TRACKING SDG7

THE ENERGY PROGRESS REPORT 2025

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

Report designed by Duina Reyes

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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

ADB	Asian Development Bank
AfDB	African Development Bank
CAGR	compound annual growth rate
CO2	carbon dioxide
COP28	2023 United Nations Climate Change Conference
DRE	decentralized renewable energy
EBRD	European Bank for Reconstruction and Development
EEO	energy efficiency obligation
EJ	exajoule
EMDEs	emerging markets and developing economies
ESMAP	Energy Sector Management Assistance Program
EV	electric vehicle
FCV	fragility, conflict, and violence
GDP	gross domestic product
GEP	Global Electrification Platform
GtCO2	gigatons of carbon dioxide
GW	gigawatt
IBRD	International Bank for Reconstruction and Development
IDA	International Development Association
IEA	International Energy Agency
IFC	International Finance Corporation
IRENA	International Renewable Energy Agency
LDC	least-developed country
LLDC	landlocked developing country
LMIC	low- and middle-income country
LPG	liquefied petroleum gas
MDB	multilateral development bank
MEPS	minimum energy performance standards
MJ	megajoule

MTF	Multi-Tier Framework
MWh	megawatt-hour
OECD	Organisation for Economic Co-operation and Development
OGS	off-grid solar
PAYG	pay-as-you-go
PPP	purchasing power parity
PV	photovoltaic
SDG	Sustainable Development Goal
SIDS	small island developing states
TFEC	total final energy consumption
TW	terawatt
UNSD	United Nations Statistics Division
USD	United States dollar
W	watt
WHO	World Health Organization

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Partnership

Tracking SDG 7: The Energy Progress Report is a product of close collaboration among the five SDG 7 custodian agencies operating through a specially constituted Steering Group. The agencies are:

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

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- 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)
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- The chapter on indicators and data was jointly prepared by the custodian agencies under the coordination of IRENA (Mirjam Reiner).

Data sources

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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 aim of SDG 7 is to "ensure access to affordable, reliable, sustainable, and modern energy for all." This report therefore summarizes global progress on electricity access, clean cooking, renewable energy, energy efficiency, 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.

The report is produced annually by 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 five custodian agencies responsible for tracking progress toward SDG 7. Figure ES.1 offers a snapshot of the primary indicators for 2025.

Progress toward 2030 targets remains off track, particularly in Sub-Saharan Africa, owing in part to the COVID-19 pandemic and 2022 energy crisis. Nonetheless, globally, policy progress and technological advances have shown some promising results, notably in boosting renewable energy deployment and achieving modest (though still insufficient) improvements in energy efficiency. Elements of the SDG 7 agenda gained new momentum through various agreements in recent years, including the consensus reached at the 2023 United Nations Climate Change Conference (COP28) to triple global renewable power capacity and double the global average annual rate of improvement in energy efficiency by 2030, and through the 2025 Dar es Salaam Declaration to expand electricity access, a declaration endorsed by 48 African countries.

Scaling up clean cooking and electricity access, boosting renewable energy use, and improving energy efficiency are essential for the achievement of the goals of SDG 7—and for meeting the development and socioeconomic environmental and socioeconomic challenges reflected in the SDG agenda as a whole. These goals will demand a fundamental shift in energy production, distribution, and consumption, supported by greater investment, enabling policies, continued innovation, enhanced ambition and long-term planning. Addressing uneven progress and regional disparities requires collaboration among governments, the private sector, international organizations, and civil society, including on ensuring access to adequate financing and technical assistance. To foster inclusive transitions, particular attention is required to help women and marginalized communities benefit from the energy transition. Empowering people—especially young people—with the skills and knowledge to engage in the energy sector fosters a forward-looking mindset that is crucial for long-term progress.

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	**958 million** people without access to electricity	**666 million** people without access to electricity (2023)
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 (2023)
7.2.1 Renewable energy share in total final energy consumption	**15.6%** share of total final energy consumption from renewables	**17.9%** share of total final energy consumption from renewables (2022)
7.3.1 Energy intensity measured as a ratio of primary energy and GDP	**4.26 MJ/USD** primary energy intensity	**3.87 MJ/USD** primary energy intensity (2022)
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	**12.1 USD billion** international financial flows to developing countries in support of clean energy	**21.6 USD billion** international financial flows to developing countries in support of clean energy (2023)
7.b.1 Installed renewable energy-generating capacity in developing and developed countries	**248 watts per capita** installed renewables capacity	**478 watts per capita** installed renewables capacity (2023)

SDG 7.1.1 • ACCESS TO ELECTRICITY

Almost 92 percent of the world's population now has access to electricity, in contrast to 87 percent in 2010. In 2023, increases in the number of people with access to electricity outpaced population growth, raising the rate of global access to 92 percent and reducing the number of people without electricity to 666 million—19 million fewer than the previous year. While this marks a positive trend, the growth rate needs to accelerate sharply to reach universal access by 2030. The population remaining unconnected is likely to live in remote areas, have lower incomes, and face greater conflict and violence than populations connected to date. Thus, renewed commitment and focus are needed to close the gap and reach universal electricity access.

The greatest growth in access between 2020 and 2023 occurred in Central and Southern Asia, while the pace of progress in Sub-Saharan Africa calls for significant acceleration. Central and Southern Asia have both made significant strides toward universal access, reducing their access gap from 414 million in 2010 to just 27 million in 2023. In Sub-Saharan Africa, 35 million people gained access to electricity in 2023, but population growth over the same period was 30 million, so the net electricity access gap for the region fell by just 5 million (from 570 million in 2022 to 565 million in 2023). The region now accounts for 85 percent of the global population without electricity, up from 50 percent in 2010. Of the countries with the largest access deficits (according to 2023 data), 18 of the top 20 were in Sub-Saharan Africa. As in the previous year, the deficits in Nigeria (86.6 million), the Democratic Republic of Congo (79.6 million), and Ethiopia (56.4 million) alone accounted for more than one-third of the world's population without electricity. Thus new efforts must focus on Sub-Saharan Africa, and especially on the countries with the greatest access gaps.

