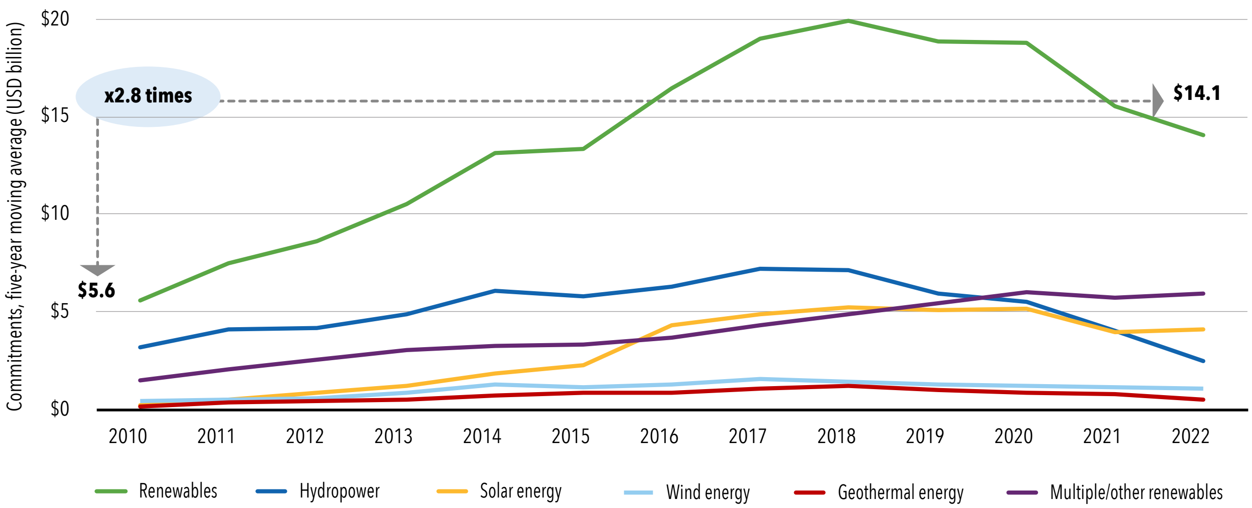
36 The multiple/other renewables category comprises unclear commitment descriptions in financial databases and lacks detail on the financial breakdown by technology. It includes bioenergy commitments, which are almost negligible; multipurpose financial instruments like green bonds and investment funds; and commitments targeting a broader range of technologies, such as renewable energy and electrification programs, technical assistance, energy efficiency programs, and other infrastructure supporting renewable energy.

The size of contributions and the choice of technology are related, with smaller investments gravitating toward the multiple technologies category. This category captures entries in financial databases that are unclear or nonspecific (therefore, it lacks detail on the financial breakdown by technology). The category includes multipurpose financial instruments like green bonds and investment funds; bioenergy commitments, which are almost negligible; and commitments targeting a broad range of technologies, such as renewable energy and electrification programs, technical assistance, energy efficiency programs, and renewable energy used to support infrastructure.

Almost half (47 percent) of commitments in 2022 were dedicated to multiple/other renewables; solar energy investments accounted for 35 percent of flows. The remaining flows went to wind energy (11 percent), hydropower (7 percent), and geothermal energy (0.4 percent). Among these technologies, investment in hydropower was USD 13.4 million per commitment (an unusually low level); the average investment in wind energy rose from USD 13.6 million in 2021 to USD 36 million in 2022 (figure 5.3).

The trend toward the "multiple/other" category adds complexity to flows. Its growth parallels the drops in commitments in recent years from large investors under the influence of national and other macroeconomic factors. It also reflects smaller but more frequent changes in how donors select their commitments, perhaps signaling a change in portfolio strategies.

FIGURE 5.3 • FIVE-YEAR MOVING AVERAGE OF INTERNATIONAL PUBLIC FINANCIAL FLOWS TO RENEWABLES, BY TECHNOLOGY, 2010–22



Source: IRENA and OECD 2024.

The moving average for all renewables for the five years ending in 2022 was USD 14.1 billion, 2.8 times greater than the moving average for the five years ending in 2010 (USD 5.6 billion) but 9.5 percent lower than the USD 15.6 billion in 2021. The trend toward smaller investments per commitment stabilized over the past four years; the average commitment was USD 11.1 million in 2022, partly because of the lack of Chinese investments, which tend to be large. Last year's report predicted this downward trend. For 2023, we may expect a recovery in this trend if investment amounts surpass USD 17.7 billion.

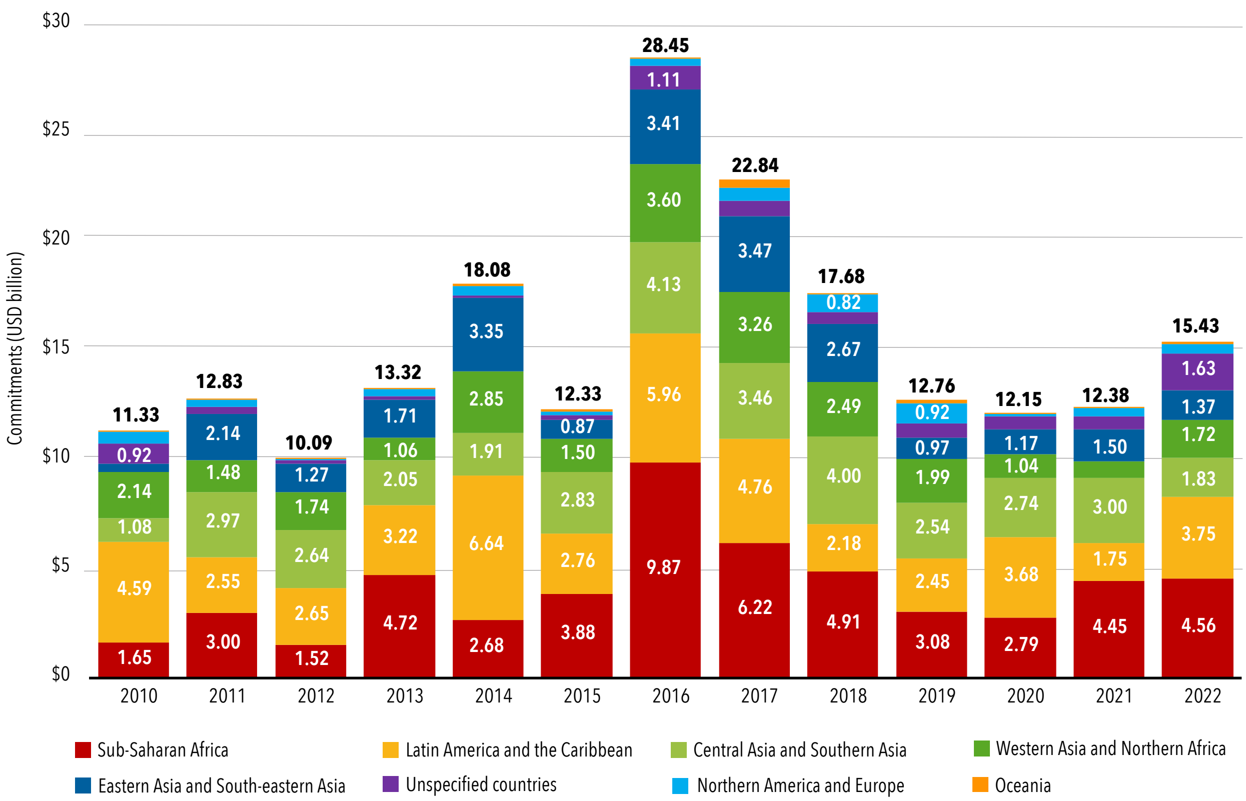
All the five-year average trends shown in figure 5.3 are bell-shaped and have different time horizons. Wind energy and hydropower were the first to peak, in 2017, at USD 1.5 billion and USD 7.2 billion, respectively. The year after, geothermal and solar energy peaked, at USD 1.2 billion and USD 5.2 billion, respectively. In 2022, solar energy investments were strong, ending the drop in the five-year average as commitments rose from USD 4.0 billion in 2021 to USD 4.5 billion. Multiple/other renewables, which peaked in 2020, remained almost flat in 2021 and 2022, reflecting a preference for bundling energy transition investments.

But the overall decline in investment continued, reflecting the need for more and larger investments in the upcoming years.

REGIONAL TRENDS

Most of the recovery of flows in 2022 came from investments in Latin America and the Caribbean. Flows to Central Asia and Southern Asia fell significantly (figure 5.4).

FIGURE 5.4 • ANNUAL INTERNATIONAL PUBLIC FINANCIAL FLOWS TO RENEWABLES, BY REGION, 2010–22

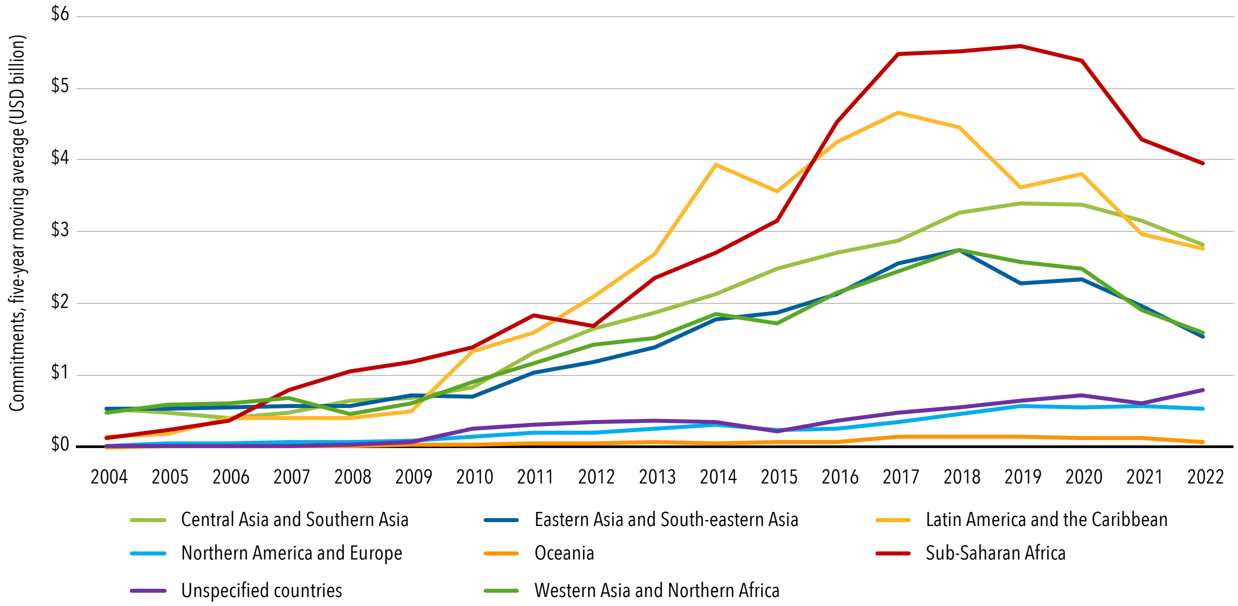


Source: IRENA and OECD 2024.
Note: See chapter 7 for the list of countries included in each region.

Public investment flows to all regions except Sub-Saharan Africa changed markedly between 2021 and 2022. Five regions saw increases in 2022; two experienced drops (figure 5.5). Oceania enjoyed the largest relative increase: 662 percent (USD 85.9 million). Flows to Western Asia and Northern Africa followed, rising 135 percent (USD 990.5 million). Flows to Latin America and the Caribbean rose 114 percent (USD 1.994 billion). Flows to Northern America and Europe were up by 24 percent (USD 90 million), but flows to Sub-Saharan Africa showed only a modest 2.5 percent increase (USD 112.5 million). Flows to Central Asia and Southern Asia fell by 39 percent (USD 1.17 billion). Those to Eastern Asia and South-eastern Asia dropped by 9 percent (USD 135.4 million).

Given annual fluctuations, five-year averages provide a clearer picture of regional trends (figure 5.5).

FIGURE 5.5 • FIVE-YEAR MOVING AVERAGE OF INTERNATIONAL PUBLIC FINANCIAL FLOWS TO RENEWABLES, BY REGION, 2004–22



Source: IRENA and OECD 2024.
Note: See chapter 7 for the list of countries included in each region.

Regional trends reveal a bell-shaped curve, apart from unspecified countries.[37] Funding to the unspecified country category grew over the past decade, as multicountry funding programs proliferated.

Sub-Saharan Africa was the top recipient of funding for renewables for the five years ending in 2022, with an annual average of USD 3.96 billion (28 percent of all commitments) driven largely by debt commitments for hydropower. Average annual commitments increased by 2.5 percent in 2022, reaching USD 4.6 billion. If these flow levels turn out to have held steady for 2023, the five-year average would drop by USD 70 million. Historically, large hydropower projects have attracted significant investment, especially from China. The recent decline in flows from China was accompanied by a decrease in hydropower investment. The global drop reflected a lack of new commitments, the completion of earlier commitments, a change in economic conditions caused by global events, and possibly changes in donors' priorities.

In recent years, solar investments have also taken priority in the region. Solar was the technology commanding the most commitments for the five years ending in 2022 (USD 2.3 billion), closely followed by multiple/other renewables (at USD 1.9 billion). Debt instruments were significant in 2022, with the five-year moving average valued at almost USD 3 billion (65 percent of flows). The debt component comprised USD 1.5 billion in concessional loans (33 percent), USD 1.5 billion in standard loans (32 percent), and USD 1.2 billion (26 percent) in grants. The largest donors for the region were the International Development Association (USD 1.4 billion), France (USD 611 million), and the International Bank for Reconstruction and Development (USD 562 million).

37 The bell-shaped distribution of some financial flows may appear flatter because the transaction amounts for North America and Europe and Oceania were relatively lower compared with those in other regions.

The five-year average for **Central Asia and Southern Asia** was the second-largest in 2022, at USD 2.8 billion. Average annual funding fell to USD 1.8 billion in 2022; if flows remain at this level for 2023, the five-year average will fall by USD 433 million. Despite the decline, the region attracts more investment now than it did in the past. Since 2010, the five-year average has more than tripled, thanks to steady increases in funding for solar and wind energy, as well as occasional large hydropower projects. In 2022, investments in wind energy reached USD 640 million; investments in solar energy, USD 525 million. These financial flows are also skewed toward debt instruments, totaling USD 1.4 billion in debt (77 percent), and including USD 731 million (40 percent) in standard loans and USD 677 million (37 percent) in concessional loans. The largest donors were Germany (USD 521 million) and the EBRD (USD 381 million).

The five-year average for **Latin America and the Caribbean** fell by almost 7 percent, from USD 2.96 billion in 2021 to USD 2.76 billion in 2022. Annual flows rose to USD 3.7 billion, up from USD 1.7 billion in 2021, pushed by USD 1.9 billion in multiple/other renewables and USD 1.3 billion in solar energy projects, mostly in the form of debt instruments—USD 3.2 billion (86 percent)—and an unexpected increase in equity (USD 282 million, 7 percent). The region is attractive to investors thanks to its range of renewable energy potential and middle- to high-income economies with track records of paying back large loans from development banks and bilateral donors (ECLAC 2017; IEA 2023).

All regions except **Western Asia and Northern Africa** at least doubled their five-year average inflows since 2010. In Western Asia and Northern Africa, flows increased by a factor of just 1.8, to USD 1.6 billion in 2022. This region has been experiencing a slowdown in international public flows since its peak of USD 3.6 billion in 2016. Flows fell to just USD 731 million in 2021; they climbed back to USD 1.7 billion in 2022. If they hold steady at USD 1.7 billion for 2023 (once these are known), the five-year average will fall by USD 155 million, to a five-year average of USD 1.3 billion. Solar and wind energy commitments are prominent in the region. Solar and wind energy auctions could have played a significant role in increased financing of solar and wind in 2016–17 (IRENA 2023). The use of standard loans declined in the past few years, accounting for the drop in overall public flows. Concessional loans remained stable, and grants fluctuated, reaching a recent high of USD 292 million in 2022.

Between 2010 and 2022, the five-year moving average committed to **unspecified countries** more than tripled, reaching an all-time high of USD 792 million, a 30 percent increase over the five-year average ending in the previous year. In 2022, unspecified countries attracted USD 1.6 billion, the largest amount ever recorded. If 2023 flows reach this level, the five-year average will increase by USD 223 million, reaching USD 1,014 million. Public flows in this category are for multiple or other renewables and tend to be global or multiregional in nature. They include green bonds and other sustainability-related funds and grants rather than commitments to specific countries. Most funding in this category is in the form of grants. In 2022, only 2.5 percent of commitments to this group were debt instruments. Top donors include the Green Climate Fund, Norway, Germany, the European Union, and the International Finance Corporation.

The five-year average in **Eastern Asia and South-eastern Asia** fell for the second year in a row in 2022, to USD 1.5 billion, a 21 percent decline. Annual flows declined 9 percent to USD 1.4 billion, down from USD 1.5 billion in 2021. If reported flows for 2023 hold steady, the five-year average will fall by USD 261 million, to USD 1.3 billion. Historically, the region has attracted flows to hydropower projects. Recent flows have been concentrated in solar, wind, and geothermal energy. The region's fluctuations in investments are explained by large hydropower and geothermal projects in the mid-2010s and perhaps instability in donor preferences, reflected by varying amounts of investment in the region by donors and variation in their technology selections. China has appeared as the largest donor in recent years, because of an extraordinary USD 2.3 billion committed in 2017. Standard and concessional loans continue to be the most common form of funding in this region, accounting for 87 percent (USD 1.2 billion) of flows in 2022.

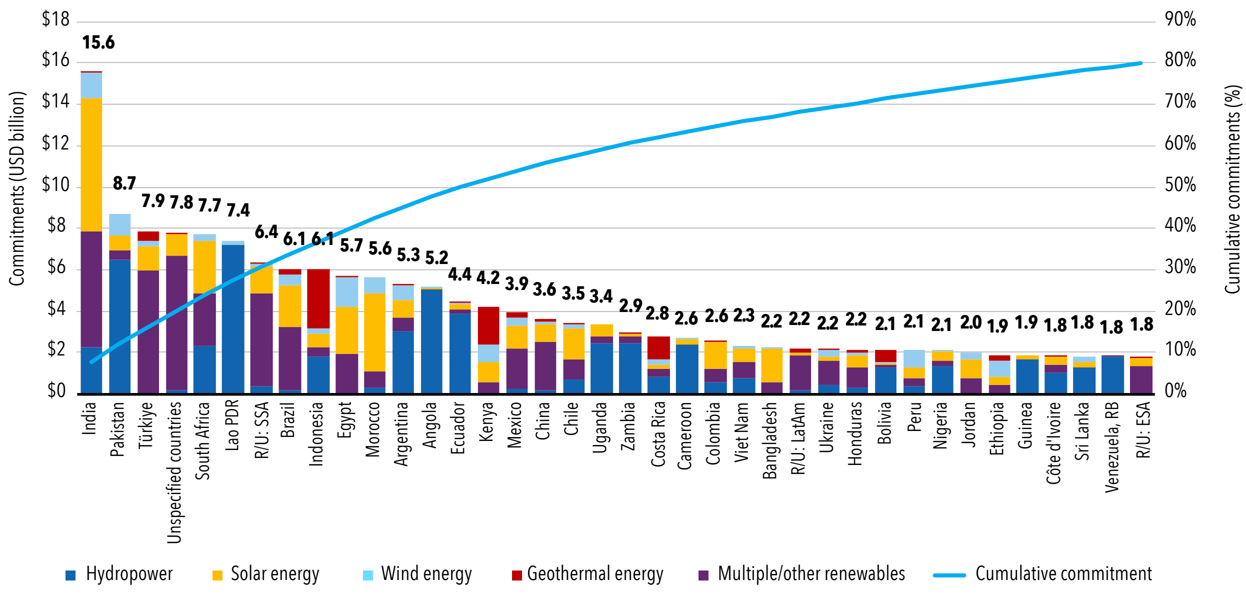
The five-year average in **Northern America and Europe** declined by 4.3 percent, from USD 566 million in 2021 to USD 542 million in 2022. Notwithstanding this reduction, the region has seen the largest increase of any region in five-year averages since 2010, with commitment amounts almost quadrupling. In 2022, countries in the region received USD 471 million, up from USD 381 million in 2021 but less than half the all-time high of USD 925 million in 2019. If 2023 flows hold steady when recorded, the five-year average will fall by USD 70 million, to USD 472 million. The EBRD has been by far the largest donor in the region over the last few years, providing USD 289 million in 2022. Flows to the region are predominantly in the form of debt instruments, with USD 319 million (68 percent) in standard loans committed in 2022. Most flows have been directed to multiple/other renewables and wind energy.

Oceania, the world's smallest region by population, with just 11.9 million people, had the lowest five-year average across regions, at USD 70 million in 2022. The figure was more than twice the average in 2010. It received just USD 99 million in 2022. If flows for 2023 hold steady, the five-year average will increase by USD 3 million. Historically, commitments were for solar, hydropower, and multiple/other renewables, provided in the form of technical assistance and government support programs. Of the USD 99 million received in 2022, USD 81 million was in the form of grants, and the rest in concessional loans.

COUNTRY TRENDS

During 2010–21, 38 countries and territories received 80 percent of all commitments. This figure remained unchanged in 2010–22 (figure 5.6).

FIGURE 5.6 • TOP RECIPIENTS OF INTERNATIONAL PUBLIC FINANCIAL FLOWS TO RENEWABLES, BY TYPE OF ENERGY, 2010–22



Source: IRENA and OECD 2024.

ESA = Eastern and South-eastern Asia; LatAm = Latin America and the Caribbean; R/U = residual/unallocated official development assistance; SSA = Sub-Saharan Africa.

Commitments to the top receiving countries are becoming marginally more widely distributed, although they remain heavily concentrated. While the distribution of flows is wider when averaged over several years, international public financial flows remain concentrated among a small group. In 2021, 80 percent of commitments went to 19 countries. While 2022 saw a wider distribution, with 25 countries receiving 80 percent of the commitments, this figure is still lower than when compared to the 2010–22 range of 38 countries. This means that the annual flows present more variation than the total average of flows over the 2010–22 period, rather than a steady stream of diversified flows to all countries.

The top five country recipients of international public flows in 2022 were Brazil (USD 1.213 billion), South Africa (USD 1.210 billion), Egypt (USD 823 million), Uzbekistan (USD 756 million), and India (USD 627 million).

Brazil received funding for 23 projects in 2022. Over the years, most international flows into the country were directed to solar energy projects in the form of loans, supplemented by equity and grants. The combination of debt instruments and a focus on solar indicates a mature market for solar projects in Brazil, where investors may perceive a low risk of default. The most significant projects of the year were the USD 340 million loan for solar development by the European Investment Bank, the USD 252 million loan by the Inter-American Investment Corporation to fund the Mendubim Solar PV project, and the USD 227 million loan from the European Investment Bank for the Sicredi Solar Energy Portfolio.

South Africa received USD 1.21 billion in 2022 across 16 projects. These investments were balanced across multiple renewable energy technologies, with solar energy playing a significant role. The International Bank for Reconstruction and Development lent USD 455 million for the Eskom Just Energy Transition Project, which aims to decommission a 1 gigawatt coal power plant and replace it largely with solar energy. Other major projects included the USD 347 million concessional loan from France to support the Just Energy Transition and the USD 227 million loan from the European Investment Bank to the Development Bank of Southern Africa for eligible renewable energy projects within the Embedded Generation Investment Programme.

Egypt received USD 823 million in 2022. The investments were spread across 24 projects, multiple technologies, and diversified financial instruments. The largest sources of funding were a USD 119 million concessional loan from Japan to fund the Komombo solar plant, the Scatec Green Bond of USD 102 million from EBRD, and a confidential USD 101 million loan from the International Finance Corporation.

Uzbekistan received USD 756 million in 2022 across 12 projects concentrated on wind energy, indicating a shift away from natural gas. The top two inflows were loans from EBRD to finance the Bash (USD 153 million) and Dzhankeldy (USD 153 million) wind power plants. Close behind, was a concessional loan of USD 141 million from the International Development Association for solar thermal energy in buildings.

India received USD 627 million in 2022 for 47 projects. Many were renewable energy projects valued at less than USD 1 million. Funding came in various forms. India also received a USD 168 million concessional loan from Germany as part of the Indo-German Solar Partnership, a USD 124 million loan from the International Bank for Reconstruction and Development as additional financing for the Rooftop Solar Program for the Residential Sector, and USD 89 million in a German concessional loan directed to hydropower initiatives in the Himalayas.

Along with regional investments, unspecified countries made up the largest category of recipients in 2022, at USD 1.635 billion. These flows cannot be allocated to any specific region. Within the regional trends, there are also substantial flows to multiple or unallocated countries. For instance, unallocated countries in Sub-Saharan Africa received USD 936 million.[38]

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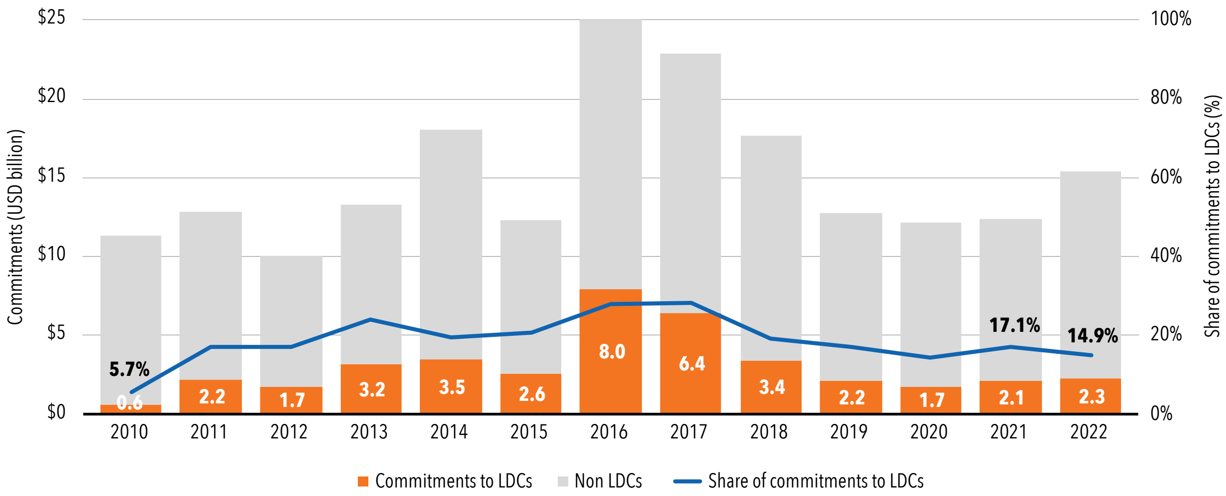
38 Investments are classified as "residual/unallocated" or "unspecified countries" when they are not specifically directed to certain countries. When commitments are residual/unallocated for a specific region, they are considered as part of regional totals. When they are directed to unspecified countries, this category is treated separately at the regional level.

SUPPORT TO LEAST-DEVELOPED COUNTRIES, LANDLOCKED DEVELOPING COUNTRIES, AND SMALL ISLAND DEVELOPING STATES

Analysis of the flow of international public finance to support renewable energy in the 45 LDCs, 32 LLDCs, and 40 SIDS[39] yields insights into flows to the poorest countries.[40]

Flows to LDCs rose 8 percent in 2022, from USD 2.1 billion in 2021 to USD 2.3 billion, but their share of total flows fell from 17 to 15 percent—well below the historical average of 21 percent (figure 5.7).

FIGURE 5.7 • INTERNATIONAL PUBLIC FINANCIAL FLOWS FOR RENEWABLES IN LEAST-DEVELOPED AND NON-LEAST-DEVELOPED COUNTRIES, 2010–22



Source: IRENA and OECD 2024.
LDC = least-developed country.

Forty-three LDCs received financing during 2022, leaving only Guinea-Bissau and Burundi without inflows for the year. Eighty percent of inflows to LDCs went to 12 countries, with Uganda (USD 566 million), Chad (USD 200 million), and the Lao People's Democratic Republic (USD 135 million) at the top of the list.

Uzbekistan drove the growth in LLDC financing in 2022. The distribution of flows was less even than it was for LDCs, with 80 percent of 2010–22 flows going to countries where 68 percent of the population lives. Historically the Lao People's Democratic Republic received more investments per capita than any other LLDC (USD 82.3 over the 2010–22 period). The smallest per capita flows went to South Sudan (USD 0.04), Turkmenistan (USD 0.12), and Eswatini (USD 1.08).

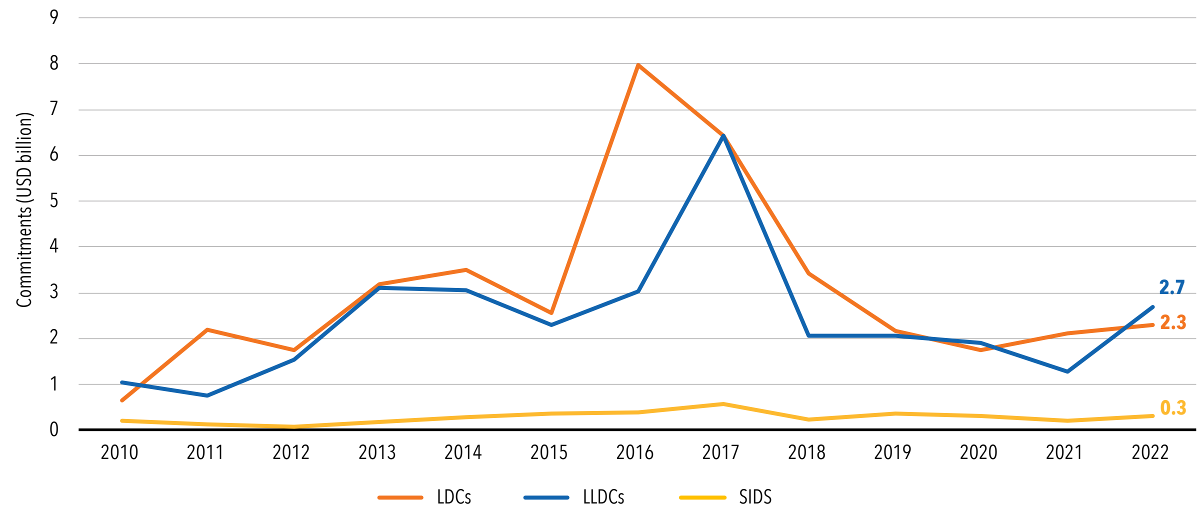
SIDS have historically received the smallest amounts of investment in absolute terms (figure 5.8). In 2022, they received USD 2.7 billion. On a per capita basis, however, some SIDS are among the most successful in attracting international public flows. Some countries benefited more than others. On average, the top recipients among SIDS

39 The United Nations' M49 regional classification includes 53 SIDS; this report excludes 13 of them from the SDG 7.a.1 classification, as explained in the methodology section at the end of the chapter. The exclusion has a negligible effect on the analysis, as only St. Kitts received any flows (of USD 19 million, or less than 0.5 percent of all flows received by SIDS since 2000).

40 The country categories are regularly updated in line with the United Nations' latest M49 classification. Some countries appear in more than one category.

(Tuvalu, Montserrat) have received more than USD 300 per capita since 2010. At the other end of the spectrum, flows were just USD 0.03 per capita in Trinidad and Tobago, USD 0.07 in French Polynesia, and USD 0.43 in Guinea-Bissau. Each of these countries received less than USD 10 million over the entire 2010–22 period.

FIGURE 5.8 • INTERNATIONAL PUBLIC FINANCIAL FLOWS TO LEAST-DEVELOPED COUNTRIES, LANDLOCKED DEVELOPING COUNTRIES, AND SMALL ISLAND DEVELOPING STATES, 2010–22



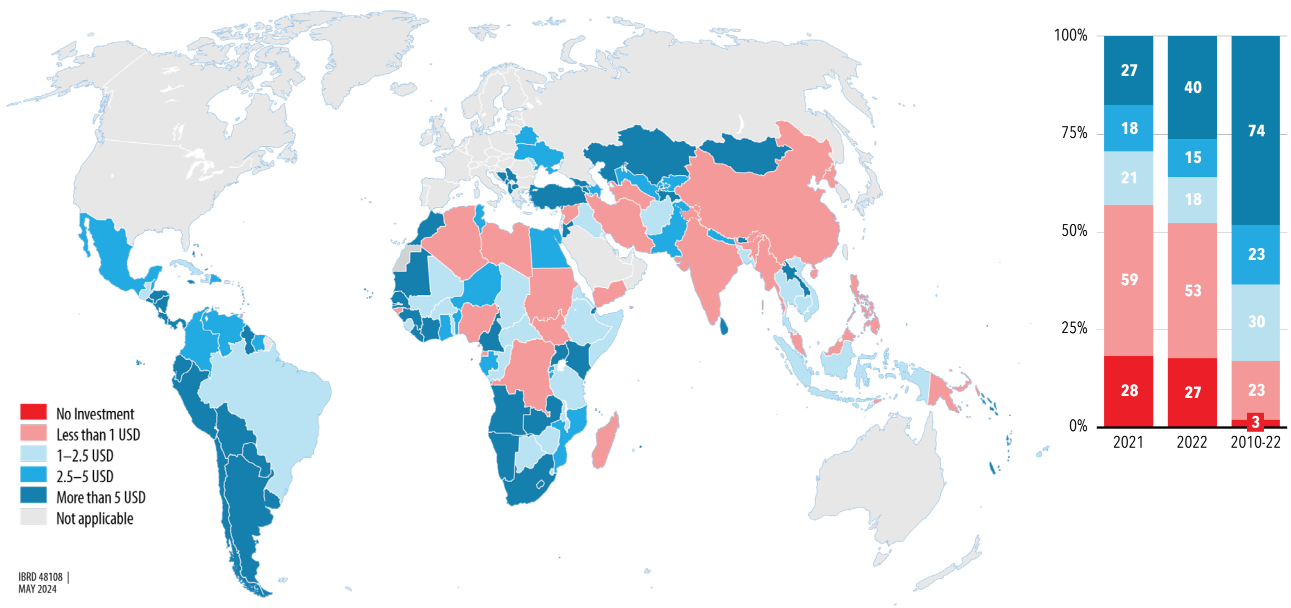
Source: IRENA and OECD 2024.
LDC = least-developed country; LLDC = landlocked developing country; SIDS = small island developing states.

DISTRIBUTION OF FINANCIAL FLOWS AMONG COUNTRIES

The number of countries that received no commitments fell slightly from 28 to 27 in 2022 (figure 5.9). Over the past decade, only three economies (the Wallis and Futuna Islands; China, Macao Special Administrative Region; and China, Hong Kong Special Administrative Region) received no international public commitments. The largest change in 2022 was the increase in the number of countries that received more than USD 5 per capita (from 27 in 2021 to 40 in 2022). Most countries receiving more than USD 5 per capita in 2022 are island countries in Oceania.

Over the 2010–22 period, total average flows were USD 2.26 per capita. The largest receiving countries on a per capita basis were small islands: Tokelau (USD 511), Tuvalu (USD 358), Montserrat (USD 339), Nauru (USD 271), and the Cook Islands (USD 261). At the bottom of the distribution are the Wallis and Futuna Islands, which have received no commitments since 2010; the Democratic People's Republic of Korea (USD 0.01); Algeria (USD 0.02); the Syrian Arab Republic (USD 0.02); Malaysia (USD 0.03); Trinidad and Tobago (USD 0.03); and South Sudan (USD 0.04). Seventy percent of SIDS received more than USD 5 per capita during 2010–22; these percentages were lower for LDCs (36 percent) and LLDCs (37 percent).

FIGURE 5.9 • AVERAGE PER CAPITA INTERNATIONAL PUBLIC FINANCIAL FLOWS FOR RENEWABLES, BY COUNTRY, 2010–22



Source: Data from IRENA and OECD (2024).
Disclaimer: This map was produced by the Geospatial Operations Support Team of the World Bank based in the Cartography Unit of the World Bank. The boundaries, colors, denominations, and other information shown do not imply any judgment on the part of the custodian agencies concerning the legal status of or sovereignty over any territory or the endorsement or acceptance of such boundaries.

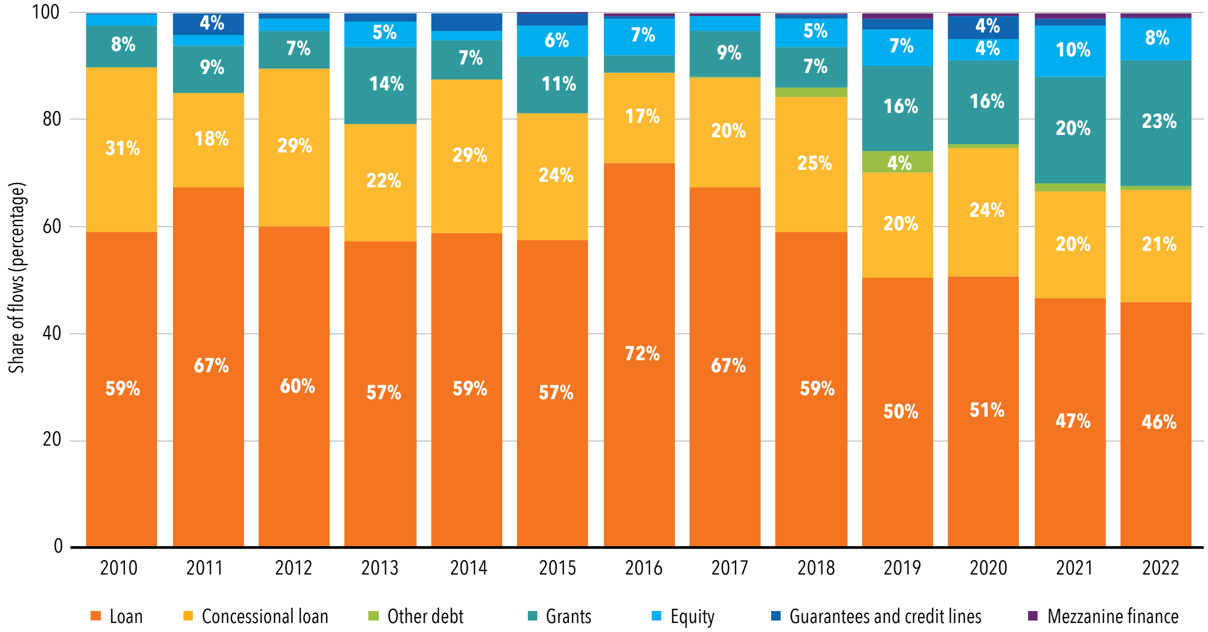
Globally, inclusive of all regions and categories within the scope of the indicator, the leading recipients of funding per capita in 2022 were Palau (USD 2,299), Montenegro (USD 143), and Vanuatu (USD 112), indicating that countries with small populations receive more international public flows per capita without receiving vast amounts of commitments. The 2022 figures show outlier behaviors for these three countries. Palau averaged USD 208 per capita in 2010–22; Montenegro, USD 41 per capita; and Vanuatu, USD 24 per capita. These large per capita values do not necessarily mean that these countries are better off than more highly populated countries; in smaller economies, the cost of implementing renewable solutions at the same relative scale as in larger countries is higher, in addition to other operational, logistical, and strategic complications.

INVESTMENTS BY FINANCING INSTRUMENT

The choice of financial instrument is as important as the quantity of the flows, as many recipient countries struggle with high debt-to-GDP ratios. Incurring more debt hinders development and limits the capacity to pay back loans, as discussed in greater detail in last year's edition of this report. Ideally, flows of international public financing to recipient countries would include larger shares of non-debt instruments or concessional loans, rather than loans at market rates.

The mix of financial instruments supporting renewables has evolved in recent years (figure 5.10). The proportion of debt from public financing sources declined to less than two-thirds of flows in 2022, down from more than 90 percent in 2010; meanwhile, the shares of grants, equity, and guarantees increased.

FIGURE 5.10 • INTERNATIONAL PUBLIC FINANCIAL FLOWS FOR RENEWABLES, BY INSTRUMENT, 2010–22



Source: IRENA and OECD 2024.

Standard loans were the most-used financial instrument in 2022, accounting for USD 7.1 billion in commitments, up 23 percent from USD 5.8 billion in 2021. Standard loans accounted for 46 percent of all flows, down from an average of 59 percent between 2010 and 2022. Loans continue to focus on renewables, with 39 percent going to solar projects, 32 percent to multiple/other renewables, 21 percent to wind energy, 7 percent to hydropower, and less than 1 percent to geothermal energy. Almost 43 percent of loans went to Latin America and the Caribbean, and 21 percent to Sub-Saharan Africa. The largest loans in 2022 were a USD 561 million loan to Brazil and other countries in Latin America and the Caribbean and a USD 455 million loan to South Africa as part of the Eskom Just Energy Transition Project.

Grants reached an all-time high of USD 3.6 billion in 2022, up 50 percent from USD 2.4 billion in 2021, making grants the second-largest financial instrument used in 2022. However, over the 2010–21 period, grants accounted for less than 10 percent of total flows; in 2022, they accounted for 23 percent. In 2022, grants went primarily for multiple/other renewables (61 percent) and solar energy (33 percent).[41] Most went to unspecified countries (36 percent), followed by Sub-Saharan Africa (33 percent). The largest grants were USD 482 million for the Norfund Climate Investment Fund capital replenishment; a USD 421 million provision to the Common Provisioning Fund, a component of the European Fund for Sustainable Development Plus (both funds being available for multiple countries within regions); and USD 228 million for the Electricity Access Scale-up Project in Uganda.

Concessional loans reached USD 3.2 billion in 2022, up 29 percent from USD 2.5 billion in 2021. These loans represented 21 percent of all flows in 2022, slightly less than the 23 percent they represented over the 2010–21 period. The distribution of concessional loans was similar to the distribution of grants, with 53 percent going to multiple/other renewables, 33 percent to solar energy, 10 percent to hydropower, and the rest to wind energy. The largest share of

41 Grants can include standard grants, interest subsidies, capital subscriptions on an encashment basis, and capital subscriptions on a deposit basis. Most grants committed are standard grants, with a few interest subsidies almost entirely dedicated to solar or wind energy projects. Capital subscriptions are often unrecorded as commitments since they are usually accounted for at the moment of disbursement to multilateral agencies or when the agencies access the funds in their accounts. See the methodology section at the end of this chapter for more information.

concessional loans went to Sub-Saharan Africa (47 percent), followed by Central Asia and Southern Asia (21 percent) and Eastern Asia and South-eastern Asia (18 percent). The largest concessional loans included USD 663 million for the Climate Investment Funds–Accelerating Coal Transition Investment Program in Eastern and South-eastern Asia and Sub-Saharan Africa, USD 347 million for the Just Energy Transition in South Africa, and USD 319 million for the Electricity Access Scale-up Project in Uganda.