The urban-rural divide continues to shrink. Rural areas continued to bear the brunt of the electricity access challenge, with 84 percent of those lacking electricity in 2023 living in rural communities. While overall progress in rural electrification outpaced that in urban areas, it was driven largely by advancements in Central and Southern Asia, where the number of people without access in rural areas dropped from 383 million in 2010 to just 24.8 million in 2023. In Sub-Saharan Africa, meanwhile, rural population growth outpaced electrification efforts, leaving 451.1 million people in rural areas without electricity in 2023.

Mini-grid and stand-alone off-grid solar solutions continue to be key to expanding electricity access owing to their ease of deployment and their ability to meet lower and more dispersed loads cost effectively. While electrification programs have traditionally focused on extending the national grid, recent experience in high-deficit countries in Sub-Saharan Africa shows that grid-extension costs are prohibitive for areas with dispersed or remote populations—and grid supply is often unreliable. Decentralized energy solutions provided 55 percent of the new connections in Sub-Saharan Africa between 2020 and 2022, proving resilient to macroeconomic challenges, as more than 50 million off-grid solar products were sold in both 2022 and 2023. Decentralized energy solutions can usually be deployed faster than grid extension at a lower cost per connection, offering the option to attract both private and public sector finance. Mini-grids are reliable and can support a wide variety of productive uses.

To realize the full potential of off-grid products to deliver reliable, affordable, and sustainable electrification solutions, more granular data, tailored funding mechanisms, and technical expertise will be needed. Improving data quality, frequent monitoring of progress, and a willingness to revisit priorities are crucial to successful implementation of decentralized renewable energy. Addressing regulatory obstacles and bureaucratic bottlenecks and complementing traditional financing with innovative approaches (such as blended financing or monetization of environmental benefits) remain priorities. Greater use of off-grid products can also strengthen women and girl's equitable economic participation in the energy workforce by making electricity more affordable for female-headed households.

SDG 7.1.2 • ACCESS TO CLEAN FUELS AND TECHNOLOGIES FOR COOKING

Although some progress has been made over the past two decades, the world is still not on track to achieve universal access by 2030 to clean cooking fuels and technologies (such as stoves powered by electricity, liquefied petroleum gas, natural gas, biogas, or ethanol). In 2023, as in 2022, 74 percent of the world's population had access, up from 64 percent in 2015. Still, roughly a quarter of the world's population—around 2.1 billion people—remains dependent on polluting fuels and technologies (charcoal, coal, crop waste, dung, kerosene, and wood) for cooking. If current trends continue, only 78 percent of the global population will have access to clean cooking by 2030. This shortfall would leave nearly 1.8 billion people without clean cooking fuels and solutions.

By region, access deficits have been shrinking in Eastern Asia and South-eastern Asia, as well as in Central Asia and Southern Asia—thanks largely to policy measures and rising incomes. However, in Sub-Saharan Africa, the number of people lacking access continues to grow at a rate of 14 million people yearly, with gains in access outpaced by rapid population growth. Moreover, in 2023, the proportion of the population that had access to clean cooking fuels and technologies was 60 percent in small island developing states (SIDS), only 28 percent in landlocked developing countries (LLDCs), and a mere 21 percent in least-developed countries (LDCs)—figures that lag significantly behind the global average. Of the 20 countries with the highest access deficits, eight (all of them LDCs) house large numbers of displaced populations. In the same eight countries, fewer than 10 percent of households use clean fuels, reflecting severe infrastructure gaps that exacerbate socioeconomic effects and heighten the vulnerabilities of these populations.

Sub-Saharan Africa continues to show a notably wider gap between urban and rural access, with 42 percent of the urban population having access compared with just 7 percent in rural areas. Globally, urban access averages around 89 percent, while rural access is around 55 percent. The lower access levels in Sub-Saharan Africa influence the global averages considerably. If Sub-Saharan Africa is excluded, the global access rate would be 94.5 percent in urban areas and 67.3 percent in rural areas.

In 2023, the dominant cooking fuels in low- and middle-income countries were gaseous fuels (liquefied petroleum gas, natural gas, and biogas) and electricity. In rural and peri-urban areas, solid biomass, such as wood, dung, and agricultural residues remain common fuels. The lack of access to clean cooking affects the poor and vulnerable disproportionately, placing a particularly heavy burden on women and children, exposing them to household air pollution and limiting their educational and economic opportunities because of the substantial amount of time they spend on cooking and gathering fuel.

At the current pace, the vast majority of low- and middle-income countries are likely to miss the 2030 universal access target unless efforts are strengthened. Although global progress over the past decade has been considerable—lifting tens of millions of people annually out of reliance on polluting fuels—in smaller, less-developed countries (including LDCs, LLDCs, and SIDS) the adoption of clean cooking has stagnated.

With just five years left to achieve universal access to clean cooking under SDG 7, urgent action is needed. Governments and stakeholders across sectors need to scale up investments, prioritize vulnerable populations, and integrate clean cooking into broader energy access efforts to ensure a just and inclusive transition for the sake of health, equity, and climate protection. Moreover, it is worth noting that while clean cooking has become a major focus of energy transition in many countries, transitioning to cleaner energy for household heating and lighting also contributes to better health and climate outcomes.