Equity reached USD 1.2 billion in 2022, up 1.6 percent from 2021. It accounted for 8 percent of all flows in 2022, up from 5 percent over the 2010–21 period. In 2022, three-quarters of equity was directed to multiple/other renewables, with the rest invested in solar energy ventures. Equity was almost equally divided into common equity and shares in collective investment vehicles. Common equity is normally directed to specific energy sources; shares in collective investment vehicles normally target multiple renewables. Equity investments were well distributed: 27 percent went to Sub-Saharan Africa, 25 percent to unspecified countries, 23 percent to Latin America and the Caribbean, 12 percent to Western Asia and Northern Africa, and the rest to other countries in Asia. The largest equity investment in 2022 totaled USD 144 million for a private investment fund for climate change in Honduras. This was followed by a USD 84.5 million transaction for a private equity fund in Egypt and USD 82.8 million in common equity by Alcazar Energy Partners II, a sustainable infrastructure fund.

Mezzanine finance reached USD 136.3 million in 2022, a small decrease from USD 136.8 million in 2021.[42] Representing less than 1 percent of flows, it was equally distributed between multiple/other renewables and solar energy. Regionally, it went to Central Asia and Southern Asia (42 percent of 2022 flows), Sub-Saharan Africa (36 percent), and Latin America and the Caribbean (21 percent). The largest investment was a USD 57.3 million preferred equity in SAEL, a waste-to-energy company in India.

Guarantees and credit lines fell to USD 16 million in 2022, a 90 percent decrease from USD 160 million in 2021. This category represented a negligible share of flows in 2022.

42 Mezzanine finance allows for the conversion of debt into equity in certain cases, such as subordinated loans, preferred equity, and other hybrid instruments. In case of default, they are repaid after all senior obligations are satisfied, and so the increased risk requires a higher return than other lenders. Preferred equity is repaid after all senior obligations and subordinated loans have been satisfied, and before common equity holders are paid. It is a more expensive source of finance than senior debt but a less expensive source than equity.

Policy insights

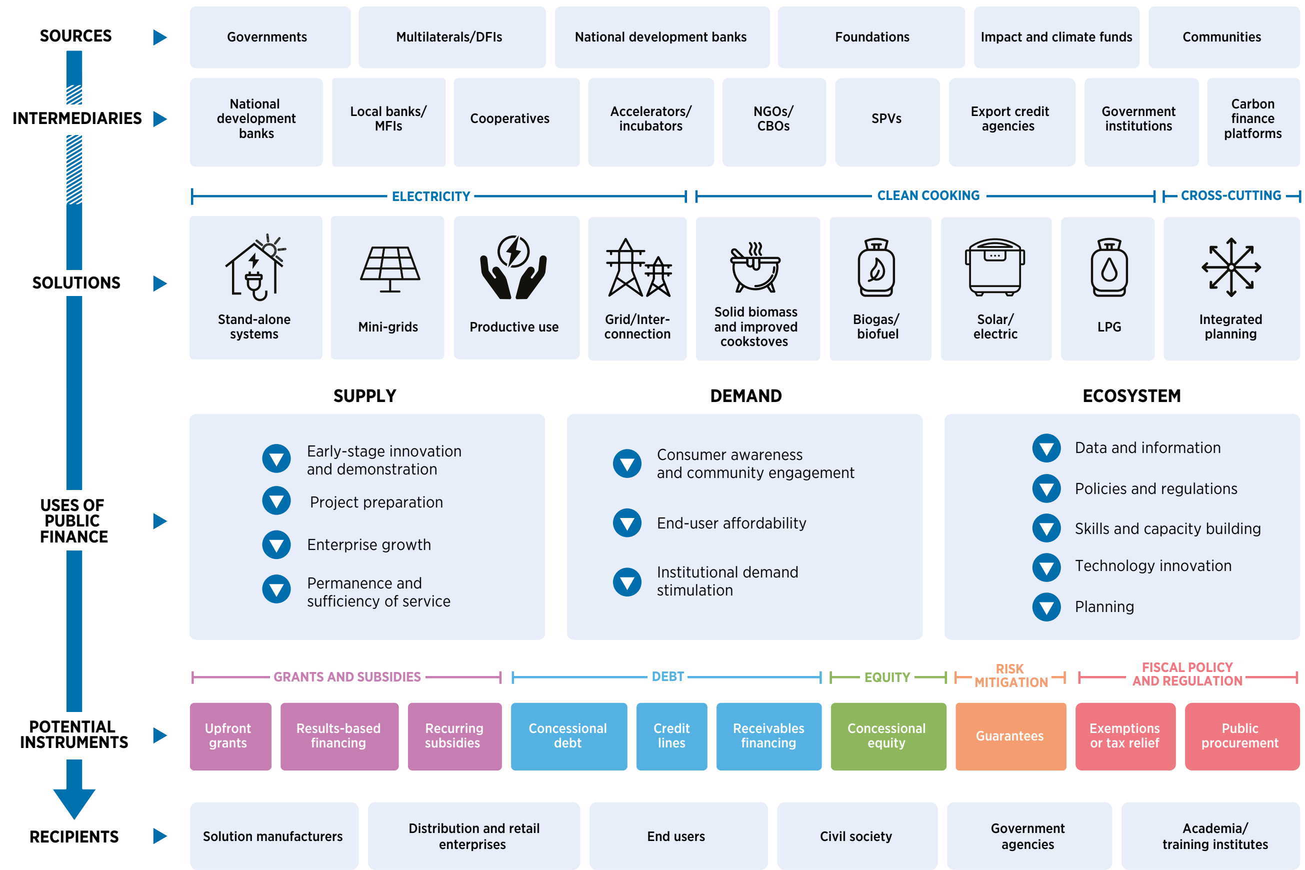
The rebound of international public financial flows in 2022 to developing countries is encouraging, but the level remains insufficient to achieve SDG 7 and other Sustainable Development Goals under the UN 2030 Agenda (see chapter 6 on investment needs). Investments are heavily concentrated in a number of countries (IRENA and CPI 2023), even as a growing number of developing countries are incurring international debt (IMF 2023). The debt financing modality at standard market rates remains the instrument most used, in spite of the recent increase in the use of grants and other non-debt instruments.

More innovative instruments and initiatives are needed to enable underinvested countries to benefit from the energy transition without compromising their fiscally constrained economies. Some countries have struggled to attract investments and access affordable capital because of shrinking fiscal space, macroeconomic constraints (UNCTAD 2022), or political conflicts. Previous editions of this report have highlighted the role international public finance has in supporting the establishment of effective policy frameworks and catalyzing private capital where private investments appear feasible to financiers, developers, and service providers. Calls for enhanced flows that reach countries in need are more relevant than ever. Answering those calls may entail changes in the international finance architecture (IEA and others 2021, 2022, 2023).

Financing to ensure universal access must be a priority, as 685 million and 2.1 billion people, respectively, live without access to electricity and clean cooking (see chapters 1 and 2 of this report). Public finance should be channeled toward deploying energy solutions for unserved and underserved areas. Those solutions will comprise integrated planning and building of energy infrastructure; investing in the ecosystem that enhances energy service provision (notably skills and capacity building, industrial development, consumer awareness and education, agriculture, and health care); bridging end-users' affordability gaps; and mobilizing private capital through policy and regulatory instruments (IRENA 2024).

Deployable technological solutions exist to close the access gap, as seen in figure 5.11, which presents the International Renewable Energy Agency's (IRENA's) framework for the flow of public finance for universal energy access. Specific financing needs vary depending on the location, the energy technology, and the type of user, but the priority must remain on scaling up nondebt sources of funding.

FIGURE 5.11 • IRENA'S PUBLIC FINANCE FRAMEWORK FOR UNIVERSAL ENERGY ACCESS



Source: IRENA 2024.
CBO = community-based organization; DFI = development finance institution; LPG = liquefied petroleum gas; MFI = microfinance institution; NGO = nongovernmental organization; SPV = special purpose vehicle.

The need to go beyond project bankability is urgent in cases where perceived risks reach the point where they cannot be mitigated through financial instruments. Within the wider public finance ecosystem, multilateral development banks, governments, and other relevant actors should work together to shift the focus from bankability toward potential impact at the program or portfolio levels. Renewable energy investment decisions need to be based on factors that not only produce financial profit, but also encompass other aspects of sustainable development that lead to crucial transformations in renewable energy markets. Finally, these reforms should include a reconfiguration of risk mitigation instruments, given the impact that real and perceived risks have on the cost of capital.

CHAPTER 6
THE OUTLOOK FOR SDG 7

Main messages

- **Outlook for progress toward 2030 goals.** Policy and technological innovations have shown promising results, especially in boosting access to renewable energy and improving energy efficiency. The COVID-19 pandemic and the 2022 energy crisis slowed progress, notably in Africa, where advances in energy access have been reversed, even though preliminary analysis of 2023 trends is optimistic. Sustainable Development Goal (SDG) 7—that is, achieving universal energy access by 2030—and putting the world on a 1.5°C pathway require investment and policy to support renewables, energy efficiency, and energy access.
- **Outlook for access to electricity.** Despite setbacks due to recent global crises, the number of people without electricity access globally is decreasing again, supported by significant adoption of solar home systems (SHSs) in Sub-Saharan Africa. However, the International Energy Agency (IEA) projects that 660 million people will remain without electricity access in 2030—85 percent of them in Sub-Saharan Africa—underscoring the need to step up efforts. Achieving universal electricity access by 2030 requires significant investment and policy support, as well as accelerated deployment of renewable energy.
- **Outlook for access to clean cooking.** Current policies and investments are not sufficient to ensure universal access to clean cooking by 2030. Estimates of the IEA and the World Health Organization (WHO) indicate 1.8 billion people will still lack access to clean cooking by the end of the decade. While significant progress has been made in Asia, the number of people without access to clean cooking in Sub-Saharan Africa is increasing, largely due to the rate of population growth outpacing access to clean cooking. Such estimates project a continued decline in the use of polluting fuels and an increase in the use of gaseous fuels and electricity for cooking by 2030. According to IEA's estimates, reaching full clean cooking access would require USD 8 billion annually through 2030, half of it for Sub-Saharan Africa alone.
- **Outlook for renewable energy.** Renewable energy continues to be the fastest-growing energy source; projections indicate that renewables will surpass coal as the predominant electricity source globally by 2025. IEA's Net Zero Emissions by 2050 Scenario and the International Renewable Energy Agency's (IRENA's) 1.5°C Scenario outline ambitious energy pathways for achieving SDG 7 and SDG 13 on climate action. Aligning with these scenarios, however, requires unprecedented capacity additions, and investment and policy support to help modern renewables reach an expected 32–35 percent share in total final energy consumption (TFEC) by 2030 -up from 18 percent today. The pledge made by more than 130 countries at the 2023 United Nations Climate Change Conference (COP28) in Dubai to triple global renewable power capacity to more than 11,000 gigawatts (GW) by 2030 is consistent with these scenarios.
- **Outlook for energy efficiency.** The global push for energy efficiency has gained momentum, driven by increasing energy costs and security concerns, even though early estimates for 2023 show a modest annual energy intensity improvement rate of 1.3 percent. Doubling the average annual energy efficiency improvement rate in global energy intensity by 2030, as agreed to at the COP28, requires robust policy action and a significant increase in investment. IEA's NZE scenario estimates the rate of improvement needed to be just over 4 percent – slightly higher than the SDG 7 target of 3.8 percent. This highlights the crucial role of energy efficiency in meeting sustainability and climate goals.

- **Investment needs.** Achieving the SDG 7 targets demands a substantial increase in clean energy investments. IEA and IRENA estimate average annual energy-focused investments in the range of USD 3–4.5 trillion by 2030,[43] significant portions of which are to be committed to investments related to the energy transition. These investments would focus on renewables, efficiency, and low-carbon technologies, and include enabling infrastructure like power grids and storage. Addressing the investment gap, particularly in developing economies, is crucial for advancing the energy transition and ensuring universal access to clean energy and technologies.

Presentation of scenarios

This chapter describes the results of global scenario analysis 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 seeks to determine what investments are required. Scenarios for the targets are taken from IEA's World Energy Outlook (IEA 2023a), IRENA's World Energy Transitions Outlook: 1.5°C Pathway (IRENA 2023), and WHO's Business-as-Usual Scenario (see annex 1). The chapter explores scenarios in which energy trends evolve under today's policies, and pathways that deliver on all energy-related SDGs, including substantial reduction of air pollution, which causes deaths and illness (SDG target 3.9), and initiation of effective action to combat climate change (SDG 13).

IEA's Stated Policies Scenario explores how energy trends evolve under today's policies, assuming no additional policies are put in place. Under this scenario, bottom-up modelling is conducted that considers how policies, pricing policies, efficiency standards, electrification programs, and specific infrastructure projects would influence energy trends. The Net Zero Emissions by 2050 Scenario considers the SDG goals of 2030 and net-zero energy sector emissions by 2050 as targets to determine what would be needed to achieve these outcomes in a cost-effective, plausible way. Under the Net Zero Emissions by 2050 Scenario, by 2030, universal access to electricity and clean cooking is achieved, modern renewables reach a 32 percent share of TFEC, and average annual energy efficiency improvements in global energy intensity reach 4.1 percent over 2022–30. 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 to 1.5°C over preindustrial levels.

IRENA's Planned Energy Scenario provides a perspective on energy system developments based on governments' energy plans and other planned targets and policies. Its 1.5°C Scenario describes an energy transition pathway that enables limiting global average temperature increase to 1.5°C by the end of the 21st century relative to preindustrial levels. The 1.5°C Scenario is underpinned by several key technological avenues and measures in terms of renewable-based power; direct use of renewables; energy intensity improvements; electrification in end-use sectors; clean hydrogen and its derivatives; and carbon capture and storage (CCS), bioenergy with CCS, and other carbon removal technologies. These avenues and measures would lead to major emission reductions between today and 2050, paving the way toward a net-zero carbon world by midcentury. The scenario also provides insights into the socioeconomic footprint of the global energy transition.

Projected clean cooking access rates, access deficits, and fuel use are estimated using the WHO Global Household Energy Model (see annex 1 for further details). In that model, uncertainty grows the further into the future that estimates are calculated, reflecting how country trends may shift based on how unsettled they were during the data period.

43 In 2022 and 2021 U.S. dollars, respectively.

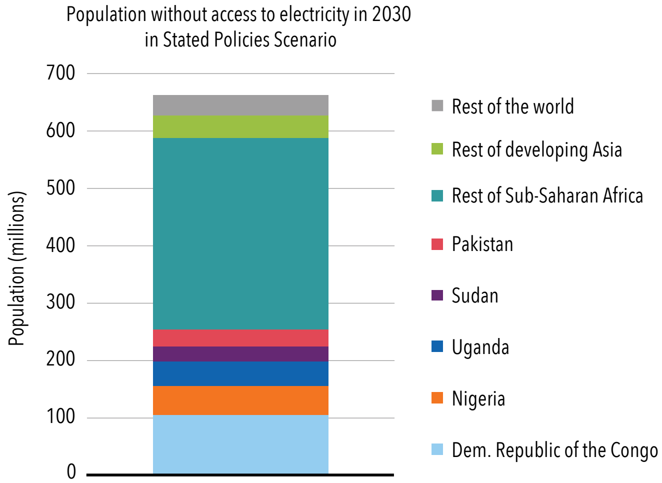
WHO's Business-as-Usual Scenario, used for deriving the clean cooking–related projections, is a hypothetical scenario under which no new policies or interventions (positive or otherwise) are implemented or take place. As such, it is useful as a baseline scenario for comparing the effects of interventions. The Business-as-Usual Scenario is calculated by extrapolating current trends into the future. The year that each country will achieve 100 percent access to clean fuels and technologies is estimated from these projections.[44]

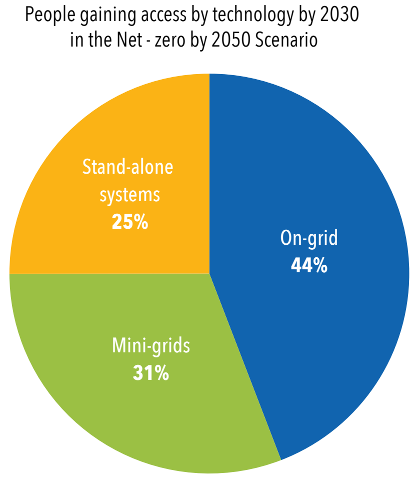
The outlook for access to electricity

According to IEA's latest estimates, the number of people worldwide without access to electricity declined in 2023 following a three-year period of multiple crises, when the number had increased (IEA 2023a). This decline has largely been driven by SHSs, whose viability as a reliable electricity source for households was clearly demonstrated, especially in Sub-Saharan Africa.

Electricity access is expected to keep improving through 2030. Trends vary significantly across countries; many will not achieve universal access by 2030 under current policies—only nine Sub-Saharan African countries have achieved universal electricity access. Under IEA's Stated Policies Scenario, 660 million people—roughly 8 percent of the global population—will remain without electricity access by 2030, 85 percent of them in Sub-Saharan Africa, where less than half of the countries without universal access to electricity have official targets, and only about 22 percent have targets at least as ambitious as SDG target 7.1. This target remains within reach for countries with adequate policies, holistic electrification plans, including centralized and decentralized solutions, and resourced implementing institutions. Countries without electrification plans and enabling frameworks are not on track to meet the target (figure 6.1).

FIGURE 6.1 • POPULATION WITHOUT ACCESS TO ELECTRICITY IN 2030 UNDER IEA'S STATED POLICIES SCENARIO AND DELIVERY OF ELECTRICITY CONNECTIONS UNDER IEA'S NET ZERO EMISSIONS BY 2050 SCENARIO, BY TECHNOLOGY REQUIRED.





Source: IEA 2023a.

Most developing countries in Asia remain on track to reach near-universal access; only 2 percent of the region's population is without electricity access in 2030. The Stated Policies Scenario shows that for the region to achieve universal access in 2030, countries such as Afghanistan, Mongolia, and Pakistan need to step up efforts. In Central

44 Detailed datasets with country data for all SDG 7 indicators can be accessed at no charge at https://trackingsdg7.esmap.org/downloads.

and South America, only the most remote populations remain without electricity access by 2030; the region achieves a 98 percent access rate. Haiti, one of the poorest countries in the world, is the sole exception, with a large share of its population expected to remain without access in 2030.

Without improvements in Sub-Saharan African countries, achieving SDG target 7.1 remains improbable. More than half of those without electricity access live in countries that do not have official electrification plans or regularly track progress.

Accessing finance is often more challenging for countries that have the greatest need to urgently improve energy access. International support in the form of concessional finance is essential, especially under current economic conditions. More importantly, public finance remains vital in deploying energy infrastructure, investing in the socioeconomic ecosystem that relies on energy as an input, bridging affordability gaps for consumers, expanding access to last-mile communities, and derisking private investments (IRENA 2024). Governments must facilitate better access to international finance so that robust electrification plans can be implemented, and capital can accordingly be allocated to access projects (IEA 2023a).

Achieving universal electricity access by 2030 requires that, every year, 110 million people on average gain access. Four out of five such people would be in Sub-Saharan Africa. Efforts must be stepped up, especially in least-developed countries, which might benefit from special support measures, including the Democratic Republic of Congo, Niger, Sudan, the United Republic of Tanzania Uganda, and Ethiopia, which together are home to half of the region's population projected to be without electricity access in 2030.

IEA's Net Zero Emissions by 2050 Scenario proposes a sustainable pathway to achieve universal access to electricity by 2030. This implies addressing affordability issues, which remain the primary hindrance to people gaining electricity access or benefiting from it. About a third of the Sub-Saharan African population without electricity access cannot afford basic energy services without additional financial incentives (IEA 2023b). Central to sustainable improvements will be support for decentralized solutions, tracking and monitoring, and the use of geospatial data as the basis for electrification planning and the creation and empowerment of entities responsible for implementing the plans. Low-capacity off-grid energy solutions—for example, small off-grid solar systems—will continue to play an important role, especially in remote areas. Nevertheless, strategies must align to support households through the gradual extension of energy services via bigger systems or grid connections.

IEA's Net Zero Emissions by 2050 Scenario indicates that almost 90 percent of new electricity connections will be based on renewables, supported by a resumed decline in the cost of solar photovoltaic (PV) and batteries.

The delivery technology is unique to each location under IEA's Net Zero Emissions by 2050 Scenario. In Sub-Saharan Africa, 43 percent of new connections by 2030 would be directly to the grid, 30 percent through mini-grids, and the remainder would be stand-alone systems (mostly SHSs). In developing countries in Asia, just over half of the new connections would be directly to the grid, and almost a third would be through mini-grids.

Robust electrification plans can help achieve universal electricity access by 2030. Sub-Saharan African countries (including Côte d'Ivoire, the Gambia, Kenya, and Rwanda) have achieved or surpassed target levels in the past. But 22 other Sub-Saharan African countries representing more than half of the region's unelectrified population (including Chad, the Democratic Republic of Congo, Madagascar, Malawi, Mozambique, and the Niger) have been witnessing a rise in the number of people without access (IEA 2022a). Many of the successful electrification plans consider the needs of health facilities, schools, productive use and agricultural enterprises, and similar organizations, alongside households' needs. Achieving universal electricity access requires investment amounting to USD 30 billion annually through 2030. These investments include electricity generation, electricity networks, and decentralized solutions. Achieving universal electricity access as outlined under IEA's Net Zero Emissions by 2050 Scenario requires a threefold growth of investments over pre-COVID levels. Electricity access must go beyond a simple connection able to power a few household items, to support the growing use of energy services that can contribute to socioeconomic prosperity as also illustrated by the World Bank's Multi-Tier Framework.