SDG 7.2 & 7.b.1 • RENEWABLE ENERGY

In 2022, the global share of renewable energy sources in total final energy consumption (TFEC)—a main indicator of progress—stood at 17.9 percent, having gradually increased by over three percentage points in the preceding 15 years. TFEC continued to rise despite the disruption caused by the pandemic and the ensuing energy crisis. While no quantitative milestone has yet been set for target 7.2 to significantly increase the share of renewable energy in the energy mix, current trends indicate that progress has not been sufficient to accomplish international climate and development objectives, including the pledge to triple global renewables-based power capacity by 2030.

To keep global climate targets within reach, the deployment of renewable energy must accelerate across the key categories of electricity, heat, and transport. Renewables-based electricity use rose by almost 8 percent from 2021 to 2022, and it has risen by 56 percent from 2015. As of 2022, renewables made up almost 30 percent of global electricity consumption. Continuous new capacity additions—mainly in wind and solar photovoltaics (PV)—more than tripled wind and solar PV generation in 2022 over 2015. (During the same period, hydropower remained predominant, meeting 15 percent of global electricity demand.)

Progress across regions and countries varies widely depending on resource availability, policy support, consumption patterns, access to adequate financing, and energy efficiency performance. The share of modern uses of renewable energy is the largest in Latin America and the Caribbean, at 28 percent of TFEC in 2022, due to use of bioenergy for industrial processes, biofuels for transport, and hydropower generation. While renewable energy constitutes around two-thirds of TFEC in Sub-Saharan Africa, modern uses of renewables—excluding traditional uses of biomass—represent only 12 percent of TFEC in the region.

The share of renewable sources in energy consumption varies widely at the national level. Only 11 countries among the top 20 energy-consuming countries recorded a higher TFEC in 2022 than in 2021. The Republic of Korea led the field in growing the modern use of renewables (+16 percent), followed by Türkiye (+15 percent). Brazil and Canada continued to lead in the share of modern uses of renewables (45 and 24 percent of TFEC, respectively). And between 2010 and 2022, the United Kingdom, Germany, and China achieved the largest increases in the share of modern uses of renewables in TFEC (+10, +8, and +8 percentage points, respectively).

In 2022, renewable sources accounted for around 21 percent of the world's use of energy for heat, while their share in transport-related TFEC rose to 3.9 percent, up from 3 percent in 2015. Global final energy consumption for transport increased 4 percent (+5 EJ) in 2022. The number of electric vehicles on the road swelled from 11.3 million in 2020 and 16.5 million in 2021 to more than 26.3 million in 2022. Including the charging of those vehicles, the renewable share of total electricity used in transport climbed from 20 percent in 2010 to 29.6 percent in 2022.

Installed renewable energy capacity reached an all-time high of 478 watts per capita in 2023, but greater efforts are needed on target 7.b: expanding infrastructure and upgrading technology to supply modern and sustainable energy services for all in developing countries. Continuing the theme of disparities, developed countries (at 1,162 watts per capita) have 3.4 times more renewable power per capita than developing countries (341 watts per capita). Sub-Saharan Africa remains critically behind at only 40 watts per capita, a level that only allows for basic energy services such as lighting or phone charging. Although LDCs (40 watts per capita), LLDCs (105 watts per capita), and SIDSs (110 watts per capita) have made gradual progress in expanding renewable capacity, deployment remains well below developing country and global levels.

Sustained action is needed to drive the uptake of renewable energy solutions. Assessments by IEA and IRENA indicate that current ambitions fall short of achieving the COP28 goal to triple global renewable power capacity by 2030. The gap risks slowing the penetration of renewables and electrification in end-use sectors—such as industry, transport, and buildings—which is critical for raising the share of renewables in TFEC. Accelerated electrification and renewable energy deployment are essential to align with the COP28 target and advance the broader energy transition outcomes envisioned at COP28.International efforts must intensify to address the uneven deployment of renewable energy, specifically supporting countries that are at risk of being left behind. However, tripling renewable capacity on its own does not ensure that deployment of renewables will be equitable, even where renewables can help close the energy access gap, support community development and productive uses, and foster sustainable industrialization. Tailored action spanning a wide range of policy interventions—including in access to adequate financing, technology and knowledge exchange, and capacity building—is needed to enable equitable energy access and the ability to escape the cycles of poverty and exploitation that stifle economic development.

SDG 7.3 • ENERGY EFFICIENCY

SDG 7.3 calls for the rate of global improvement in energy intensity to double by 2030, relative to the 1990–2010 average. Sluggish global progress in recent years means that, going forward, energy intensity will have to improve by 4 percent per year on average in order to meet the original SDG 7.3 target. This is roughly consistent with the goal of doubling the global average annual rate of energy efficiency improvement by 2030 agreed on at COP28. The global trend shows that primary energy intensity, defined as the ratio of total energy supply to gross domestic product (GDP), declined by 2.1 percent in 2022—a substantial improvement over the 0.5 percent witnessed in 2021.

The global energy crisis in 2022 was a severe shock to energy markets across the world. In every major region, energy supply grew more slowly than GDP; with total energy supply decreasing by around 5 percent in Europe. As economic growth outpaced energy demand, energy intensity improved in all major regions in 2022, albeit at different speeds. It fell by more than 4 percent in Northern America and Europe and by almost 6 percent in Oceania. The slowest progress, under 1 percent, came in Eastern and South-eastern Asia. Energy intensity in other major regions improved at rates similar to the global average of around 2 percent.

From 2010 to 2022, energy intensity accelerated (relative to 1990–2010) in 15 of the 20 countries with the largest total energy supply. These countries are central to achieving SDG target 7.3, since they represent 75 percent of the world's energy use—and GDP. In this period, the annual rate of improvement in energy intensity more than doubled in Australia, France, Italy, Japan, the Republic of Korea, Mexico, Saudi Arabia, Thailand, and Türkiye. But the 2.6 percent improvement rate required to meet SDG target 7.3 was exceeded only by China, France, Germany, and the United Kingdom.

Progress in energy intensity across end-use sectors improved in 2010 and 2022 over the previous decade. The average improvement rate for buildings rose from 1.2 percent per year in 2000–10 to 1.3 percent per year in 2010–22, and for industry from 0 to 1.4 percent per year. For passenger vehicles the annual improvement rate rose from 0.7 percent in 2000–10 to 1.6 percent in 2010–22, while heavy-duty trucks saw a smaller change, from 0.4 to 0.5 percent in the same period.

Shifts to more efficient and renewable sources for the generation of electricity, coupled with the electrification of end uses, are contributing to improvements in energy intensity. Between 1990 and 2010, the efficiency of generation went from about 40 to 42 percent. The pace quickened to about 46 percent between 2010 and 2022, meaning that efficiency of generation improved twice as fast in nearly half the time—largely due to the integration of renewable energy.

SDG 7.a.1 • INTERNATIONAL PUBLIC FINANCIAL FLOWS TO DEVELOPING COUNTRIES IN SUPPORT OF CLEAN ENERGY

Financial flows to developing countries to support clean energy research and development and renewable energy production reached USD 21.6 billion in 2023—a 29 percent increase from 2022. While there is no quantitative target for international public financial flows under indicator 7.a.1, developing countries received lower flows in 2023 than in 2016, when international flows peaked at USD 28.4 billion. Nevertheless, the tri-year growth during 2021–23 is a positive sign, especially as it occurred amid crises (economic, health-related, and geopolitical) that prompted donors to redirect funds to other priorities, such as humanitarian aid and health. Most of the growth occurred in major developing economies, as opposed to least-developed countries (LDCs), landlocked developing countries (LLDCs), and small island developing states (SIDS). LDCs' share of overall flows dropped by 0.5 percentage points, for example, as growth in non-LDC economies outpaced that of LDCs. Accelerating the growth trajectory while expanding finance to those furthest behind will be key to driving progress toward SDG 7.

Only two world regions have seen real progress in international public flows, compared with their historic peak in 2016. Central Asia and Southern Asia attracted record-high flows of USD 5.6 billion, a more than 2.5-fold increase between 2022 and 2023. Developing countries in Northern America and Europe also reached a record high, surpassing USD 1 billion for the first time since 2000. While Sub- Saharan Africa, Western Asia and Northern Africa, and Eastern Asia and South-eastern Asia saw a substantial increase between 2022 and 2023, the flows remained well below their peak levels. Flows to Latin America and the Caribbean and to Oceania dropped to USD 3.47 billion and USD 64 million, respectively.

Country commitments remain heavily concentrated, although they are gradually diversifying. The top five country recipients of international public flows in 2023 were India (almost USD 3 billion), Türkiye (USD 1.4 billion), Uzbekistan (USD 1.2 billion), South Africa (USD 935 million), and Nigeria (USD 829 million). The number of countries and territories accounting for 80 percent of flows grew from 19 in 2021 to 25 in 2022 and then to 29 in 2023. Forty-three LDCs received flows during 2023, though 81 percent of those flows went to just 9 countries. Flows to LLDCs increased by almost 33 percent to reach USD 3.62 billion in 2023. Flows to SIDS increased by 31.5 percent, reaching USD 401 million in 2023 (Although SIDS have historically received the smallest amounts of investment in absolute terms, they are among the highest recipients on a per capita basis.)

Since 2010, international public financial flows for clean energy have remained largely debt based. Debt-based instruments drove most of the increase in international public flows in 2023, with their share expanding from 70 percent to 83 percent between 2022 and 2023. Grants account for 9.8 percent of flows, having declined by 39 percent. Equity financing accounts for 3.7 percent of flows; guarantees for 3 percent. Although this capital structure is unlikely to change in the future, there have been calls over the past few years to move away from profit-driven debt-based financing to more grants and concessional debt. This is especially relevant as major central banks raised interest rates to their peak levels by 2023, pushing the cost of new and existing debt to record highs.

Solar energy drove most of the growth in 2023, as flows increased by 84 percent to reach USD 9.44 billion, accounting for 44 percent of the total in 2023—solar's highest ever share in a single year. A substantial portion of commitments went to isolated grids and stand-alone systems. Flows to wind and hydropower energy projects remained below their peaks but increased by 41 percent and 61 percent to reach USD 2.4 billion and USD 2.3 billion respectively, collectively making up 22 percent of the total. The remaining 34 percent of flows funded projects involving electrification, energy efficiency, expansion of grid transmission and distribution, or multiple renewables.

Lack of sufficient and affordable financing remains one of the key reasons for the slow, uneven progress in achieving SDG 7. A suite of actions is needed to scale up investments while ensuring their equitable distribution. Necessary actions include reforming multilateral and bilateral lending to expand the availability of public capital; mobilizing more concessional finance, grants, and risk mitigation instruments; improving risk tolerance among donors; and enacting appropriate national policy frameworks, regulations, and reforms through integrated and rigorous planning. The exact mix of these actions must be tailored to suit the context in which they are applied.

THE OUTLOOK FOR SDG 7

Access to electricity. Since 2010, the world has reduced the number of people without access to electricity by 665 million, and 21 countries have reached at least near universal access. However, IEA projects that 645 million will still lack access in 2030, even though a fifth of the countries that still lack universal access are on track to reach near universal access by 2030 under today's policies. Achieving universal access will require a renewed focus on Sub-Saharan Africa, where 85 percent of the population lacking access resides. The push will require strong buy-in and commitment from African countries in order to attract the substantial investment and policy support that will be needed. Stronger efforts and enhanced cooperation are well underway and should help to narrow the gap in coming years.