The outlook for access to clean cooking fuels and technologies

Current policies are insufficient to achieve universal access to clean cooking. If the current trends continue, IEA and WHO estimate that 21 percent of the world's population—or around 1.8 billion people—will still lack access to clean cooking by 2030 (figure 6.2). Both IEA and WHO have reported significant progress in Asia, whereas for Africa, almost the same number of people as today are expected to remain without access to clean cooking fuels and technologies at the end of the decade (IEA 2023c). Under the current policy and investment environments, the access deficit in Sub-Saharan Africa alone could exceed 1 billion by 2030. Many African countries are not expected to achieve universal clean cooking access even into the 2050s (IEA 2023c).

Achieving universal access to clean cooking is an essential part of a just energy transition and essential for protecting our climate. A successful transition to net-zero emissions by 2050 requires significant improvements in decarbonizing cooking fuels, electricity, the power grid, and other infrastructure. In this context, a global roadmap has been proposed (United Nations 2023) outlining key milestones toward this global goal including: (1) eliminate cooking poverty and achieve cleaner cooking for all by 2030, (2) achieve universal cooking with modern cooking services and accelerate the decarbonization of cooking fuels by 2040, and (3) achieve net-zero clean cooking by 2050.[45]

IEA estimates that achieving universal access to clean cooking requires providing access to over 300 million people each year—about half of them in Sub-Saharan Africa—through the decade's end. The effort required in Sub-Saharan Africa is equivalent to repeating the best single-year advances in the rest of the world every year from now till 2030. While African countries are implementing clean cooking plans, they lack the resources to support them. Today, less than 20 percent of clean cooking plans are backed by clear financing schemes.

In terms of changes in the fuel mix, WHO projected 67 and 8 percent, respectively, of the LMIC population to primarily use gas and electricity for cooking if current trends continue through 2030. However, by 2030, 18 and 5 percent, respectively, will still rely on unprocessed biomass and charcoal, whereas 2 percent will use kerosene and coal. The use of gaseous fuels is expected to drive the majority of the increase in the percentage of the LMIC population using clean fuels and technologies for cooking.

Under IEA's Net Zero Emissions by 2050 Scenario, liquefied petroleum gas continues to lead as the fuel for clean cooking. It represents a 45 percent share of fuels among people gaining access to clean cooking by 2030; electricity represents a 12 percent share; and other sources, such as bioethanol and biogas, represent an approximately 10 percent share (figure 6.2). Until 2030, high-quality improved cookstoves provide a first transitional step to cleaner cooking for one-third of households globally, providing meaningful benefits as a fast and feasible solution for rural households that infrastructure will be slow to reach.

Under IEA's Net Zero Emissions by 2050 Scenario, the demand for modern uses of energy grows minimally till 2030, whereas the use of firewood and charcoal falls 50 percent. In some regions, new infrastructure would be needed. For

45 The roadmap estimates that the annual public investments required to achieve universal access to cleaner cooking and to eliminate cooking poverty from 2020 to 2030 amount to USD 7.4 billion. Additionally, the investments needed for universal access to modern energy cooking services from 2030 to 2040 are estimated at USD 13 billion. The roadmap also highlights that the annual health, gender, and climate co-benefits from achieving universal access to cleaner cooking and eliminating cooking poverty by 2030 total USD 192.3 billion, which is more than 25 times the estimated public-sector investment. Furthermore, the annual benefits of transitioning to exclusive use of modern energy for cooking by 2040 amount to USD 232.3 billion, about 17 times the estimated public financing.

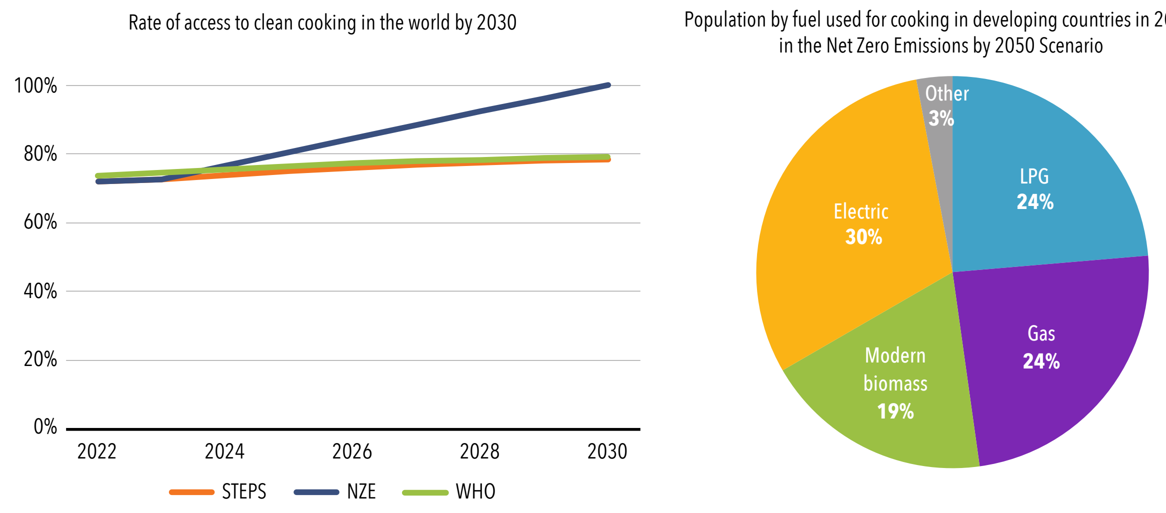
instance, in Sub-Saharan Africa, the demand for liquefied petroleum gases grows threefold by 2030, requiring an expansion of distribution services, and an increase in cylinders and refilling stations. By 2030, electric cooking alone in Sub-Saharan Africa drives up the electricity demand 16 percent from today; this growth could potentially strain distribution systems if not managed well (IEA 2023c).

Achieving universal access to clean cooking brings immense health, social, and climate co-benefits. Improved health outcomes will result from reduced exposure to household air pollution. The resulting time savings from less fuelwood collection, often several hours a day, would offer households members, particularly women and children with more time for activities like schooling, income generation or leisure. Such a transition could also lead to a net reduction of 1.5 gigatonnes of carbon dioxide equivalent ($GtCO_2eq$) in greenhouse gas emissions resulting from the incomplete biomass combustion and deforestation—equal to the emissions from aviation and shipping today.

Investments in clean cooking stoves, technologies, and infrastructure by 2030 would need to reach USD 8 billion annually, half of it aimed at Sub-Saharan Africa (IEA 2023c). This represents a substantial increase from the current annual investment of USD 2.5 billion. Accelerating the global transition to clean cooking and reaching the 2030 and 2050 targets also require substantial political engagement. While some progress has been made in this regard, with 98 LMICs having included household energy or clean cooking–related goals in their Nationally Determined Contributions as of March 2023, current commitments are insufficient to reach the 2050 net-zero emissions target. Governments need to incorporate clean cooking demand into their energy planning strategies and ensure appropriate institutional frameworks, enable public investment, and facilitate private sector engagement.

Each country should develop its own unique roadmap for the clean cooking transition, based on its specific circumstances and stage of development. This requires a systemic approach supported by national action as well as international collaboration. A significant increase in public funding is crucial to attract private investment, make clean cooking more affordable, and foster innovation in clean fuels and technologies. Climate finance, particularly carbon finance, if properly managed, can be pivotal in making clean cooking more accessible, especially for the most underserved communities.

FIGURE 6.2 • CLEAN COOKING ACCESS RATE BY 2030 IN IEA'S STEPS AND NZE SCENARIOS, AND IN WHO'S BUSINESS AS USUAL SCENARIO; AND COOKING FUELS MIX IN 2030 UNDER IEA'S NZE SCENARIO



Source: IEA 2023a and WHO.
LPG = liquefied petroleum gas; NZE = Net Zero Emissions by 2050 Scenario; STEPS = Stated Policies Scenario; WHO = World Health Organization.

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, various long-term scenarios for a net-zero energy sector by 2050 require a tripling of installed capacity of renewables-based power by 2030. This is reflected in the COP28 agreement for tripling renewables-based power, which calls for at least 11,000 GW by 2030 (UNFCCC 2023), in line with IEA's Net Zero Emissions by 2050 Scenario, and IRENA's 1.5°C Scenario.

The outlook for renewables under IEA's Stated Policies Scenario and IRENA's Planned Energy Scenario remains positive in all regions despite the impact of recent crises on supply chains and prices. This positive outlook is supported by targeted policies and falling technology costs. Under IEA's Stated Policies Scenario, the share of all renewables (including traditional uses of biomass) in TFEC is projected to rise from 18 percent in 2022 to 23 percent in 2030, and the share of modern uses of renewables, which excludes traditional use of biomass, is projected to increase from 12 percent in 2022 to 19 percent in 2030. By contrast, under IRENA's Planned Energy Scenario, the overall share of modern uses of renewables in TFEC grows to 18 percent in 2030, due to an expansion of renewables, namely, in electricity and transport.

Renewables in the electricity sector continue to be the fastest-growing energy source worldwide. With governments increasingly prioritizing renewable projects and addressing short-term supply chain concerns, annual capacity additions for renewables in 2022–30 are projected to triple over the trends seen in 2015–21; solar PV and wind are projected to spearhead this expansion. By 2025, renewables are expected to surpass coal as the predominant source of electricity generation. Solar PV leads as the renewable electricity source, meeting nearly half (49 percent) of the growth in electricity demand from 2022 over the period, followed by wind (37 percent). Hydropower continues to be the largest low-emission electricity source globally through 2030, providing flexibility and supporting other essential power system services. This combined with end-use electrification enables the share of renewables-based electricity in TFEC to rise above 10 percent by 2030, up from 6 percent in 2022. This includes increased use of electricity in transport due to higher electric vehicle (EV) penetration.

Renewables-based heat has had a steadily progressing share in end use, although the pace of progress is slow. Modern uses of bioenergy constitute the major driver of growth for renewables-based heat through 2030. In transport, liquid biofuels experience robust expansion—albeit limited without the adoption of new blending requirements or the reinforcement of implementation in regions where they are currently lacking. Renewable heat experiences growth in the industrial and residential sectors; modern bioenergy leads in this regard, driven by renewable mandates in Europe and experimental initiatives in China. The demand for biogas and modern uses of biomass for heating also rises, fueled by industrial expansion (IEA 2022b).

Policy action remains key, especially for end-use renewables to grow at the pace needed to meet climate ambitions. Although cost increases and competing budgetary pressures pose a risk of probable delay in reaching some targets, locally sourced end-use renewables can be part of the toolkit for boosting energy security—and reducing risks, and in turn costs.

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

The projected increases in the use of renewable energy that are likely to occur under the Stated Policies Scenario are insufficient for reaching global climate targets or the SDGs. The use of renewables increases twice as rapidly under the Net Zero Emissions by 2050 Scenario as under the Stated Policies Scenario (IEA 2023d). Under the more ambitious Net Zero Emissions by 2050 Scenario, modern uses of renewables would represent just over a third of TFEC in 2030 (figure 6.3).

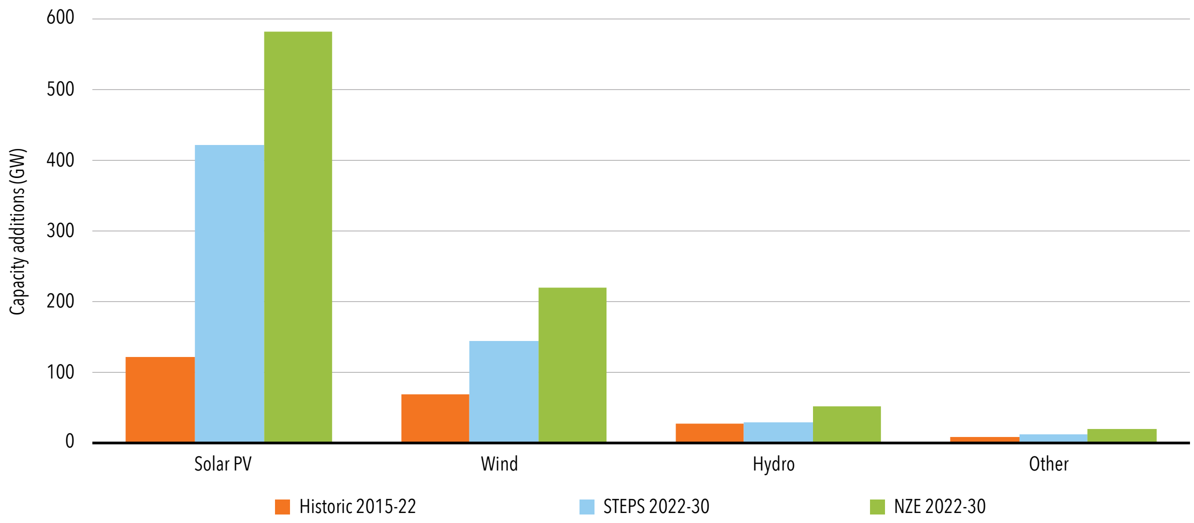
FIGURE 6.3 • RENEWABLES' SHARE IN TOTAL FINAL ENERGY CONSUMPTION IN 2022 AND UNDER IEA SCENARIOS BY 2030

Source: IEA 2023a.

CCUS = carbon capture, utilization, and storage; NZE = Net Zero Emissions by 2050 Scenario; STEPS = Stated Policies Scenario.

The share of renewables-based electricity generation increases the most rapidly—to just about 60 percent from the current level by 2030, or a 16 percentage point increase over that in the Stated Policies Scenario. Globally, renewables-based electricity generation increases 12 percent annually, to approximately 22,520 terawatt-hours by 2030. This is supported by unprecedented solar PV and wind capacity additions, reaching, respectively, 580 GW and 230 GW a year on average over 2022–30 (figure 6.4). Annual investment in renewables-based power triples over the decade, to over USD 1.2 trillion a year by 2030. This is supported by additional spending on expanding and modernizing electricity networks and battery storage and improving the operational flexibility of existing assets to better integrate renewables.

FIGURE 6.4 • AVERAGE ANNUAL CAPACITY ADDITIONS OF RENEWABLE POWER GENERATION, BY TECHNOLOGY, UNDER IEA SCENARIOS



Source: IEA 2023a.
GW = gigawatt; NZE = Net Zero Emissions by 2050 Scenario; PV = photovoltaics; STEPS = Stated Policies Scenario.

Under IEA's Net Zero Emissions by 2050 Scenario, increased electrification of energy end uses is a primary means to boost renewables' share in TFEC. Under this scenario, electricity's share in the final energy demand rises to 28 percent by 2030, compared with about 22 percent under the Stated Policies Scenario. This growth is driven primarily by the electrification of transport and heat.

Direct use of renewables, principally biofuels, constitutes 11 percent of fuel for road transport, on average. Combined with growing electrification, renewables' share in transport rises to nearly 17 percent (IEA 2023a).

The use of renewables for heat encompasses space and water heating, cooking, industrial processes, and other uses. This heat 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—using solar thermal–based water heating, biomass, and low-carbon gases, for example—can also reduce the use of fossil fuels. In 2022, renewables represented 12 percent of the total energy consumed for heating worldwide. By 2030, this share increases to 31 percent under the Net Zero Emissions by 2050 Scenario.

The share of traditional uses of biomass falls to 4 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 by 2030, since developing countries replace it with more modern and efficient fuels and technologies.

Across regions, variations in energy policy, socioeconomic trends, and natural resource endowments result in varying growth trajectories for renewables. Developing economies represent over 80 percent of the growth in electricity generation through 2030 under the Stated Policies Scenario and almost 90 percent under the Net Zero Emissions by 2050 Scenario. Under the Stated Policies Scenario, the outlook to 2030 for renewables-based electricity generation ranges from 10 percent in the Middle East and 16 percent in Northern Africa, at the low end, to over 80 percent in Central and South America, where hydropower is the backbone of the power mix. Under the Net Zero Emissions by 2050 Scenario, renewables-based electricity generation has a growing share in all regions, approaching or exceeding half of all electricity generation by 2030 in many.

Under the Net Zero Emissions by 2050 Scenario, the supply of low-emission hydrogen increases from 0.3 million metric tons (Mt) today to 90 Mt in 2030 and 450 Mt in 2050. The share of low-emission hydrogen in TFEC reaches 10 percent. Achieving net-zero emissions by 2050 also requires carbon capture technologies. Under the Net Zero Emissions by 2050 Scenario, in 2030, just above 1.2 $GtCO_2$ is captured via carbon capture, utilization, and storage and CO_2 removal technologies that do not include nature-based measures.

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

IRENA's 1.5°C Scenario requires a significant scale-up of renewable energy and energy-efficient solutions but also other energy transition technologies and related infrastructure. It entails a transformation of how societies consume and produce energy. The decade to 2030 will be crucial for raising the level of ambition. While a diverse selection of technologies is essential to fully decarbonize the energy system by 2050, the urgency of the 2030 deadline reduces the options available. Only renewable power and energy efficiency measures can be scaled up quickly enough to meet this approaching milestone. To ensure long-term success, however, this accelerated deployment must be complemented by continuous innovation and development across a much broader suite of technologies.

IRENA's 1.5°C Scenario details six key categories of performance indicators. These indicators help provide a broad overview of the required level of transition (figure 6.5), which includes scaling up renewable energy's share in TFEC and electricity generation to, respectively, 35 and 68 percent by 2030, with a corresponding increase in the share of energy supplied from electricity to 29 percent. The average annual primary energy intensity improvement rate would need to increase to 3.3 percent between 2020 and 2030, more than double the rate observed in the previous decade. The production of clean hydrogen would need to increase to 125 Mt by 2030. Finally, some investment in CO_2 removal technologies will also be required, namely, in the hard-to-abate sectors, such as industry and some transport sectors.

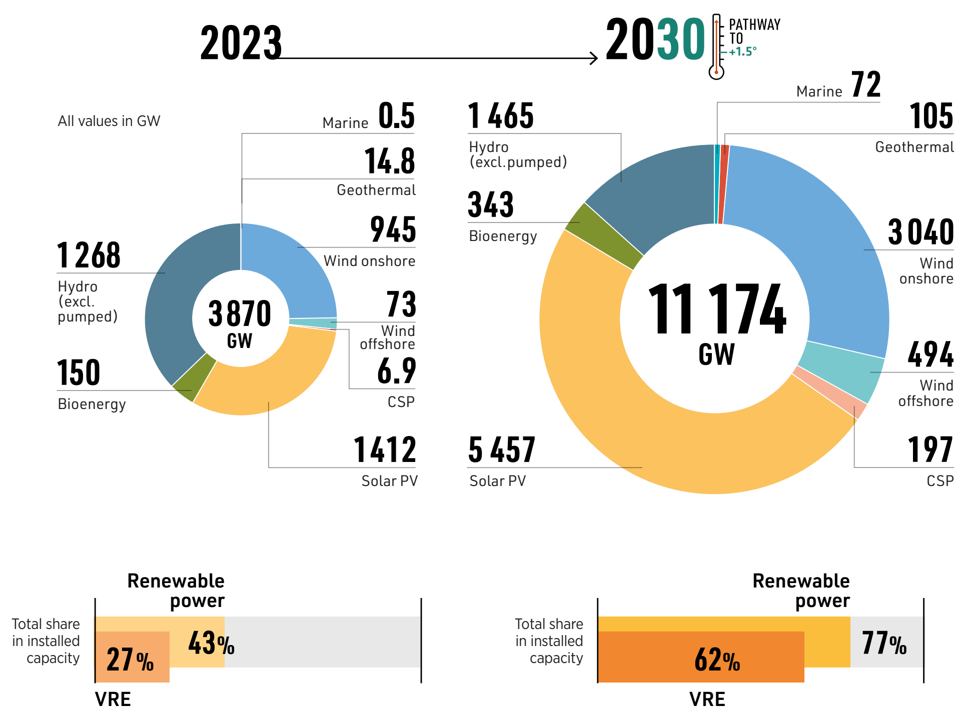
FIGURE 6.5 • KEY PERFORMANCE INDICATORS FOR IRENA'S 1.5°C SCENARIO IN 2030

KPI	Indicator		Recent years: 2020	2030: PES	2030: 1.5°C Scenario
KPI.01 RENEWABLES (POWER)	Electricity generation (TWh/yr)	Global	7 468	16 504	27 358
		G20	6 237	14 269	22 397
	Renewable energy share in electricity generation (%)	Global	28%	46%	68%
		G20	28%	48%	69%
KPI.02 RENEWABLES (DIRECT USES)	Renewable energy share in TFEC (%)	Global	18%	23%	35%
		G20	16%	22%	36%
	Modern use of bioenergy (EJ)[1]	Global	21	30	50
		G20	19	26	36
KPI.03 ENERGY INTENSITY	Energy intensity improvement rate (%)	Global	1.7%	1.8%	3.3%
		G20	2.1%	2.1%	3.6%
KPI.04 ELECTRIFICATION IN END-USE SECTORS (DIRECT)	Electrification rate in TFEC (%)	Global	22%	23%	29%
		G20	24%	26%	31%
KPI.05 CLEAN HYDROGEN AND DERIVATIVES	Production of clean hydrogen (Mt)	Global	0.7 Mt/yr[2]	2	125
		G20	0.5 Mt/yr[2]	2	94
KPI.06 CCS, BECCS AND OTHERS	CO_2 captured from CCS, BECCS and other removal measures (Gt)	Global	0.04 $GtCO_2/yr$[3]	0.1	2.2
		G20	0.03 $GtCO_2/yr$[3]	0.1	2.1

Source: IRENA 2023.
Notes: The Planned Energy Scenario, the reference case for WETO 2023, is based on countries' current plans.
1. Includes non-energy uses.
2. Operational project capacity through October 2022 (IEA Hydrogen Project Database).
3. Operational project capacity through March 2023 (IEA CCUS Database).
BECCS = bioenergy with carbon capture and storage; CCS = carbon capture and storage; CO_2 = carbon dioxide; EJ = exajoule; G20 = Group of Twenty; Gt = gigatonne; KPI = key performance indicator; Mt = megatonne; PES = Planned Energy Scenario; TFEC = total final energy consumption; TWh/yr = terawatt hours per year.