Access to clean cooking. Since 2010, the number of people with no access to clean cooking has dropped by 900 million, predominantly through the use of liquified petroleum gas (LPG). Estimates from IEA and WHO project a continued decline in the use of polluting fuels and an increase in the use of cleaner fuels (predominantly liquefied petroleum gas) and electricity for cooking. Yet universal access by 2030 remains out of reach under current policies and investments. The same estimates show that 1.8 billion people will still lack access to clean cooking by the end of the decade, with around 58 percent of them in Sub-Saharan Africa, 36 percent in Asia, and the 4 percent in Latin America and the Caribbean. Heading to 2030, improvements will continue to be marked by strong regional disparities. Achieving universal clean cooking access would require strong policy commitment and investments of USD 10 billion annually through 2030.

Renewable energy. Renewable energy is the fastest-growing energy source today. Under today's policies, global projections show renewables set to surpass coal as the predominant source for electricity in 2025. To meet the pledge to triple renewables made at COP28, the world would need to reach at least 11,000 gigawatts of global installed renewable power capacity by 2030. This roughly translates to uses of sustainable renewables (notably off-grid solar) reaching an expected 32–35 percent share in TFEC by 2030 based on IEA and IRENA scenarios. Under current plans and policies the world is expected to make significant progress, though a gap of between 3.8 and 4.2 terawatts will remain in 2030.

Energy efficiency. The focus on improving energy efficiency has gained important political momentum, driven by rising security concerns, recent energy price spikes, and the increased ambitions expressed in the doubling target agreed at COP28. Early estimates for 2024 show a modest annual energy intensity improvement rate of 1 percent, around half the pace of progress achieved over 2010–19. Achieving the COP28 target of doubling global energy intensity by 2030 will require robust policy action and a significant increase in investment. The rate of improvement will have to be just over 4 percent to achieve the target, double the projected rate under today's policies to 2030.

Financing and investment needs. Achieving the SDG 7 targets demands a substantial increase in clean energy investments. IEA and IRENA estimate that average annual investments related to the energy transition will have to be in the range of USD 4.2–4.5 trillion by 2030. Addressing the investment gap, particularly in developing economies, and tackling the high cost of capital, will be critical.

CHAPTER 1
ACCESS TO ELECTRICITY

Photo: © Me 3645 Studio / Moment / Getty Images

Main messages

- **Global trend.** Progress toward the goal of improving access to electricity has recovered from its 2022 slump. In 2023, new connections outpaced population growth, raising global access to 92 percent and reducing the number of people without electricity to 666 million—19 million fewer than in the previous year. While this marks a return to a positive trend, the growth rate remains far short of what is needed to reach universal access by 2030. The remaining unconnected population is more likely to live in remote areas, have lower incomes, and face challenges of fragility, conflict, and violence (FCV), than those connected to date. This population would be best served through a combination of grid, mini-grid, and off-grid solutions.
- **Regional highlights.** Central and Southern Asia have made significant strides toward universal access, narrowing their electricity access gap from 414 million in 2010 to just 27 million in 2023. However, closing the gap in Sub-Saharan Africa has been more challenging. While 35 million new people in Sub-Saharan Africa gained access to electricity in 2023, the gap shrank by only 5 million net of population growth—from 570 million in 2022 to 565 million in 2023. As a result, Sub-Saharan Africa now accounts for 85 percent of the global population without electricity—up from 50 percent in 2010. Thus, to reach the target of universal access to electricity, electrification rates in Sub-Saharan Africa must accelerate dramatically.
- **Top 20 access-deficit countries.** Eighteen of the 20 countries with the largest electricity access deficits in 2023 were in Sub-Saharan Africa. As in the previous year, the deficits in Nigeria (86.6 million), the Democratic Republic of Congo (79.6 million), and Ethiopia (56.4 million) accounted for more than one-third of the globe's population without electricity. To advance progress toward Sustainable Development Goal (SDG) 7.1.1, targeted efforts are required to accelerate access in countries with the largest deficits. Responding to this need, the Mission 300 initiative led by the World Bank and African Development Bank (AfDB) seeks to accelerate electrification efforts in Sub-Saharan Africa and targets aims to facilitate access to 300 million people by 2030—more than half the estimated 2023 electricity deficit. Mission 300 will spur other initiatives in the region and targets raising over USD 90 billion in funding to reach its electrification targets.
- **The urban-rural divide.** The electricity access challenge is greatest in rural areas, where 84 percent of the world's people without electricity live. While overall progress in rural electrification was greater than that in urban areas, the gain was largely driven by advancements in Central and Southern Asia, where the number of rural people without access was cut from 383 million in 2010 to just under 25 million in 2023. By contrast, in Sub-Saharan Africa, rural population growth outstripped electrification efforts, leaving 451 million people in rural areas without electricity in 2023. To close the access gap in the most inclusive manner, a better understanding of end consumers will be required: their needs, demographics, affordability thresholds, and decision-making criteria. To gain that understanding, governments must emphasize quality data collection and capacity building at the level of national statistical organizations and other agencies. Definitions of access should also be harmonized within countries and across regions.

- **Decentralized renewable energy (DRE).** Expanding access through grid expansion is complicated by the fact that populations without electricity tend to live in remote locations (many of which are beset by conflict) and to consume only small amounts of energy. Advances in DRE technologies and business models offer good options for reaching these market segments, enabling cash-strapped governments to engage the private sector, development partners, and consumer finance experts in efforts to design cost-effective DRE-based solutions such as those that benefited an estimated 561 million people worldwide in 2023, as well as more than half of the new connections in Sub-Saharan Africa between 2020 to 2022 (ESMAP 2024). The DRE sector has proven resilient to macroeconomic challenges, with more than 50 million off-grid solar products being sold in both 2022 and 2023. (This includes products sold to households for use as a primary electricity source, as well as products intended for use as an additional source, complementing an intermittent grid connection.) Looking ahead to 2030, off-grid solar is the most cost-effective solution for 41 percent of people without access to electricity. An especially promising path forward is to combine household electricity access with technologies (e.g., solar water pumps, cold storage) that enable micro, small, and medium enterprises to generate income from the electricity available to them. Thus, the USD 1.2 billion invested in the off-grid solar sector in 2022–23, largely through debt financing (ESMAP 2024), must sharply increase to meet the SDG 7 goal of universal access by 2030.
- **Building on the gender-energy nexus.** Challenges persist in addressing the interlinkages between electricity access and gender. World Bank data shows that households headed by women in Africa and South Asia are less likely to enjoy off-grid access than in other regions, with affordability being a key barrier. Women also remain underrepresented across the energy sector. Better access will allow women to increase their incomes, thereby facilitating their economic empowerment. Wider access will also make it easier to gather vital information on women's health, education, and well-being. These issues are explored in box 1.3, which closes the chapter.

Are we on track?

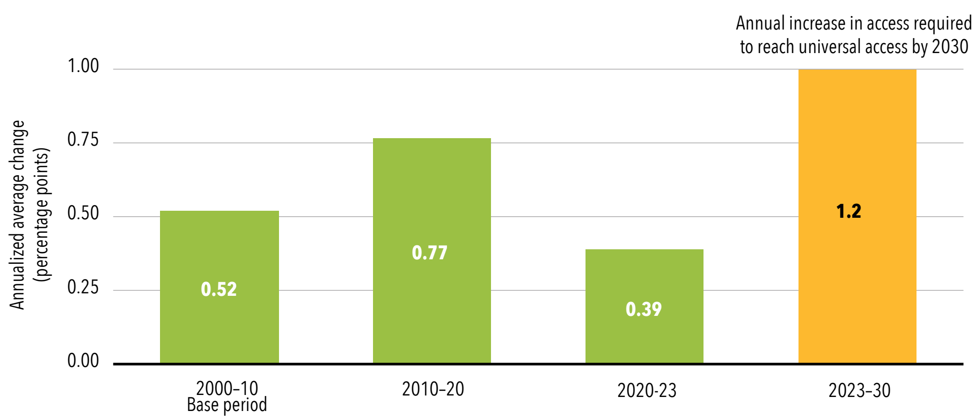
In 2023, just under 92 percent of the global population had access to electricity (figure 1.1), leaving 666 million people without access. In 2023, 565 million without access were in Sub-Saharan Africa, where access rates must accelerate, particularly for low-income households in remote areas, if targets are to be met. Following current trends, 645 million people will still lack electricity in 2030. Responding to this need, the Mission 300 initiative led by the World Bank and African Development Bank (AfDB) will tackle these challenges head-on, facilitating access to 300 million people in the region over the next five years. However, the path to achieving universal access by 2030 will be difficult unless other partners step in with ambitious initiatives to close the gap.

FIGURE 1.1 • PERCENTAGE OF POPULATION WITH ACCESS TO ELECTRICITY

Source: World Bank 2025.

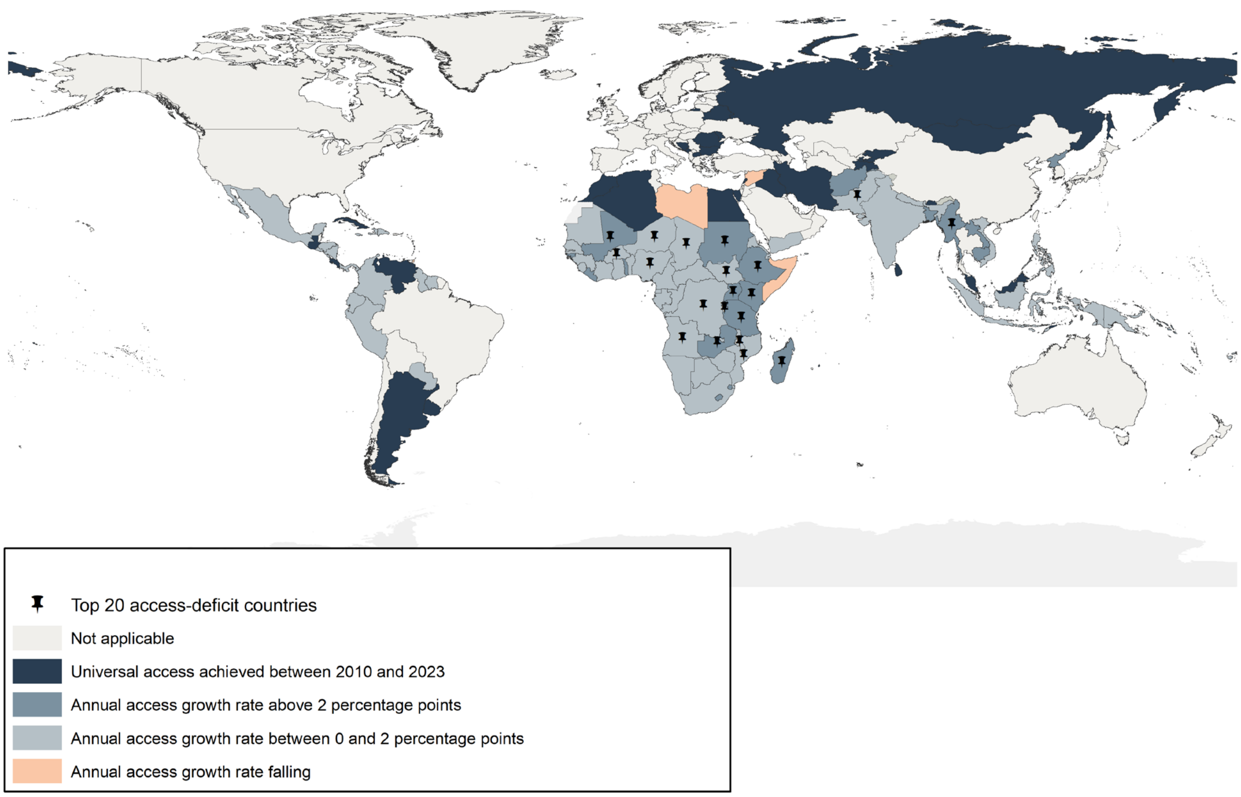
Significant progress was made between 2010 and 2020, when access to electricity grew by an average of 0.77 percentage point per year (figure 1.2). However, growth slowed to an average of 0.39 percentage point between 2020 and 2023, putting increased pressure on future efforts to achieve SDG 7. Achieving universal access by 2030 will now require an annual increase of 1.2 percent—a doubling of the recent pace of progress, even as the remaining unconnected population becomes harder to reach and increasingly unable to afford electricity (figure 1.3).