Advancing the energy transition at the required pace and scale would need the electricity sector to be decarbonized completely by midcentury. Tripling renewables-based power capacity by 2030 is technically feasible and economically viable but requires commitment, policy support, and investment at scale. IRENA's monitoring and analysis of renewable energy development and deployment reveals that the technological maturity achieved for renewables—with policy support, greater competitiveness, and abundant resources—has positioned the industry at the very heart of climate, development, and energy security strategies. Since 2015, new installed renewables-based power capacity additions have consistently outpaced new fossil fuel and nuclear power installations combined, reaching an estimated 473 GW in 2023 alone. However, tripling renewable power capacity globally will also require considerable progress elsewhere, including accelerated investments in infrastructure and system operation (e.g., power grids, storage), updated policies and regulations (e.g., power market design and regulation, streamlining permitting), measures to strengthen supply chains and develop transition-related skills, and a major scale-up of investment, including public funds, supported by international collaboration. Also, under IRENA's 1.5°C Scenario, rapid electrification of heating and transport applications, alongside increased green hydrogen production, would significantly boost the demand for electricity. According to IRENA's 1.5°C Scenario, by 2030, the global total installed renewables-based power generation capacity would need to grow from 3,870 GW in 2023 to 11,174 GW, through exploration of diverse renewable sources (figure 6.6). Renewable energy would meet 68 percent of the total electricity need by then.

FIGURE 6.6 • GLOBAL INSTALLED RENEWABLES-BASED POWER CAPACITY IN 2023 AND 2030 UNDER IRENA'S PLANNED ENERGY SCENARIO AND 1.5°C SCENARIO



Source: IRENA 2023.
Note: Bioenergy includes biogas, biomass waste, and solid biomass.
CSP = concentrated solar power; GW = gigawatt; PV = photovoltaic; VRE = variable renewable energy.

Outside the power sector, progress is more mixed. Under IRENA's 1.5°C Scenario, transport, in particular, road vehicles, would see rapid transition in the decade. Progress in transport electrification in 2023 fell short of the required pace. Road transport is the subsector with the highest potential for electrification. Under IRENA's 1.5°C Scenario, the electrification rate in the global transport sector would rise to almost 7 percent by 2030. Successful launch of new EV models, financial incentives, and improvement of charging infrastructure have been strong drivers, yet the current stock of battery EVs and plug-in hybrid electric vehicles would need to grow from 40 million today to 360 million by 2030—a target that cannot be achieved at current growth rates.

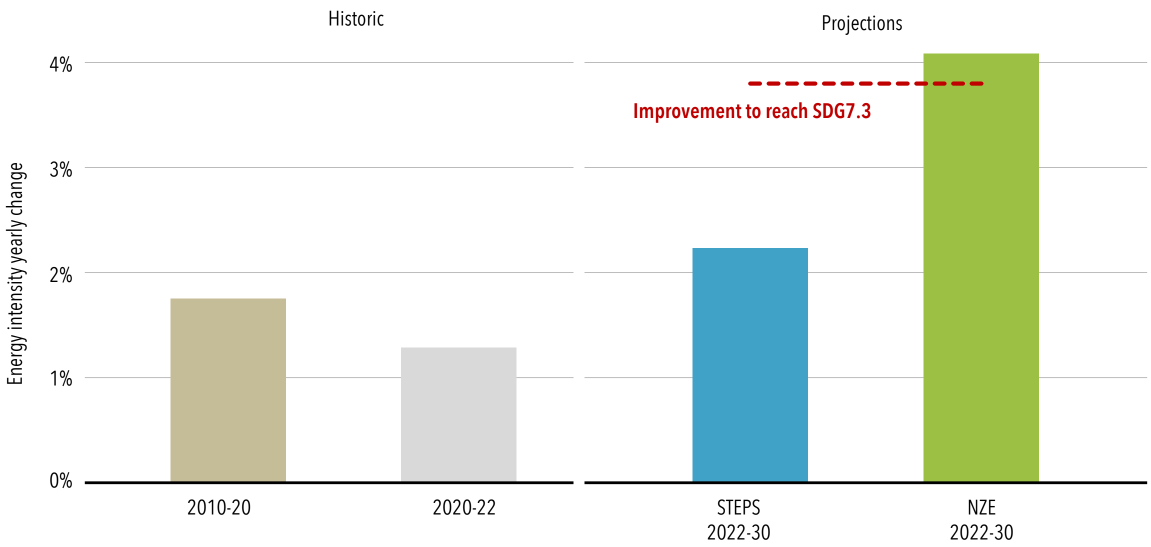
Direct uses of renewables (e.g., bioenergy, solar thermal, and geothermal) are needed to bring much-needed solutions in transport, buildings, and industry for energy services that are hard to electrify. Under IRENA's 1.5°C Scenario, the direct use of modern bioenergy would rise from 21 exajoules (EJ) to 46 EJ by 2030; the area of solar thermal collectors would increase threefold to 1,553 million square meters; and the consumption of geothermal-based heat would increase 60 percent. Under IRENA's 1.5°C Scenario, clean hydrogen production would grow from 2 Mt today to 125 Mt by 2030 (IRENA 2023). Hydrogen has been largely consumed for industrial applications in this decade, although a small quantity is used in the transport sector.

Sales of heat pumps, essential for the decarbonization of the heating sector, are showing signs of a slowdown. Heat pump sales grew 11 percent globally in 2022—notably, in Europe, where they increased 38 percent, partly due to energy security concerns. However, preliminary data show that heat pump sales decreased in most European markets in 2023, falling about 5 percent relative to 2022 (Azau 2024).

The outlook for energy efficiency

The key indicator used to track global progress on energy efficiency is energy intensity, measured as the ratio of primary energy supply to an economy's gross domestic product. The Russian invasion of Ukraine and the ensuing energy crisis resulted in a renaissance of energy efficiency, after two years of stalled progress during the COVID-19 pandemic. Increases in energy costs, energy security concerns, and supply disruptions have prompted policy makers to recognize the important role of energy efficiency in making energy more affordable and secure. This recognition culminated with the consensus reached at COP28 to target a doubling of the energy efficiency improvement rate by 2030. Despite this policy momentum, early estimates for 2023 indicate an annual energy intensity improvement rate of 1.3 percent, largely reflecting an increase in energy demand of 1.7 percent in 2023 and a slowdown of efficiency improvements in China (IEA 2023e). Under IEA's Stated Policies Scenario, the outlook for annual energy intensity improves to 2.3 percent by 2030, slightly stronger than progress on energy intensity over the decade ending in 2020 (figure 6.7).

FIGURE 6.7 • HISTORICAL AND PROJECTED IMPROVEMENT IN GLOBAL ENERGY INTENSITY BY SCENARIO, 2010–30



Source: IEA 2023a.
NZE = Net Zero Emissions by 2050 Scenario; SDG = Sustainable Development Goal; STEPS = Stated Policies Scenario.

Policy action has scaled up significantly since early 2022. Countries representing 70 percent of the global energy demand introduced or significantly strengthened efficiency policy packages. Annual energy efficiency investments rose 45 percent since 2020, with particularly strong growth for EVs and heat pumps. Because the impacts of new government policies and investment growth are not always immediate, these efficiency gains may be realized only over a period of years.

Moreover, this year's slower progress in global energy intensity obscures exceptional gains in some countries and regions, where strong policy action, increased investments, and changes in consumer behavior led to improvements well above the average global rate. Robust improvements, from 4 percent to 14 percent, have been recorded by the European Union and the United States, as well as by many other countries since the beginning of the energy crisis, including the Republic of Korea, Türkiye, and the United Kingdom of Great Britain and Northern Ireland (IEA 2023e).

Energy efficiency is one of the building blocks of IEA's Net Zero Emissions by 2050 Scenario. To achieve net zero emissions by mid-century, the rate of global primary energy intensity improvement doubles to 4.1 percent by 2030 from just over 2 percent in 2022. While this doubled rate exceeds the SDG 7 target of 3.8 percent, it is necessary given the lack of sufficient progress in recent years. Doubling the annual rate of energy intensity improvement by 2030 not only reduces emissions, but also boosts energy security and affordability, saving the energy equivalent of all worldwide oil use in road transport today. While priorities vary by country, the key improvements at the global level come from upgrading the technical efficiency of equipment such as electric motors and air conditioners, from efficiency gains due to electrification, a shift away from solid biomass use in low-income countries, and the more efficient use of energy and materials (IEA 2023d).

For energy efficiency improvements to double, there is a need for robust government policy packages incorporating information, regulations, and incentives, and a tripling of global investments. These will generate efficiency gains in every sector. Between now and 2030, cars become 5 percent more efficient each year, largely through electrification and a switch to smaller vehicles. In industry, annual energy productivity increases 2.3 percent per year, and electricity accounts for 30 percent of energy use by 2030. The retrofit rates for buildings more than double to 2.5 percent per year, generating sufficient energy savings to power all buildings in China and India today. Appliances including air conditioners and refrigerators require 30–40 percent less energy, and consumers make active behavioral changes, for example, limiting heating to 19–20°C.

While achieving this rate of improvement will be challenging, it is not unprecedented. Of the 150 countries for which data exist since 2012, in almost all (91 percent), energy intensity improved by 4 percent or more at least once and by more than half (53 percent) at least three times. The challenge for governments will be to sustain this level of improvement for the rest of the decade. Fortunately, many of the necessary policies and technologies are already in place. In most sectors, governments can make rapid progress toward doubling by building upon existing policies and accelerating the deployment of already-available technologies. Many existing minimum energy performance standards of governments are already at or very close to the levels set forth under the Net Zero Emissions by 2050 Scenario. Implementation and enforcement of these standards across all key sectors by all governments would aid in the collective achievement of a doubling of energy efficiency progress.

Under IRENA's 1.5°C Scenario, the average annual energy intensity improvement rate would need to increase to over 3.3 percent per year over 2020–30. A key step in this regard is the deployment of energy efficiency measures that improve technical efficiency, for example, more efficient boilers, air conditioners, motors, heat pump systems, and appliances, as well as the deployment of technologies that support the direct end use of renewables, for example, solar thermal.

Investments needed to achieve SDG 7

Global clean energy investments, encompassing renewables-based power, renewables-based fuel, efficiency, end-use electrification, and grids, rose by over 5 percent in 2023. These investments were crucial in advancing renewables and boosting energy efficiency and helped to counterbalance the increased reliance on coal and oil. Without this surge in clean energy investments, emissions could have spiked threefold.

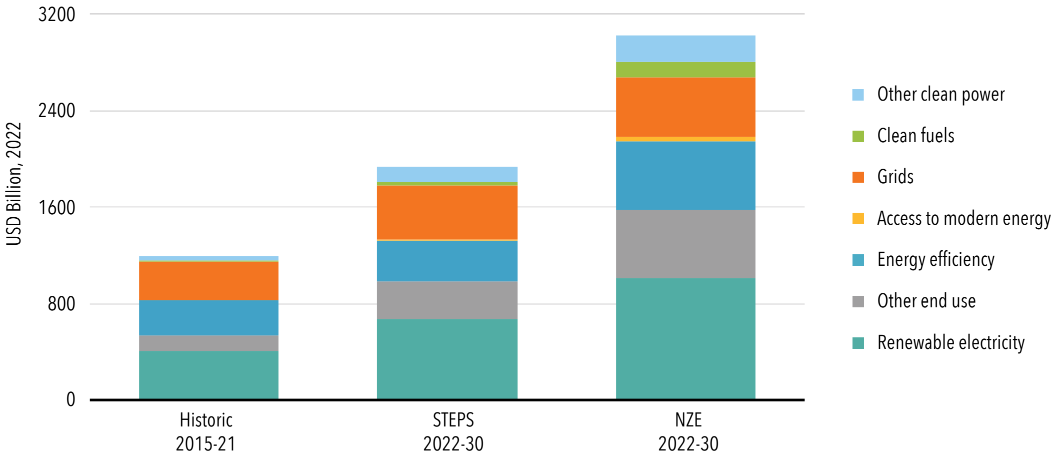
Between 2015 and 2021, annual clean energy investments averaged over USD 1 trillion (in 2022 dollars). Both IEA and IRENA emphasize the pressing need to escalate investments in the energy transition. According to IEA's Net Zero Emissions by 2050 Scenario, meeting the SDG 7 targets requires an average annual investment of USD 3 trillion in the energy sector over 2022–30, whereas clean energy investments under the Stated Policies Scenario average close to USD 2 trillion in the same period.

The bulk of the investment required to meet the SDG 7 targets under the Net Zero Emissions by 2050 Scenario is allocated to renewables-based electricity generation (including batteries) and end-use efficiency; the investment amounts to USD 1,016 billion and USD 566 billion per year, respectively (again, in 2022 dollars). However, additional average annual spending of USD 2022 494 billion on expanding and modernizing electricity networks is essential to support investments in renewables-based power. Grid investments have not kept pace with generation, especially in emerging markets and developing economies, posing a potential barrier to clean energy transitions without appropriate incentives.

Under IEA's Net Zero Emissions by 2050 Scenario, achieving universal energy access in developing economies necessitates average annual investments of USD 30 billion for electricity access and USD 8 billion for access to clean cooking over 2022–30 (figure 6.8). Half of this investment is required in Sub-Saharan Africa.

Even though these investments represent only 10 percent of annual spending in the upstream oil and gas sector, reaching these levels for access remains challenging due to the small-scale nature of projects and the affordability challenges faced by end users. Before COVID-19, investments in electricity access fell significantly short of the required levels and were concentrated in a few countries. The status of access to clean cooking is even more alarming; investments in 2019 fell far below the required levels, especially in Africa, where they would need to grow 15 times over current levels. International support through development aid and from multilateral development banks will be crucial in mobilizing investment levels and mitigating the risks associated with access and other energy investments in emerging markets and developing economies.

FIGURE 6.8 • HISTORICAL AVERAGE ANNUAL INVESTMENT IN SELECTED TECHNOLOGIES AND UNDER IEA SCENARIOS, 2022–30

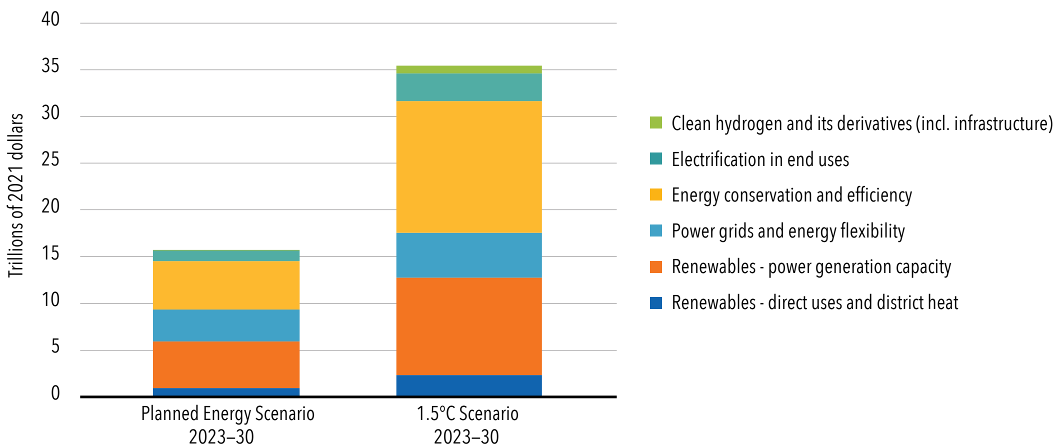


Source: IEA 2023a.
NZE = Net Zero Emissions by 2050 Scenario; PV = photovoltaic; STEPS = Stated Policies Scenario.

Under IRENA's 1.5°C Scenario, cumulative investments between now and 2030 total USD 45 trillion (in 2021 dollars), and the technologies for the transition represent 81 percent of these investments, or USD 36 trillion (figure 6.9). Total cumulative energy sector investments under the Planned Energy Scenario until 2030 are USD 29 trillion. Therefore, an additional cumulative investment of USD 16 trillion would be needed under IRENA's 1.5°C Scenario through 2030.

Investments in efficiency, grid expansion, and flexibility are essential, while any financing for fossil fuels and related infrastructure should align with the transition goals if only to avoid stranding assets. Therefore, IRENA's 1.5°C Scenario requires an average annual outlay of USD 4.5 trillion (2021 dollars) in clean energy transition investments through 2030. These outlays would focus on renewables, efficiency, and low-carbon technologies and include enabling infrastructure, such as power grids and energy storage.

FIGURE 6.9 • GLOBAL CUMULATIVE CLEAN ENERGY TRANSITION INVESTMENTS: PLANNED ENERGY SCENARIO AND 1.5°C SCENARIO, 2023–30



Source: IRENA 2023.

Conclusion

Across this comprehensive analysis of the progress and challenges associated with SDG 7, which aspires for universal access to affordable, reliable, sustainable, and modern energy by 2030, a nuanced picture emerges. Despite notable advances in some areas, significant hurdles remain, underscoring the imperative need for a more concerted and multifaceted approach to align current trajectories with the SDG targets. While innovative technologies and policy interventions have helped expand access to electricity and clean cooking facilities, particularly in Asia, regional disparities persist. These disparities highlight the critical need for enhanced international cooperation, innovative financing mechanisms, and robust, forward-looking policy frameworks capable of adapting to the evolving energy landscape.

The urgency of scaling up renewable energy sources and enhancing energy efficiency is clear, not only to meet SDG 7 but also to address broader environmental challenges and socioeconomic objectives. Reaching the ambitious targets of SDG 7 requires a paradigm shift in how energy is produced, distributed, and consumed. This entails a significant increase in investments and necessitates an enabling policy environment that fosters clean energy transitions across the globe. Policy makers thus have a pivotal role to play in creating conducive environments for the adoption of renewable energy and energy efficiency technologies, facilitating the mobilization of necessary investments, and implementing measures that ensure energy access for all.

Besides the need for direct investments in renewable energy and energy efficiency measures, there is a need for comprehensive strategies that address the full spectrum of challenges associated with achieving SDG 7. This includes developing sustainable clean cooking solutions, which remains a significant issue in many parts of the world, especially Sub-Saharan Africa. Also important is to expand electricity access through proven solutions like SHSs and mini-grids, which have shown promise in reaching remote populations.

The transition toward a sustainable energy future requires not only technological innovation but also significant improvements in infrastructure, regulatory frameworks, and human capital. It requires governments, the private sector, international organizations, and civil society to work collaboratively to create the conditions for the large-scale adoption of clean energy solutions. This collaborative effort should aim to mitigate the financial risks associated with clean energy projects, make clean energy technologies more affordable for end users, and ensure that the benefits of the energy transition are equitably distributed.

The journey toward reaching SDG 7 and ensuring a sustainable energy future for all has many challenges but also brings many opportunities. The path forward requires not only a significant scale-up of current efforts, but also a holistic approach that addresses the interconnectedness of energy access, renewable energy adoption, energy efficiency, and socioeconomic development, ensuring no one is left behind in the global transition to a sustainable energy future.


Photo: © Unsplash

CHAPTER 7
TRACKING PROGRESS TOWARD SDG 7 ACROSS TARGETS: INDICATORS AND DATA

Leveraging national data efforts worldwide, this annual report is a joint effort of the five custodian agencies responsible for monitoring progress toward the targets of Sustainable Development Goal (SDG) 7—universal access to affordable, reliable, sustainable, and modern energy by 2030 (table 7.1). The World Bank and World Health Organization (WHO) are responsible for tracking progress toward SDG target 7.1 (universal access to modern energy services). The International Energy Agency (IEA), International Renewable Energy Agency (IRENA), and United Nations Statistics Division (UNSD) are responsible for tracking SDG target 7.2 (the share of renewable energy in the energy mix). IEA and UNSD are responsible for tracking SDG target 7.3 (improvements in energy efficiency). IRENA is also responsible for tracking target 7.a (international cooperation—with the Organisation for Economic Co-operation and Development, OECD) and target 7.b (promotion of energy infrastructure). The World Bank's Energy Sector Management Assistance Program produces and publishes the report.

This chapter provides a descriptive summary of each indicator's data and methodological challenges. Further details can be found in the United Nations' metadata repository for SDG indicators (https://unstats.un.org/sdgs/metadata/). Detailed datasets with country data for all SDG 7 indicators can be accessed at no charge at https://trackingsdg7.esmap.org/downloads.

TABLE 7.1 • SDG 7 TARGETS, INDICATORS, AND CUSTODIAN AGENCIES

TARGET	INDICATOR	CUSTODIAN AGENCY OR AGENCIES	RELEVANT CHAPTER IN THIS REPORT
7.1–By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1–Proportion of population with access to electricity	World Bank	Chapter 1
	7.1.2–Proportion of population with primary reliance on clean fuels and technology for cooking	World Health Organization	Chapter 2
7.2–By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1–Renewable energy share in total final energy consumption	International Energy Agency, International Renewable Energy Agency, UN Statistics Division	Chapter 3
7.b–By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing states, and landlocked developing countries, in accordance with their respective programs of support	7.b.1–Installed renewable energy-generating capacity in developing and developed countries (in watts per capita)	International Renewable Energy Agency	
7.3–By 2030, double the global rate of improvement in energy efficiency	7.3.1–Energy intensity measured in terms of primary energy and GDP	International Energy Agency, UN Statistics Division	Chapter 4
7.a–By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency, and advanced and cleaner fossil fuel technology, and promote investment in energy infrastructure and clean energy technology	7.a.1–International financial flows to developing countries in support of clean energy research and development and renewable energy production, including in hybrid systems	International Renewable Energy Agency, Organisation for Economic Co-operation and Development	Chapter 5

Note: GDP = gross domestic product.