FIGURE 1.2 • AVERAGE ANNUAL INCREASE IN ACCESS TO ELECTRICITY, 2000–23



Source: World Bank 2025.

FIGURE 1.3 • ANNUAL CHANGE IN ELECTRICITY ACCESS RATES IN ACCESS-DEFICIT COUNTRIES, 2010–23



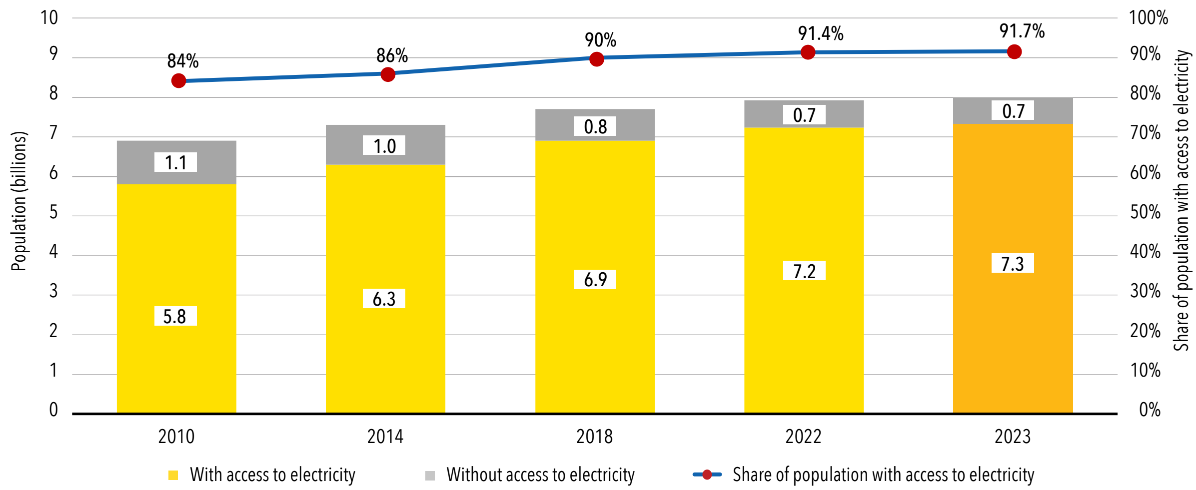
Source: World Bank 2025.

Looking beyond the main indicators

Access deficits and population growth

Global electricity access rose from 84 percent in 2010 to 91.7 percent in 2023 (figure 1.4), despite the setback suffered in 2022. Post-COVID supply chain disruptions eased in 2023, but high inflation, coupled with currency devaluation in many countries, made electricity less affordable for many consumers while straining the finances of private companies, utilities, and governments (ESMAP 2024). The result has been a slowing of progress over the past five years. Expanding access in remote, low-income areas (where grid expansion is typically not the least-cost option) will require a strong focus on decentralized solutions, such as off-grid and mini-grid systems.

FIGURE 1.4 • GAINS IN GLOBAL ELECTRICITY ACCESS AND POPULATION GROWTH, 2010–23

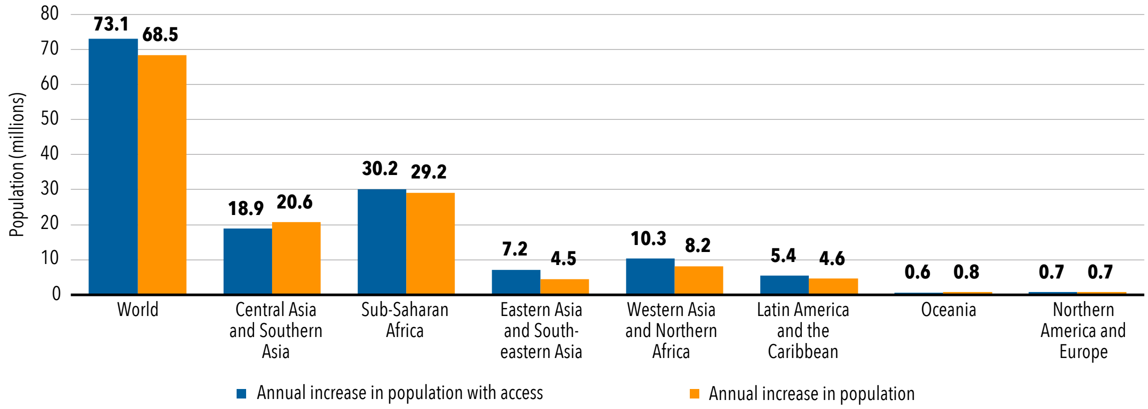


Source: World Bank 2025.

In absolute numbers, access to electricity is increasing globally (figure 1.5), with 73.1 million people gaining access annually between 2021 and 2023, slightly outpacing annual population growth (68.5 million) during the period. However, regional disparities persist. Eastern Asia, Western Asia, and Latin America have progressed steadily. Central and Southern Asia, which accounted for 36 percent of the global access deficit in 2010, made remarkable progress, reducing the region's share to just 4 percent by 2023. Meanwhile economic progress in South Asia has raised income levels, driving higher consumer demand for electricity and allowing governments to scale up grid expansion and integrated electricity markets (Chen 2022).