Access to electricity

Measuring access to electricity (SDG indicator 7.1.1) is not as straightforward as simply counting the number of people with electricity. It is a complex process involving data collection and validation efforts carried out by national and international players, including governments, energy utilities, private companies, and multilateral development organizations. Understanding the intricacies of electricity access in low-income countries and countries marked by fragility, conflict, or violence requires a comprehensive look at the multiple attributes of access in different settings.

While most microdata from household, enterprise, and agricultural surveys provide useful information to energy practitioners and ministries, they fail to capture the more nuanced aspects of electricity access in households—for example, the economic activities of a household's individual members Further complexities arise when trying to account for the scale-up of decentralized energy solutions that are not typically distinguished in routine national surveys and energy statistics.

Because the concept of electricity access does not lend itself to easy definition, efforts are underway, through the World Bank's Multi-Tier Framework, to better capture the spectrum of energy services sought and used by households: capacity, availability, reliability, affordability, quality, formality, healthiness, and safety.[46] Such efforts can provide more precise, more detailed information about the number of people benefiting from interventions and the nature and magnitude of improvements in electrification. Such information is critical to inform policy and decision-making. Where data are not available for multi-tier metrics, country-level surveys or censuses complement data collection.

To improve the tracking of access, capacity-building activities, including bilateral and regional training of energy statisticians, must be further developed. Data sets should also be made easier to use and compare, to help governments and energy practitioners apply new technologies and data analytics. For example, the Atlas of Sustainable Development Goals, published online by the World Bank, presents interactive storytelling and data visualizations on trends in electricity access, among other key SDG indicators.[47] Finally, leveraging large-scale open databases, for example, satellite-based data that could provide real-time information, will help clarify where and how electricity is being used, as well as socioeconomic trends in its use.

46 Information on the Multi-Tier Framework can be found at https://mtfenergyaccess.esmap.org/.

47 A new edition of the Atlas of Sustainable Development Goals has been published in 2023 (Pirlea et al. 2023). The 2020 edition can be found at https://datatopics.worldbank.org/sdgatlas/.

Access to clean cooking fuels and technologies for cooking

SDG indicator 7.1.2 measures the number of people using clean fuels and technologies as their primary energy source for cooking in the household. Households considered to have access to clean cooking are those that primarily rely on electricity, biogas, solar, alcohol fuels, natural gas, and liquefied petroleum gas for household cooking purposes. Here, "clean" refers to the combinations of fuels and technologies that meet the emissions targets set out in the WHO (2014) guidelines for indoor air quality and household fuel combustion. Improving the collection of data on the parallel use of multiple cooking solutions (also known as "stove stacking") in low- and middle-income countries would allow a more complete representation of the population exposed to pollution and resultant diseases. Presently, however, such data are too limited in geographic coverage to be used in global tracking efforts.

Household surveys and censuses are the primary data sources for global estimates. Using their data as the main inputs, the Global Household Energy Model is applied to estimate the use of clean cooking fuels and technologies. Knowing the extent to which household surveys capture modes and duration of use is therefore vital for designing, implementing, and monitoring the effectiveness and outcomes of clean cooking policies and programs.

By refining household surveys and censuses, countries can gain a more complete picture of household energy use; access to clean cooking fuels and technologies; and the effects of cooking practices on air pollution, gender, climate, and other impacts. The WHO and World Bank developed the guidebook Measuring Energy Access and a harmonized set of "Core Questions on Household Energy Use" (World Bank and WHO 2021; WHO n.d.). The questions improve upon previous surveys by not only establishing whether a household has electricity access and what its primary cooking fuel is, but also assessing the type of electricity access; the quality of access; impediments to access; the types of fuels and devices used for cooking, heating, and lighting; and important safety and livelihood impacts of household energy use.[48]

Beyond the SDG 7 indicators, including additional and more comprehensive questions in surveys will also help monitor trends in and broader outcomes of access to clean cooking. At the moment, most energy-related data collected by national household surveys do not capture everything needed to understand the role of household energy services in mitigating poverty and other impacts; hence, they do not permit extensive energy policy analysis. Including questions on cooking time, fuel collection, and health implications would increase the granularity of clean cooking estimates and help in the formulation of better national and global policies (World Bank and WHO 2021).

48 More information on CHEST can be found at: https://www.who.int/tools/clean-household-energy-solutions-toolkit.

Renewable energy

Progress toward SDG target 7.2—substantially increasing the share of renewable energy in the global energy mix—is tracked using renewable energy's share of total final energy consumption as the key indicator. Here, too, accurate tracking requires comprehensive data across all energy sources (renewable and nonrenewable) and across supply, transformation, and final consumption. The methodology used to derive total final energy consumption, total energy supply, and energy balances is detailed in United Nations (2018).

To increase the accuracy of tracking renewables, two methodological challenges must be met: (1) monitoring the rapid development of geographically distributed energy sources, such as off-grid and micro-grid solar photovoltaic and wind, and (2) enhancing countries' capacity to measure traditional uses of biomass (solid biofuels) by households. Biomass is the largest source of renewable (if not clean) energy in low- and middle-income countries.

National-level household and industry surveys could do more to boost the reliability of renewable energy statistics. For example, a broader range of questions on how biomass is used in households and organizations could help determine the extent to which biomass can be considered a sustainable energy source. Traditional fuelwood harvesting is associated with deforestation, yet fuelwood is still assumed to be a renewable energy source for lack of an agreed definition of sustainable harvesting, or accurate measures of fuelwood harvests. Survey-based data could help better quantify the "renewable" fraction of biomass use, and perhaps prompt significant revisions of earlier estimates.

Energy efficiency

Energy intensity, defined as the ratio of total energy supply to economic output, is used to track progress toward SDG target 7.3—doubling the global rate of improvement in energy efficiency (UN 2018). Measuring the total energy supply requires credible information on, among others, primary energy production across all sources, as well as trade in all energy products. Information on supply is collected from administrative sources or via surveys of higher-level players, such as energy suppliers.[49] This information includes commercially traded energy sources and is of fairly good quality in most countries.

To improve the tracking of energy intensity it will be important to analyze the drivers of demand across sectors, such as industry, transport, and buildings (both residential and commercial/industrial). Collecting demand-side data is much more complex, time consuming, and expensive than collecting supply-side data, due to the diversity of end users. Consumer surveys can complement data collection efforts when energy suppliers have limited or no information on how much energy is consumed by different types of users.

Analyzing energy efficiency within sectors requires countries to monitor intensities at the end-use level. Efficiency indicators might include energy expended per passenger-kilometer by vehicle type for passenger transport (tonne-kilometer for freight transport); energy for space heating and cooling, by unit of area, for buildings; or, for industry, energy used in the physical production of each unit of a particular good. More details on a methodological framework for energy efficiency indicators, as well as country experiences, can be found in IEA (2014).

Besides finer disaggregation of data, better energy efficiency indicators will depend on greater cross-organizational coordination in activities beyond the energy sector, including, among others, building records, vehicle registrations, and industrial reports. Many countries have already begun to collect end-use data and compile energy efficiency indicators to support their policy making and planning.[50]

49 Data collected by various agencies in response to legislation or regulation (not necessarily for statistical purposes) may be used to compile energy statistics after ensuring their quality and addressing limitations related to their purpose.

50 An example, besides the IEA energy efficiency indicators themselves (IEA 2014), is the Odyssee database for Europe (https://www.indicators.odyssee-mure.eu/).

International financial flows to developing countries in support of clean and renewable energy

Indicator 7.a.1 measures international public financial flows to developing countries in support of clean energy research and development, and renewable energy production, including in hybrid systems. The measurement utilizes data from IRENA and the OECD.

Good measurement of international public investment flows has four components: (1) tracking financial flows, (2) standardizing commitment details, (3) centralizing data collection, and (4) presenting flows in a constant way.

To track public financial flows, it is critical to understand how aid recipients intend to spend the investments for end-use projects and programs. Recipients are defined as end-use organizations and projects run by public investors. The amount of private finance leveraged through public funds, which the OECD already monitors in its data on private finance mobilization, provides valuable supplementary information to analyses of public flows. International financial flows are typically disbursed in multiple phases and through multiple stakeholders (local governments, ventures, or funds). Some commitments may also be canceled or modified after data have been gathered. Thus, where reporting institutions revise financial investment figures, historical investment information covering multiple years should be considered to reveal changes in amounts.

Standardizing commitment details by sharing best practices among public investors and donors, refining reporting directives, and encouraging public investors and donors helps ensure that collected data comply with international standards. The standardization process also makes data more accurate and granular. For example, commitment data may specify, among other attributes, technology, type of finance (project-level finance, infrastructure, research, or technical assistance), and type of financial mechanism.

Energy-related details are often excluded while collecting investment data. The majority of data on public investments in clean energy and renewables continues to be collected in a decentralized manner, adversely affecting consistency. For comparability across public donors, data collection must be centralized, through the use of online data entry portals and questionnaires prefilled to the extent possible with data from other agencies. The OECD/Development Assistance Committee Creditor Reporting System database is exemplary in this regard and also allows self-reporting by donors.

Exchange rates and inflation must be taken into account when comparing international commitments across countries. The OECD methodology is used in this report to deflate international flows by adjusting for inflation from the year the flows occurred to a baseline year (2021) and by converting local currency values to US dollars using exchange rates from the baseline year (2021).

Installed renewable electricity: Generating capacity in developing and developed countries

Indicator 7.b.1 tracks the installed capacity of power plants that generate electricity from renewable sources of energy (expressed in watts per capita). The 36 energy types disaggregated by IRENA as renewable fall into six broad categories: hydropower, marine energy (ocean, tidal, and wave energy), wind energy, solar energy (photovoltaic and thermal energy), bioenergy, and geothermal energy.

Capacity is defined as the net maximum electrical capacity installed at year end. Assessing a country's electricity production capacity is a valuable way to track progress toward target 7.b because it is an actual reflection of efforts. For many nations, the focus on increasing electricity production, especially from renewable sources, is a crucial step in their journey toward sustainable and modernized services.

Capacity data are collected in the course of IRENA's annual questionnaire cycle. Countries receive questionnaires at the beginning of each year and report renewable energy data for the previous two years. To minimize the reporting burden, the questionnaires for some countries are prefilled with data collected by other agencies (e.g., Eurostat). The questionnaires are then sent to the countries, so they can provide any additional details requested by IRENA. Validated data, by country, are published each year in late June in IRENA's Renewable Energy Statistics. IRENA (2023) is the most recent edition. Population data are extracted from the "World Population Prospects 2022" (UN Population Division 2022) and represent a country's population at mid-year (July 1).

A measure of indicator 7.b.1 in watts per capita is computed by dividing a country's renewable electricity–generating capacity at year end by its population in that year. Capacity data are drawn from this computation, and they account for the immense variations in needs between countries. Population data are used instead of gross domestic product, since population is the most basic indicator of country demand for modern and sustainable energy services.

Importantly, the indicator's focus on electricity capacity does not capture trends in the modernization of technologies in important, energy-intense sectors such as heat production and transport. Overall, electricity accounts for only about a quarter of the energy used globally; the share is even smaller in most developing countries. With electricity access continuing to increase, however, the focus on electricity capacity will grow in relevance.

Conclusion

Since the first effort back in 2013, improvements in reporting, advances in countries' statistical capacities, and enhanced models have raised the quality, reliability, and consistency of data on progress toward SDG 7 targets. This progress should be seen as a reminder of the value of pursuing a common framework using standardized data collection and estimation methodologies. The common framework will be possible only through cooperation among national statistical offices and other national agencies compiling energy information, and among those offices and relevant international bodies. International cooperation in the compilation of global databases will harmonize estimates across regions and countries and raise awareness of the need for good data.

As the custodian agencies work together on the global tracking of SDG 7, they have found ways to refine their collaboration and strengthen their support to countries. For example, the custodian agencies responsible for this report host webinars for statistical agencies and energy authorities, produce statistical guidance and reports on data collection, and regularly consult with national statistical offices and other national agencies on the estimates they provide. Continuing efforts by the World Bank, WHO, and other custodians to mainstream energy access questions into national household surveys are an important form of support to those offices. Programs to support national and regional data-collection efforts have also contributed to stronger capabilities. More such support is required to build national statistical capacities.

The IEA and UNSD have a long history of working together to build national reporting capacity. For instance, both agencies jointly organize workshops with the United Nations Framework Convention on Climate Change to help countries improve institutional coordination and, consequently, their compilation of energy balances, thereby improving the SDG 7 indicators. Recently, thanks to the IEA Sub-Saharan Africa program funded by the European Union, Nigeria established a new household survey and is planning a survey for industry.

The custodian agencies for SDG 7 emphasize a need to strengthen resources for better collection of national-level data under current and planned international programs supporting the energy transition. Building on recent improvements in data collection for the SDGs, national statistical capacities must be further strengthened. National and international institutions interested in policy success should increase resources for this purpose.

Finally, the custodian agencies would like to express their appreciation of the work and dedication of the many colleagues who collect national-level data around the world. Without their efforts, no precise estimates could be produced, and no tracking would be possible. Their work underpins the international efforts culminating in this report and ensures that the SDG 7 targets are kept in full view.

Appendix. Regional classifications of countries/territories

This report classifies countries and territories according to the United Nations' SDG classification for regions; the most recent classification for developing countries; and the special groupings for the least-developed countries, landlocked developing countries, and small island developing states (table 7.2). The SDG regional groupings are not the same as the M49 regional grouping of the United Nations, which focuses more closely on geography. The United Nations discontinued its developing countries classification in late 2022. This report will continue to use the most recent UN classification for developing countries to ensure continuity for indicators 7.a.1 and 7.b.1 (as well as 12.a.1).

TABLE 7.2 • GROUPINGS OF REGIONS, COUNTRIES, AND TERRITORIES AS USED IN THIS REPORT

CATEGORY	COUNTRIES/TERRITORIES WITHIN THE CATEGORY
Northern America and Europe	Åland Islands, Albania, Andorra, Austria, Belarus, Belgium, Bermuda, Bosnia and Herzegovina, Bulgaria, Canada, Channel Islands, Croatia, Czechia, Denmark, Estonia, Faroe Islands, Finland, France, Germany, Gibraltar, Greece, Greenland, Guernsey, Holy See (the), Hungary, Iceland, Ireland, Isle of Man, Italy, Jersey, Kosovo, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Monaco, Montenegro, Netherlands (Kingdom of the), North Macedonia, Norway, Poland, Portugal, Republic of Moldova, Romania, Russian Federation (the), Saint Pierre and Miquelon, San Marino, Sark, Serbia, Slovakia, Slovenia, Spain, Svalbard and Jan Mayen Islands, Sweden, Switzerland, Ukraine, United Kingdom of Great Britain and Northern Ireland (the), United States of America (the)
Sub-Saharan Africa	Angola, Benin, Botswana, British Indian Ocean Territory, Burkina Faso, Burundi, Cabo Verde, Cameroon, Central African Republic (the), Chad, Comoros (the), Congo (the), Côte d'Ivoire, Democratic Republic of the Congo (the), Djibouti, Equatorial Guinea, Eritrea, Eswatini, Ethiopia, French Southern and Antarctic Territories, Gabon, Gambia (the), Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mayotte, Mozambique, Namibia, Niger (the), Nigeria, Réunion, Rwanda, Saint Helena, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, South Sudan, Eswatini, Togo, Uganda, United Republic of Tanzania (the), Zambia, Zimbabwe
Latin America and the Caribbean	Anguilla, Antigua and Barbuda, Argentina, Aruba, Bahamas (the), Barbados, Belize, Bolivia (Plurinational State of), Bonaire, Sint Eustatius and Saba, Bouvet Island, Brazil, British Virgin Islands, Cayman Islands, Chile, Colombia, Costa Rica, Cuba, Curaçao, Dominica, Dominican Republic (the), Ecuador, El Salvador, Falkland Islands (Malvinas), French Guiana, Grenada, Guadeloupe, Guatemala, Guyana, Haiti, Honduras, Jamaica, Martinique, Mexico, Montserrat, Nicaragua, Panama, Paraguay, Peru, Puerto Rico, Saint Barthélemy, Saint Kitts and Nevis, Saint Lucia, Saint Martin (French Part), Saint Vincent and the Grenadines, Sint Maarten (Dutch part), South Georgia and the South Sandwich Islands, Suriname, Trinidad and Tobago, Turks and Caicos Islands, United States Virgin Islands, Uruguay, Venezuela (Bolivarian Republic of)
Western Asia and Northern Africa	Algeria, Armenia, Azerbaijan, Bahrain, Cyprus, Egypt, Georgia, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Qatar, Saudi Arabia, State of Palestine (the), Sudan (the), Syrian Arab Republic (the), Tunisia, Türkiye, United Arab Emirates (the), Western Sahara, Yemen
Oceania	American Samoa, Australia, Christmas Island, Cocos (Keeling Islands), Cook Islands (the), Fiji, French Polynesia, Guam, Heard Island and McDonald Islands, Kiribati, Marshall Islands, Micronesia (Federated States of), Nauru, New Caledonia, New Zealand, Niue, Norfolk Island, Northern Mariana Islands, Palau, Papua New Guinea, Pitcairn, Samoa, Solomon Islands, Tokelau, Tonga, Tuvalu, United States minor outlying islands, Vanuatu, Wallis and Futuna Islands
Eastern Asia and South-eastern Asia	Brunei Darussalam, Cambodia, China, China, Hong Kong Special Administrative Region, China, Macao Special Administrative Region, Democratic People's Republic of Korea (the), Indonesia, Japan, Lao People's Democratic Republic (the), Malaysia, Mongolia, Myanmar, Philippines (the), Republic of Korea (the), Singapore, Thailand, Timor-Leste, Viet Nam
Central Asia and Southern Asia	Afghanistan, Bangladesh, Bhutan, India, Iran (Islamic Republic of), Kazakhstan, Kyrgyzstan, Maldives, Nepal, Pakistan, Sri Lanka, Tajikistan, Turkmenistan, Uzbekistan

CATEGORY	COUNTRIES/TERRITORIES WITHIN THE CATEGORY
Developed countries	Åland Islands, Albania, Andorra, Australia, Austria, Belarus, Belgium, Bermuda, Bosnia and Herzegovina, Bulgaria, Canada, Channel Islands, Christmas Island, Cocos (Keeling) Islands, Croatia, Cyprus, Czechia, Denmark, Estonia, Faroe Islands, Finland, France, Germany, Gibraltar, Greece, Greenland, Guernsey, Heard Island and McDonald Islands, Holy See (the), Hungary, Iceland, Ireland, Isle of Man, Israel, Italy, Japan, Jersey, Kosovo, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Monaco, Montenegro, Netherlands (Kingdom of the), New Zealand, Norfolk Island, North Macedonia, Norway, Poland, Portugal, Republic of Korea (the), Republic of Moldova (the), Romania, Russian Federation (the), Saint Pierre and Miquelon, San Marino, Sark, Serbia, Slovakia, Slovenia, Spain, Svalbard and Jan Mayen Islands, Sweden, Switzerland, Ukraine, United Kingdom of Great Britain and Northern Ireland (the), United States of America (the)
Developing countries	Afghanistan, Algeria, American Samoa, Angola, Anguilla, Antigua and Barbuda, Argentina, Armenia, Aruba, Azerbaijan, Bahamas (the), Bahrain, Bangladesh, Barbados, Belize, Benin, Bhutan, Bolivia (Plurinational State of), Bonaire, Sint Eustatius and Saba, Botswana, Bouvet Island, Brazil, British Indian Ocean Territory, British Virgin Islands, Brunei Darussalam, Burkina Faso, Burundi, Cabo Verde, Cambodia, Cameroon, Cayman Islands, Central African Republic (the), Chad, Chile, China, China, Hong Kong Special Administrative Region, China, Macao Special Administrative Region, Chinese Taipei, Colombia, Comoros (the), Congo (the), Cook Islands (the), Costa Rica, Côte d'Ivoire, Cuba, Curaçao, Democratic People's Republic of Korea (the), Democratic Republic of the Congo (the), Djibouti, Dominica, Dominican Republic (the), Ecuador, Egypt, El Salvador, Equatorial Guinea, Eritrea, Eswatini, Ethiopia, Falkland Islands (Malvinas), Fiji, French Guiana, French Polynesia, French Southern and Antarctic Territories, Gabon, Gambia (the), Georgia, Ghana, Grenada, Guadeloupe, Guam, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, India, Indonesia, Iran (Islamic Republic of), Iraq, Jamaica, Jordan, Kazakhstan, Kenya, Kiribati, Kuwait, Kyrgyzstan, Lao People's Democratic Republic (the), Lebanon, Lesotho, Liberia, Libya, Madagascar, Malawi, Malaysia, Maldives, Mali, Marshall Islands (the), Martinique, Mauritania, Mauritius, Mayotte, Mexico, Micronesia (Federated States of), Mongolia, Montserrat, Morocco, Mozambique, Myanmar, Namibia, Nauru, Nepal, New Caledonia, Nicaragua, Niger (the), Nigeria, Niue, Northern Mariana Islands, Oman, Pakistan, Palau, Panama, Papua New Guinea, Paraguay, Peru, Philippines (the), Pitcairn, Puerto Rico, Qatar, Réunion, Rwanda, Saint Barthélemy, Saint Helena, Saint Kitts and Nevis, Saint Lucia, Saint Martin (French Part), Saint Vincent and the Grenadines, Samoa, Sao Tome and Principe, Saudi Arabia, Senegal, Seychelles, Sierra Leone, Singapore, Sint Maarten (Dutch Part), Solomon Islands, Somalia, South Africa, South Georgia and the South Sandwich Islands, South Sudan, Sri Lanka, State of Palestine (the), Sudan (the), Suriname, Syrian Arab Republic (the), Tajikistan, Thailand, Timor-Leste, Togo, Tokelau, Tonga, Trinidad and Tobago, Tunisia, Türkiye, Turkmenistan, Turks and Caicos Islands, Tuvalu, Uganda, United Arab Emirates (the), United Republic of Tanzania (the), United States minor outlying islands, United States Virgin Islands, Uruguay, Uzbekistan, Vanuatu, Venezuela (Bolivarian Republic of), Viet Nam, Wallis and Futuna Islands, Western Sahara, Yemen, Zambia, Zimbabwe
Least-developed countries	Afghanistan, Angola, Bangladesh, Benin, Burkina Faso, Burundi, Cambodia, Central African Republic (the), Chad, Comoros (the), Democratic Republic of the Congo (the), Djibouti, Eritrea, Ethiopia, Gambia (the), Guinea, Guinea-Bissau, Haiti, Kiribati, Lao People's Democratic Republic (the), Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mozambique, Myanmar, Nepal, Niger (the), Rwanda, Sao Tome and Principe, Senegal, Sierra Leone, Solomon Islands, Somalia, South Sudan, Sudan (the), Timor-Leste, Togo, Tuvalu, Uganda, United Republic of Tanzania (the), Yemen, Zambia
Landlocked developing countries	Afghanistan, Angola, Bangladesh, Benin, Burkina Faso, Burundi, Cambodia, Central African Republic (the), Chad, Comoros (the), Democratic Republic of the Congo (the), Djibouti, Eritrea, Ethiopia, Gambia (the), Guinea, Guinea-Bissau, Haiti, Kiribati, Lao People's Democratic Republic (the), Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mozambique, Myanmar, Nepal, Niger (the), Rwanda, Sao Tome and Principe, Senegal, Sierra Leone, Solomon Islands, Somalia, South Sudan, Sudan (the), Timor-Leste, Togo, Tuvalu, Uganda, United Republic of Tanzania (the), Yemen, Zambia
Small island developing states	American Samoa, Anguilla, Antigua and Barbuda, Aruba, Bahamas (the), Barbados, Belize, Bonaire, Sint Eustatius and Saba, British Virgin Islands, Cabo Verde, Comoros (the), Cook Islands (the), Cuba, Curaçao, Dominica, Dominican Republic (the), Fiji, French Polynesia, Grenada, Guam, Guinea-Bissau, Guyana, Haiti, Jamaica, Kiribati, Maldives, Marshall Islands (the), Mauritius, Micronesia (Federated States of), Montserrat, Nauru, New Caledonia, Niue, Northern Mariana Islands, Palau, Papua New Guinea, Puerto Rico, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Samoa, Sao Tome and Principe, Seychelles, Singapore, Sint Maarten (Dutch Part), Solomon Islands, Suriname, Timor-Leste, Tonga, Trinidad and Tobago, Tuvalu, United States Virgin Islands, Vanuatu

CATEGORY	COUNTRIES/TERRITORIES WITHIN THE CATEGORY
"Developing countries" under indicator 7.a.1. These are a modified list of countries specific to international public finance flows	Afghanistan, Albania, Algeria, Angola, Antigua and Barbuda, Argentina, Armenia, Azerbaijan, Bahamas (the), Bangladesh, Barbados, Belarus, Belize, Benin, Bhutan, Bolivia (Plurinational State of), Bosnia and Herzegovina, Botswana, Brazil, Burkina Faso, Burundi, Cabo Verde, Cambodia, Cameroon, Central African Republic (the), Chad, Chile, China, China, Hong Kong Special Administrative Region, China, Macao Special Administrative Region, Chinese Taipei, Colombia, Comoros (the), Congo (the), Cook Islands (the), Costa Rica, Côte d'Ivoire, Cuba, Democratic People's Republic of Korea (the), Democratic Republic of the Congo (the), Djibouti, Dominica, Dominican Republic (the), Ecuador, Egypt, El Salvador, Equatorial Guinea, Eritrea, Eswatini, Ethiopia, Fiji, French Polynesia, Gabon, Gambia (the), Georgia, Ghana, Grenada, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, India, Indonesia, Iran (Islamic Republic of), Iraq, Jamaica, Jordan, Kazakhstan, Kenya, Kiribati, Kosovo, Kyrgyzstan, Lao People's Democratic Republic (the), Lebanon, Lesotho, Liberia, Libya, Madagascar, Malawi, Malaysia, Maldives, Mali, Marshall Islands (the), Mauritania, Mauritius, Mexico, Micronesia (Federated States of), Mongolia, Montenegro, Montserrat, Morocco, Mozambique, Myanmar, Namibia, Nauru, Nepal, New Caledonia, Nicaragua, Niger (the), Nigeria, Niue, North Macedonia, Pakistan, Palau, Panama, Papua New Guinea, Paraguay, Peru, Philippines (the), Republic of Moldova (the), residual/unallocated ODA: Central Asia and Southern Asia, residual/unallocated ODA: Eastern and South-eastern Asia, residual/unallocated ODA: Latin America and the Caribbean, residual/unallocated ODA: Northern America and Europe, residual/unallocated ODA: Oceania excl. Aus. and N. Zealand, residual/unallocated ODA: Sub-Saharan Africa, residual/unallocated ODA: Western Asia and Northern Africa, Rwanda, Saint Helena, Saint Lucia, Saint Vincent and the Grenadines, Samoa, Sao Tome and Principe, Senegal, Serbia, Seychelles, Sierra Leone, Solomon Islands, Somalia, South Africa, South Sudan, Sri Lanka, State of Palestine (the), Sudan (the), Suriname, Syrian Arab Republic (the), Tajikistan, Thailand, Timor-Leste, Togo, Tokelau, Tonga, Trinidad and Tobago, Tunisia, Türkiye, Turkmenistan, Tuvalu, Uganda, Ukraine, United Republic of Tanzania (the), Unspecified countries, Uruguay, Uzbekistan, Vanuatu, Venezuela (Bolivarian Republic of), Viet Nam, Wallis and Futuna Islands, Yemen, Zambia, Zimbabwe

Note: ODA = official development assistance.

ANNEX 1. METHODOLOGICAL NOTES

Chapter 1. Access to electricity

THE WORLD BANK'S GLOBAL ELECTRIFICATION DATABASE

The World Bank's Global Electrification Database compiles nationally representative household survey data and census data for the period 1990–2022. It incorporates data from the Socio-Economic Database for Latin America and the Caribbean, the Middle East and North Africa Poverty Database, and the Europe and Central Asia Poverty Database, all of which are based on similar surveys. The database relies on the Bank's Multi-Tier Framework, which classifies access along a tiered spectrum, from Tier 0 (no access) to Tier 5 (the highest level of access). At the time of this analysis, the database contained 1,404 surveys from 149 countries in 1990–2022.

A multilevel, nonparametric model is applied to extrapolate data for missing years (described below). The modelling approach originally developed by the World Health Organization (WHO) to estimate clean fuel usage was adapted to project electricity access and fill in missing data points.[1] Where data were available, access estimates were weighted by population. Multilevel, nonparametric modelling considers the hierarchical structure of data (country and regional levels), using the regional classification of the United Nations.

The model was applied in all countries with at least one data point. To use as much real data as possible, results based on survey data were reported in their original form for all years available. The statistical model was used to fill in data for years in which data were missing and to conduct global and regional analyses. In the absence of survey data for a given year, information from regional trends was used. The difference between real data points and estimated values is clearly identified in the database. Countries classified as high-income are assumed to have electrification rates of 100 percent for the years the countries belong to the category.

For 1990–2010, the statistical model was based on insufficient data points or outdated household surveys. To avoid having electrification trends in this period overshadow efforts since 2010, the model was run twice, once with survey data and assumptions for 1990–2022 (for model estimates for 1990–2022) and once with survey data and assumptions for 2010–22 (for model estimates for 2010–22). The first run extrapolates electrification trends for 1990–2022, given the available data points. The second considers only real data collected since 2010 and estimates the historical evolution in the most recent years. The outputs from the two model runs were then combined to generate a final value for access to electricity. If survey data were available, the original observation remained in the final database. Otherwise, the larger value generated by the model runs was chosen as the final data point.

1 The model draws on the modelling of solid fuel use for household cooking presented in Bonjour and others (2013).

Under the WHO methodology adapted for the purpose of assessing access, regional trends affect the estimation of yearly values in countries with missing data points in certain years. Depending on the regional trend and how many years have passed since the last available year of data for a certain country, the model can interpolate unrealistic access rates of 100 percent. To avoid reporting unrealistic rates, the country's latest survey data are extended. In this version of the report, this was done Nepal, and Nigeria.

COMPARISON BETWEEN DEMAND-SIDE DATA AND SUPPLY-SIDE DATA

While the World Bank's Global Electrification Database collects data mainly from household surveys and censuses, the IEA's Energy Access Database draws from government reports of household electrification (usually based on connections reported by utilities). IEA considers a household to have access if it receives enough electricity to power a basic bundle of energy services.

The two approaches sometimes yield different estimates. Estimates based on household surveys are moderately higher than estimates based on energy sector data because they capture a wider range of phenomena, including off grid access, "informal" connections (connections not made by or known to the utility), and self-supply systems.

Comparison of the two datasets in the previous edition of this report (updated in this edition) highlights their respective strengths. Household surveys, which are typically conducted by national statistical agencies, offer two advantages for measuring electrification. First, thanks to efforts to harmonize questionnaire designs, electrification questions are largely standardized across country surveys. Although not all surveys reveal detailed information on the forms of access, questionnaire designs capture emerging phenomena, such as off-grid solar access. Second, data from surveys convey user-centric perspectives on electrification. Survey data capture all forms of electricity access, painting a more complete picture of access than may be possible from data supplied by service providers. But greater investment in data collection and capacity building is needed to generate a comprehensive and accurate survey-based understanding of electricity access.

Government data on electrification reported by national ministries of energy are supply-side data on utility connections. They offer two principal advantages over national surveys. First, administrative data are often available on an annual basis and may therefore be more up to date than surveys, which are conducted every two to three years. (Moreover, since 2010, only about 20 percent of countries have published or updated their electricity data at intervals of two to three years in time for global data collection.) Second, administrative data are not subject to the challenges that can arise when conducting field surveys. Household surveys (particularly those implemented in remote and rural areas) may suffer from sampling errors that may lead to underestimation of the access deficit.

MEASURING ACCESS TO ELECTRICITY PROVIDED THROUGH OFF-GRID SOLAR SOURCES

The rates and levels of access to off-grid solar energy shared in this chapter are based on data shared by affiliates in the bi-annual data collection undertaken by GOGLA, Lighting Global, and Efficiency for Access.

Eligible off-grid solar lighting products included in the affiliate data collection are defined as systems that include a solar panel, a battery, and at least one light point. Every six months, affiliate companies fill out a questionnaire on their product sales by country, system type/size, and business model; they also share product specifications and capacities. Although companies are ultimately responsible for the accuracy of the self-reported data submitted, the data are checked for quality by an independent consultancy (Berenschot), as well as by GOGLA, Lighting Global, and the Energy Savings Trust.

Manufacturers and distributors of off-grid solar products report their sales, but the results shared in public reports cover only products sold by manufacturers of off-grid solar products. This is to avoid double counting sales reported by both manufacturers and distributors. The product sales reported by manufacturers include both business-to-business transactions (e.g., sales to distributors, governments, and nongovernmental organizations) as well direct business sales to customers. The latest Off-Grid Solar Market Trends Report (GOGLA and others 2022) estimates that sales of GOGLA affiliate companies represent 28 percent of the total off-grid solar market, although estimates of percentages by country, as well as by system size and business model, vary significantly.

In addition to using standardized impact metrics[2] created by the GOGLA Impact Working Group, additional steps are taken to calculate tiers of energy access:

Tier 1. To estimate Tier 1 energy access, a "SEforALL factor" is applied to the sales numbers.[3] That factor estimates the service-level impact of smaller technologies. This tool reviews the system size and capacity of each product and estimates whether it has helped to unlock either partial or full Tier 1 access. It then calculates the total number of people who have achieved either partial or full Tier 1 access.

Tier 2. Products that have a capacity of more than 50 watts peak, or that are more than 20 watts peak and come packaged with a television, are deemed to provide Tier 2 energy access. This approach is designed to align product specifications or energy service with the requirements for Tier 2 access of the Multi-Tier Framework. Products that have enabled a household to achieve Tier 2 access are not included in the final Tier 1 estimates.

MEASURING ACCESS TO ELECTRICITY PROVIDED THROUGH MINI-GRID SOURCES

IRENA collects off-grid capacity and generation data from a variety of sources. These include IRENA questionnaires; national and international databases; and unofficial sources, such as project reports, news articles, academic studies, and websites. For some countries, IRENA also estimates off-grid solar PV capacity, based on solar panel import statistics obtained from the United Nations' COMTRADE Database.

The agency's 2022 decentralized energy database contains global data on off-grid renewable energy in Africa, Asia, South America, Central America and the Caribbean, and Oceania. Its database covers off-grid renewable power capacity (in megawatts), biogas production (in cubic meters), and energy access (in numbers of inhabitants). This chapter uses energy access data estimated for people with access to hydropower, solar mini grids (Tiers 1 and 2), and biogas.

IRENA publishes off-grid statistics by the end of December each year. Details on the methodology used in this report are set forth in IRENA (2018).

2 The Global Impact Metrics are available online here: https://www.gogla.org/impact/gogla-impact-metrics.

3 Where a product provides partial Tier 1 access a methodology devised by SEforALL can be applied to calculate how several products can be combined to reach Tier 1 equivalency. The methodology was designed to account for "energy stacking" and so to prevent Tier 1 access from being underrepresented in calculations.

Chapter 2. Access to clean fuels and technologies for cooking

DATA SOURCES

The WHO Household Energy Database contains nationally representative household survey data (WHO 2024). Regularly updated, it relies on several sources (table A1.1) and serves as the basis for all modelling efforts in this report. The database contains more than 1,600 surveys conducted in 171 countries (including high-income countries) between 1960 and 2022. A quarter of the surveys cover the years 2013 to 2018; 284 new surveys cover 2016 to 2022. Modeled estimates are provided only if there is underlying survey data on cooking fuels, so there are no estimates for Lebanon, Libya and Bulgaria.

Population data are from the United Nations Urbanization Prospects (2018).

TABLE 2.1 • OVERVIEW OF DATA SOURCES FOR CLEAN FUELS AND TECHNOLOGY

NAME	ENTITY	NUMBER OF COUNTRIES	DISTRIBUTION OF DATA SOURCES (IN PERCENT)	QUESTION
Census	National statistical agencies	109	18.4	What is the main source of cooking fuel in your household?
Demographic and Health Survey (DHS)	Funded by USAID; implemented by ICF International	82	17.2	What type of fuel does your household mainly use for cooking?
Living Standards Measurement Survey (LSMS), income expenditure surveys, and other national surveys	National statistical agencies, supported by the World Bank	26	3.00	Which is the main source of energy for cooking?
Multiple Indicator Cluster Surveys (MICS)	UNICEF	90	10.90	What type of fuel does your household mainly use for cooking?
Study on Global AGEing and Adult Health (SAGE)	WHO	6	0.40	NA
World Health Survey	WHO	50	3.80	NA
National surveys		117	35.80	NA
Other		84	10.30	NA

MODEL

As household surveys are conducted irregularly and reported heterogeneously, the WHO Global Household Energy Model (developed in collaboration with the University of Glasgow) is used to estimate trends in household use of six fuel types:

- unprocessed biomass (e.g., wood)
- charcoal
- coal
- kerosene
- gaseous fuels (e.g., LPG)
- electricity

Trends in the proportion of the population using each fuel type are estimated using a Bayesian hierarchical model, with urban and rural disaggregation, drawing on country survey data. Smooth time functions were the only covariate. Estimates for total polluting fuel use (unprocessed biomass, charcoal, coal, and kerosene) and total clean fuel use (gaseous fuels, electricity, and an aggregation of other clean fuels, such as alcohol) are produced by aggregating estimates of relevant fuel types. Estimates produced by the model automatically respect the constraint that the total fuel use equals 100 percent.

GHEM is implemented using the R programming language and the NIMBLE software package for Bayesian modelling with Markov chain Monte Carlo (MCMC). Summaries can be obtained to provide both point estimates (e.g., means) and measures of uncertainty (e.g., 95 percent credible and 95 percent prediction intervals). The GHEM is applied to the WHO household energy database to produce a comprehensive set of estimates, together with associated measures of uncertainty, of the use of four specific polluting fuels and two specific clean fuels for cooking by country for each year from 1990 to 2019. Further details on the modelling methodology and validation can be found in Stoner and others (2020), and a more detailed analysis of individual fuel use can be found in Stoner and others (2021).

Only surveys with less than 15 percent of the population reporting “missing,” “no cooking,” and “other fuels” were included in the analysis. Surveys were also discarded if the sum of all mutually exclusive categories reported was not within 98–102 percent. Fuel use values were uniformly scaled (divided) by the sum of all mutually exclusive categories, excluding “missing,” “no cooking,” and “other fuels.” Countries classified by the World Bank as high-income (59 countries) in the 2022 fiscal year were assumed to have transitioned to clean household energy. They are, therefore, reported as having 100 percent access to clean fuel and technologies; no fuel-specific estimates were reported for high-income countries. In addition, no estimates were reported for low- and middle-income countries without data suitable for modelling (Bulgaria, Lebanon, and Libya). Modeled fuel-specific estimates were reported for 129 low- and middle-income countries plus 3 countries with no World Bank income classification (Venezuela, Niue, and Cook Islands); estimates of overall clean fuel use were reported for 191 countries.

UNCERTAINTY INTERVALS

Many of the point estimates we provide here are accompanied by 95 percent uncertainty intervals, which imply a 95 percent chance that the true value lies within the given range. Small annual changes in the point estimate may be statistical noise arising from either the modelling process or survey variability and may, therefore, not reflect a real variation in the numbers relying on different fuels between years. The uncertainty intervals should, therefore, be considered when assessing changes in the access rate or in the use of specific fuels between years.

Moreover, for some countries, a lack of recent survey data (e.g., in the last 10 years) naturally leads to very wide uncertainty intervals associated with estimates for 2022 and preceding years. For countries with very wide uncertainty intervals, point estimates should be treated with some caution.

GLOBAL AND REGIONAL AGGREGATIONS

Population data from the United Nations Population Division's World Urbanization Prospects (United Nations 2018) were used to derive the population-weighted regional and global aggregates. Low- and middle-income countries without data were excluded from all aggregate calculations; high-income countries were excluded from aggregate calculation for specific fuels.

The aggregation methods used ensure that uncertainty in the percentage of people and absolute number of people using different fuels for cooking in individual countries propagate into the uncertainty intervals accompanying global and regional estimates.

ANNUALIZED GROWTH RATES

The annualized increase in the access rate is calculated as the difference between the access rate in year 2 and that in year 1, divided by the number of years to annualize the value:

(Access Rate Year 2–Access Rate Year 1) / (Year 2–Year 1)

This approach takes population growth into account by working with the final national access rate.

PROJECTIONS

Projected access rates, access deficits, and fuel use can be estimated using the GHEM, where uncertainty increases the further into the future estimates are calculated, reflecting how country trends may shift based on how unsettled they were during the data period.

Projections in this chapter are hypothetical scenarios in which no new policies or interventions (positive or otherwise) take place. As such, they are useful as baseline scenarios for comparing the effect of interventions. The scenarios are calculated by extrapolating current trends into the future.

Chapter 3. Renewables

DEFINITIONS

Renewable energy sources. Total renewable energy from hydropower (excluding pumped hydro), wind, solar photovoltaic, solar thermal, geothermal, tide/wave/ocean, renewable municipal waste, solid biofuels, liquid biofuels, and biogases.

Renewable energy consumption. Final consumption of direct renewables along with the amount of electricity and heat consumption estimated from renewable energy sources. Ambient heat harnessed by heat pumps is not accounted for in this report, due to limited data availability.

Direct renewables. Bioenergy, and direct uses of solar thermal and geothermal energy.

Total final energy consumption. The sum of the final energy consumption in the transport, industry, and other sectors (equivalent to the total final consumption minus nonenergy use). Total final consumption excludes energy transformed into other forms of energy (e.g., natural gas used to generate electricity), as well as energy used by energy industries.

Traditional uses of biomass. Biomass uses are considered traditional when biomass is consumed in the residential sector in countries outside the Organisation for Economic Co-operation and Development. International Energy Agency statistics divide traditional uses of biomass into primary solid biomass, charcoal and unspecified primary biomass, and waste. The United Nations Statistics Division has a similar classification with a more detailed breakdown on products. Traditional consumption/use of biomass is a “conventional proxy” because it is estimated rather than measured directly, due to limited data availability as regards the use of solid biomass in traditional and inefficient cookstoves.

Modern uses of renewable energy consumption. Total renewable energy consumption minus traditional consumption/ use of biomass.

METHODOLOGY FOR MAIN INDICATOR

The indicator used in this report to track SDG 7.2 is the share of renewable energy in total final energy consumption. Data from the International Energy Agency (IEA) and United Nations Statistics Division (UNSD) energy balances are used to calculate the indicator according to the formula:

$$\%TFEC_{RES} = \frac{TFEC_{RES} + \left(TFEC_{ELE} \times \frac{ELE_{RES}}{ELE_{TOTAL}}\right) + \left(TFEC_{HEAT} \times \frac{HEAT_{RES}}{HEAT_{TOTAL}}\right)}{TFEC_{TOTAL}}$$

The variables are derived from the energy balance flows: TFEC = total final energy consumption as defined in the definitions above, ELE = gross electricity production, HEAT = gross heat production, whereas the subscript RES corresponds to the part coming from renewable energy sources.

The denominator is the TFEC of all energy products (as defined above). The numerator, renewable final energy consumption, is a series of calculations defined as the direct consumption of renewable energy sources plus the final consumption of electricity and heat estimated to have come from renewable sources. To perform the calculation at the final energy level, this estimation allocates the amount of electricity and heat consumption deemed to come from renewable sources based on the share of renewables in gross production.

METHODOLOGY FOR ADDITIONAL METRICS BEYOND THE MAIN INDICATOR

The amount of renewable energy consumption can be divided into three sectors to refer to how the energy is consumed: electricity, heat, and transport. They are calculated from the energy balance and are defined as follows:

Electricity refers to the amounts of electricity consumed by end users. Electricity used in the transport sector is excluded from this aggregation. Electricity used to produce district heat is not included because it is not part of the final consumption, whereas electricity used to produce heat in electric boilers and heaters is included here, as official data at the final energy service level is unavailable to determine it was used as heat.

Heat refers to the amount of energy consumed for heat-raising purposes in industry and other sectors, as well as other uses not included in Electricity and Transport, such as fuels used to pump water. Because official data at the final energy service level are unavailable, heat generated from electricity by final consumers in electric boilers and heaters is not included in this aggregate.

Therefore, the heat category here is not equivalent to the final energy end use service. It is also important to note that in this chapter, in the context of an "end use," heat does not refer to the same quantity as the energy product, "Heat," in the energy balance used in the formula above.

Transport refers to the amounts of energy consumed in the transport sectors. Most of the electricity used in the transport sector is consumed in the rail and road sectors, and, in some cases, pipeline transport. The amount of renewable electricity consumed in the transport sector is estimated as the product of the annual shares of renewable sources in gross national electricity production and the amount of electricity used nationally in the transport sector.

METHODOLOGY FOR INDICATOR SDG 7.B.1

Indicator 7.b.1 measures the installed renewable energy–generating capacity in developed and developing countries (in watts per capita). It is computed by dividing the maximum year-end installed capacity of renewable electricity–generating power plants by the country's midyear population. Data from the International Renewable Energy Agency (IRENA) are used to calculate this indicator.

IRENA's electricity capacity database contains information on installed electricity-generating capacity, measured in megawatts. The data set covers all countries and areas from the year 2000, records whether capacity is on-grid or off-grid, and is divided into 36 renewable energy types, which together constitute the six main sources of renewable electricity. For the population part of this indicator, IRENA uses population data from the United Nations World Population Prospects (UN 2021).

More details on the methodology used in this chapter can be found in the SDG indicators metadata repository (https://unstats.un.org/sdgs/metadata/files/Metadata-07-0b-01.pdf).

Chapter 4. Energy efficiency

Total energy supply (TES) in megajoules (MJ)

This represents the amount of energy available in the national territory during the reference period. It is calculated as follows: Total energy supply = Primary energy production + Import of primary and secondary energy – Export of primary and secondary energy – International (aviation and marine) bunkers – Stock changes. (Definition consistent with International Recommendations for Energy Statistics.)

Data sources: Energy balances from the International Energy Agency (IEA), supplemented by the United Nations Statistics Division (UNSD) for countries not covered by IEA as of 2017.

Gross domestic product (GDP) in 2017 U.S. dollars (USD) at purchasing power parity (PPP)

Sum of gross value-added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. GDP is measured in constant 2017 USD PPP.

Data source: International Monetary Fund's World Economic Outlook database (https://www.imf.org/en/Publications/SPROLLs/world-economic-outlook-databases/), complemented by data from the World Bank's World Development Indicators (https://databank.worldbank.org/source/world-development-indicators) and the CEPII's CHELEM database (http://www.cepii.fr/CEPII/en/bdd_modele/bdd_modele_item.asp?id=17).

Primary energy intensity in MJ/2017 USD PPP

$$Primary\ energy\ intensity = \frac{TES\ (MJ)}{GDP\ (USD\ 2017\ PPP)}$$

Ratio between TES and GDP is measured in MJ per 2017 USD PPP. Energy intensity (EI) indicates how much energy is used to produce one unit of economic output. A lower ratio indicates that less energy is used to produce one unit of economic output.

EI is an imperfect indicator, as changes are affected by other factors other than energy efficiency, particularly changes in the structure of economic activity.

Average annual rate of improvement in energy intensity (%)

Calculated using compound annual growth rate (CAGR):

$$CAGR = \left(\frac{EI_{t2}}{EI_{t1}}\right)^{\frac{1}{(t2-t1)}} - 1\ (\%)$$

Where:

EI_{t2} is energy intensity in year *t1*

EI_{t1} is energy intensity in year *t2*

Negative values represent decreases (or improvements) in energy intensity (less energy is used to produce one unit of economic output or per unit of activity), while positive numbers indicate increases in energy intensity (more energy is used to produce one unit of economic output or per unit of activity).

Total final energy consumption (TFEC) in MJ

Sum of energy consumption by the different end-use sectors, excluding nonenergy uses of fuels. TFEC is broken down into energy demand in the following sectors: industry, transport, residential, services, agriculture, and others. It excludes international marine and aviation bunkers, except at the world level, where it is included in the transport sector.

Data sources: Energy balances from IEA, supplemented by UNSD for countries not covered by IEA as of 2017.

Value added in 2017 USD PPP

Value-added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources. The industrial origin of value-added is determined by the International Standard Industrial Classification, revision 3.

Data source: WDI database.

Industrial energy intensity in MJ/2017 USD PPP

$$Industrial\ energy\ intensity = \frac{Industrial\ TFEC\ (MJ)}{Industrial\ value\ added\ (USD\ 2017\ PPP)}$$

Ratio between industry TFEC and industry value-added, measured in MJ per 2017 USD PPP.

Data sources: Energy balances from IEA and value-added from WDI.

Services energy intensity in MJ/2017 USD PPP

$$Services\ energy\ intensity = \frac{Services\ TFEC\ (MJ)}{Services\ value\ added\ (USD\ 2017\ PPP)}$$

Ratio between services TFEC and services value-added measured in MJ per 2017 USD PPP.

Data sources: Energy balances from IEA and value-added from WDI.

Agriculture energy intensity in MJ/2017 USD PPP

$$Agriculture\ energy\ intensity = \frac{Agriculture\ TFEC\ (MJ)}{Agriculture\ value\ added\ (USD\ 2017\ PPP)}$$

Ratio between agriculture TFEC and agriculture value-added measured in MJ per 2017 USD PPP.

Data sources: Energy balances from IEA and value-added from WDI.

Passenger transport energy intensity in MJ/passenger-kilometer

$$Passenger\ transport\ energy\ intensity = \frac{Passenger\ transport\ TFEC\ (MJ)}{Passenger\text{-}kilometers}$$

Ratio between passenger transport final energy consumption and passenger transport activity measured in MJ per passenger-kilometers.

Data source: IEA Mobility Model.

Freight transport energy intensity in MJ/tonne-km

$$Freight\ transport\ energy\ intensity = \frac{Freight\ transport\ TFEC\ (MJ)}{Tonne\text{-}kilometers}$$

Ratio between freight transport final energy consumption and activity measured in MJ per tonne-kilometer.

Data source: IEA Mobility Model.

Residential energy intensity in MJ/unit of floor area

$$Residential\ energy\ intensity = \frac{Residential\ TFEC\ (MJ)}{Residential\ floor\ area\ (m^2)}$$

Ratio between residential TFEC and square meters of residential building floor area.

Data source: IEA Mobility Model.

Fossil fuel electricity generation efficiency (%)

$$Generation\ efficiency = \frac{Electricity\ output\ from\ coal, oil, and\ natural\ gas}{Coal, oil, and\ natural\ gas\ input}\ (\%)$$

Ratio of the electricity output from fossil fuel–fired (coal, oil, and gas) power generation and the fossil fuel TES input to power generation.

Data source: IEA Energy Balances.

Power transmission and distribution losses (%)

$$Power\ transmission\ and\ distribution\ losses = \frac{Electricity\ losses}{(Electricity\ output\ main + Electricity\ output\ CHP + Electricity\ imports)}\ (\%)$$

Where:
Electricity losses are electricity transmission and distribution losses;
Electricity output main is electricity output from main activity producer electricity plants; and
Electricity output CHP is electricity output from combined heat and power plants.

Data source: IEA Energy Balances.

Chapter 5. International public financial flows to developing countries in support of clean energy

DATA SOURCES

SDG indicator 7.a.1 is a subset of two combined databases used to track international public financial flows—the Creditor Reporting System (CRS) of the Organisation for Economic Co-operation and Development's (OECD's) Development Assistance Committee (DAC) and IRENA's Renewable Energy Public Finance Database. The CRS database includes various financial flows provided by investors to countries for multiple purposes; it is updated quarterly.[4] Only a subset of the commitments in the CRS database is required for this indicator. To obtain that subset, we downloaded bulk data from the CRS from 2000 onward, consolidated the files; removed unused columns, noncommitments, and private donor flows (flow code 30); and filtered the data to include clean energy investments (purpose codes 23210–23290, 23410, 23631).

IRENA's database covers commitments beyond the CRS database, particularly by non-DAC donors that do not report their commitments through the CRS. These flows account for around 40 percent of the financial value of commitments. We categorized each commitment by type of energy, financial instrument, and other metadata that matches the CRS. Reporting occurs a few months before the CRS. After the CRS data were released, we reviewed each commitment across the datasets to remove duplicates from the IRENA data. We compiled both sources and used the combined dataset for SDG 7.a.1.

DEFLATING NOMINAL US DOLLAR PRICES TO CONSTANT PRICES AND EXCHANGE RATES

Commitments are measured in millions of US dollars at constant prices, using an exchange rate for a base year. The base year is updated annually; it usually reflects a three-year lag in the publication cycle and a one-year lag in the latest reporting data (that is, the 2024 cycle will report commitments up to 2022 at 2021 constant prices).

International finance flows expressed in nominal terms are deflated to remove the effects of inflation and exchange rate changes so that all flows, from all donors and in all years, are expressed as the purchasing power of a U.S. dollar in a recent year (2021 in this report). A combination of the OECD deflators for DAC donors and deflators calculated by IRENA for other international donors not included in the CRS database is used.[5] The following formula converts the nominal investment amounts in current US dollars to US dollars at constant prices and exchange rates:

4 The data are available at https://stats.oecd.org/Index.aspx?DataSetCode=crs1.

5 The OECD publishes DAC deflators for each donor. For more information, see https://www.oecd.org/dac/financing-sustainable-development/development-finance-standards/informationnoteonthedacdeflators.htm. IRENA sometimes tracks flows from donors that are not identified in the DAC list and that do not have an allocated DAC deflator. The agency follows the same methodology as the OECD to calculate country-specific DAC deflators.

$$USD_{constant,n,m} = \frac{USD_{current,n}}{DAC\ Deflator_{,n,m}}$$

where n is the current year (nominal) and m the constant year (real).

REGIONAL AGGREGATIONS AND CLASSIFICATIONS

Regional aggregations start with the microdata of commitments. Each commitment is dedicated to either a specific country or an unspecified country or mix of countries. Where commitments could not be categorized under specific countries or territories following the United Nations' M49 classification, they were classified as "residual/unallocated ODA [official development assistance]," followed by the name of the region. Where the region was unclear, the commitment was classified under "unspecified countries." Residual flows to specific regions are aggregated under the geographical region aggregates. Residual flows to unspecified countries are aggregated directly under the totals, rather than under any region. International flows for which no information about the region or country is available are classified as multilateral and excluded from the indicator, as some of this finance may be directed to countries outside the scope of the SDG 7.a.1 indicator.

We continue aggregating financial flows based on the SDG regions and subregions defined by the United Nations and published as the M49 classifications. For other kinds of classifications, we keep a modified list of countries from "developing regions" to determine which countries are to be included in the aggregation and data dissemination. Chapter 7 discusses these classifications.

MEASURING FINANCIAL FLOWS THROUGH COMMITMENTS

Financial flows are recorded as donor commitments. A commitment is defined as a firm obligation, expressed in writing and backed by the necessary funds. Bilateral commitments are recorded as the full number of expected transfers for the year in which commitments are announced, irrespective of the time required for the completion of disbursements, which may occur over weeks, months, or years.

Tracking financial commitments can yield quite different results than approaches that consider financial disbursements. Disbursement information would provide a more accurate picture of actual financial flows for renewable energy each year, but data on disbursements are often limited or not available. Tracking commitments allows for a more comprehensive and granular analysis of financial flows and ensures methodological consistency across data sources. It may, however, produce large annual fluctuations in financial flows when large projects are approved. In addition, financial commitments may not always translate into disbursements, as contracts may be voided, cancelled, or altered. Any changes must be reflected in annual values.

FINANCIAL INSTRUMENTS

The financial instruments used by public financial institutions were categorized based on the OECD list of financial types and the IRENA classifications for concessional loans and credit lines (table A1.2). This taxonomy excludes debt relief mechanisms. Some of these instruments have yet to be used in connection with commitments made in the years covered by this chapter.

TABLE A1.2 • DESCRIPTION OF INSTRUMENTS USED FOR INTERNATIONAL PUBLIC FINANCIAL FLOWS

	FINANCIAL INSTRUMENT	DESCRIPTION
Debt		
	Standard loan	Legal debt obligations assumed by recipient, including transfers in cash or in kind (creditor acknowledges the nontradability of obligations should any claim arise from nonpayment). As payment obligations on a standard loan are senior obligations (loans entitle creditors to receive payments against their claims before anyone else), they are referred to as senior loans. These loans have better lending terms than those provided by private financial institutions, including longer payment terms, lower interest rates, and grant elements. They are not necessarily market-rate loans. Where no concessional information is available, commitments are categorized as loans, not concessional loans.
	Concessional loan	Loans that meet official development assistance criteria of at least a 45 percent grant element for least-developed countries, landlocked developing countries, and small island developing states; 15 percent for lower-middle-income countries; and 10 percent for upper-middle-income countries and multilateral development banks within the Creditor Reporting System database—or when specified as "concessional" by the public donor itself in the International Renewable Energy Agency's Public Investments database. Concessional loans incur external debt from recipients, albeit at a significantly lower interest rate than developed countries could get from commercial banks or private finance institutions.
	Bonds	Fixed-interest debt instruments issued by governments, public utilities, banks, or companies that are tradable in financial markets.
	Asset-backed securities	Securities whose value and income are backed by a pool of underlying assets.
	Reimbursable grants	Contributions provided to a recipient institution for investment purposes with the expectation of long-term reimbursement under conditions specified in the financing agreement. The provider assumes the risk of total or partial failure of the investment; it can also decide when to reclaim its investment.
	Other debt securities	Financial instruments that represent a debt obligation but are neither standard loans, concessional loans, bonds, or asset-backed securities. They can be issued by various entities, including governments, corporations, or financial institutions. Examples include promissory notes, commercial paper, and medium-term notes. These securities typically have varying maturities, interest rates, and risk profiles; they may be traded in secondary markets, providing liquidity to investors. They serve as an alternative means of raising capital or financing projects, offering issuers and investors additional options for diversifying their portfolios and managing risk.
Grants		
	Standard grant	Transfers in cash or in kind that create no legal debt for the recipient.
	Interest subsidy	Payment to soften the terms of private export credits, loans, or credits by the banking sector.
	Capital subscription on deposit basis	Payments to multilateral agencies in the form of notes and similar instruments, unconditionally cashable on sight by the recipient institutions. The deposit basis refers to the accounting of the capital once it is deposited in the multilateral agencies' funds.
	Capital subscription on encashment basis	Payments to multilateral agencies in the form of notes and similar instruments, unconditionally cashable on sight by the recipient institutions. The encashment basis refers to the accounting of the capital once it is accessed (cashed) by the multilateral agencies from its funds.
Mezzanine finance		
	Subordinated loan	A loan that, in the event of default, will be repaid only after all senior obligations have been satisfied. In return for this increased risk, mezzanine debtholders receive a higher return for their investment than secured or more senior lenders.
	Preferred equity	Equity that, in the event of default, will be repaid only after all senior obligations and subordinated loans have been satisfied but before common equity holders are paid. It is a more expensive source of finance than senior debt, but less expensive than equity.
	Other hybrid instruments	Such instruments include convertible debt or equity.

	FINANCIAL INSTRUMENT	DESCRIPTION
Equity		
	Common equity	Share of ownership in a corporation that gives the owner claims on the residual value of the corporation after the corporation meets creditors' claims.
	Shares in collective investment vehicles	Collective undertakings through which investors pool funds for investment in financial or nonfinancial assets. These vehicles issue shares (for corporate structures) or units (for trust structures).
	Reinvested earnings	Reinvested earnings are applicable only to foreign direct investment (FDI). Reinvested earnings on FDI consist of the retained earnings of an FDI enterprise that are treated as if they were distributed and remitted to foreign direct investors in proportion to their ownership of the equity of the enterprise and then reinvested by them in the enterprise.
Guarantees		
	Guarantees/ insurance	Promise of indemnification up to a specified amount in the case of default or nonperformance of an asset (such as a failure to meet loan repayments or to redeem bonds or expropriation of an equity stake). Guarantees typically cover political and commercial risks (credit, regulatory/contractual) that investors are unwilling or unable to bear.
	Credit lines	Arrangements between a bank and a borrower establishing a maximum loan balance that the bank will permit the client to maintain. A credit line guarantees that funds will be available, but no financial assets exist until funds are advanced.

Source: OECD and IRENA.

CHANGES TO THE DATA

Several revisions were made in 2024 to the combined public investments database (OECD and IRENA). Some commitments were cancelled, some were reclassified to different years, and some recipient countries were removed from the dataset. All figures were subsequently updated to reflect 2021 prices and exchange rates (table A1.3).

Table A1.3 • 2024 revisions to public flows, 2000–21

YEAR	BEFORE REVISION (2020 USD MILLIONS)	AFTER REVISION (2021 USD MILLIONS)	DIFFERENCE (2021 USD MILLIONS)
2000	1,469	1,535	66
2001	2,038	1,739	–300
2002	1,381	1,283	–98
2003	3,102	2,878	–225
2004	2,166	1,723	–443
2005	2,218	2,772	553
2006	3,327	3,231	–96
2007	4,349	4,391	42
2008	2,919	4,066	1,148
2009	8,263	4,896	–3,367
2010	11,912	11,334	–578
2011	12,603	12,826	223
2012	10,808	10,085	–723
2013	14,176	13,322	–855
2014	16,626	18,076	1,450

2015	12,588	12,329	–259
2016	21,874	28,454	6,580
2017	26,365	22,840	–3,525
2018	15,752	17,680	1,929
2019	13,987	12,758	–1,229
2020	12,229	12,151	–78
2021	10,775	12,385	1,610
Total	**210,927**	**212,754**	**1,827**

Source: IRENA and OECD 2024.

The difference over the past two decades reflects an additional USD 1.8 billion in commitments, driven by massive upward revisions for 2016 (USD 6.6 billion), 2018 (USD 1.9 billion), 2014 (USD 1.4 billion), and 2008 (USD 1.1 billion). Huge drops in commitments for 2017 (USD 3.5 billion) and 2009 (USD 3.4 billion) reflect commitments from China that did not materialize or for which the commitment year changed.

Chapter 6. Outlook for SDG 7

All investment figures from IEA scenarios are in constant 2021 USD at market exchange rate while from IRENA scenarios in constant 2015 USD at market exchange rate.

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 always ensures the security of fuel and electricity supplies, 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 modeled 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 modeled 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. IRENA's scenarios outlined in this report were 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 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 2022 flagship publication *World Energy Transitions Outlook: 1.5°C Pathway*. The Planned Energy Scenario provides a perspective on energy system developments based on governments' energy plans and other planned targets and policies that were in place as of early 2022. 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. 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 two 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.

WHO PROJECTIONS

Projected access rates, deficits in access, and fuel usage that are presented in Outlook chapter are estimated using the WHO Global Household Energy Model (detailed in the Methodological Notes for Chapter 2). The uncertainty of these estimates grows with projections further into the future, reflecting potential shifts in country trends based on their volatility during the data period.

The projections presented in this chapter are based on a hypothetical Business-as-Usual scenario derived from the current trends that assumes that no new policies or interventions (either positive or negative) occur. Thus, these scenarios serve as useful baselines for evaluating the impact of potential interventions. The scenarios are derived by extrapolating current trends into the future..

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CHAPTER 6 • OUTLOOK FOR SDG 7

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Attribution—Please cite this work as follows: IEA, IRENA, UNSD, World Bank, WHO. 2024. Tracking SDG 7: The Energy Progress Report. World Bank, Washington DC. © World Bank.

The Energy Progress Report is a joint report of the Custodian Agencies: the International Energy Agency (IEA), the International Renewable Energy Agency (IRENA), the United Nations Statistics Division (UNSD), the World Bank, and the World Health Organization (WHO).

It receives inputs from the SDG 7 Technical Advisory Group, which comprises more than 30 organizations around the world. The report has been made possible by the support of our partners.

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