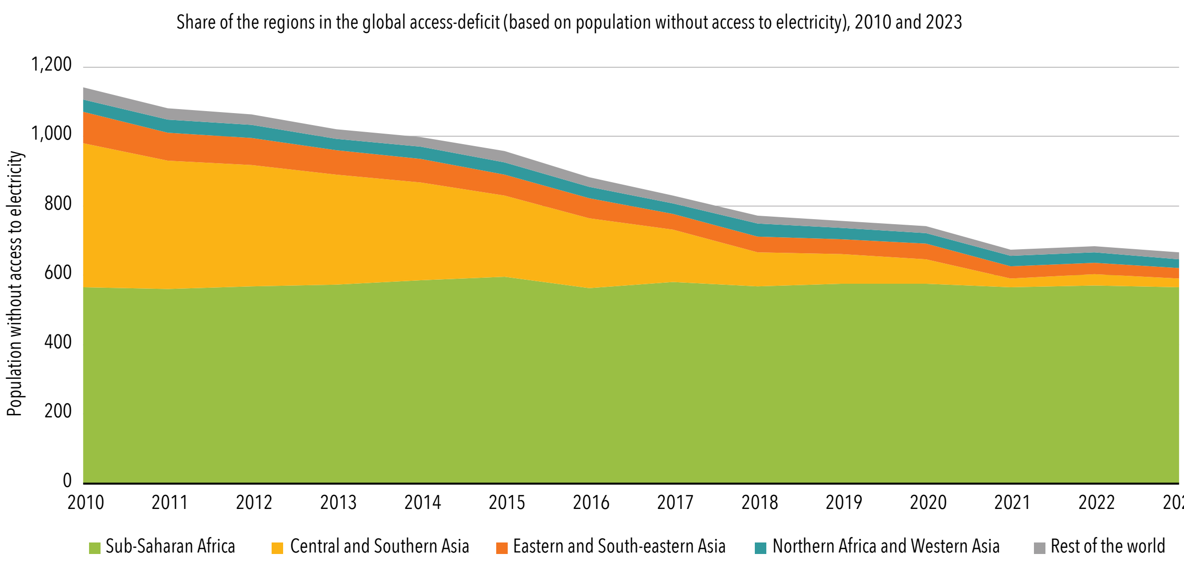
Sub-Saharan Africa continues to have the largest access gap (figure 1.6), a gap increasingly concentrated in countries and regions suffering from fragility, conflict, and violence. These conditions hamper economic progress, limit government capacity for implementing grid expansion, and constrain consumer demand. Annual electrification gains in Sub-Saharan Africa, at 30.2 million/year over 2021–23, barely outpaced population growth during the period (29.2 million/year).

FIGURE 1.5 • ANNUAL INCREASES IN ELECTRIFICATION AND POPULATION, BY REGION, 2021–23



Source: World Bank 2025.

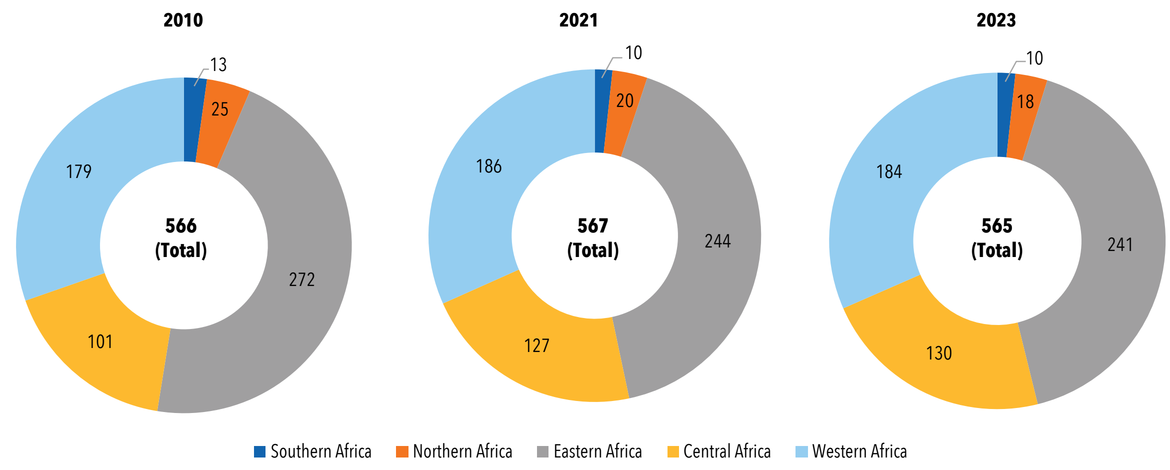
FIGURE 1.6 • NUMBER OF PEOPLE WITHOUT ACCESS TO ELECTRICITY, IN SELECTED REGIONS, 2010–23



Source: World Bank 2025.

From 2010 to 2023, progress on closing the electricity access deficit in Africa has been far from uniform, as shown in figure 1.7. Southern Africa's deficit declined from 13 million in 2010 to 10 million in 2021, remaining stable through 2023. Northern Africa steadily reduced its deficit from 25 million in 2010 to 20 million in 2021 and 18 million in 2023, driven by significant gains in Algeria, Morocco, and Tunisia. Eastern Africa also saw progress, reducing its deficit from 272 million in 2010 to 244 million in 2021 and 241 million in 2023. However, Central Africa's deficit increased, growing from 101 million in 2010 to 127 million in 2021 and 130 million in 2023. Western Africa had mixed results, with the access gap increasing from 179 million in 2010 to 186 million in 2021 before dropping slightly to 184 million in 2023.

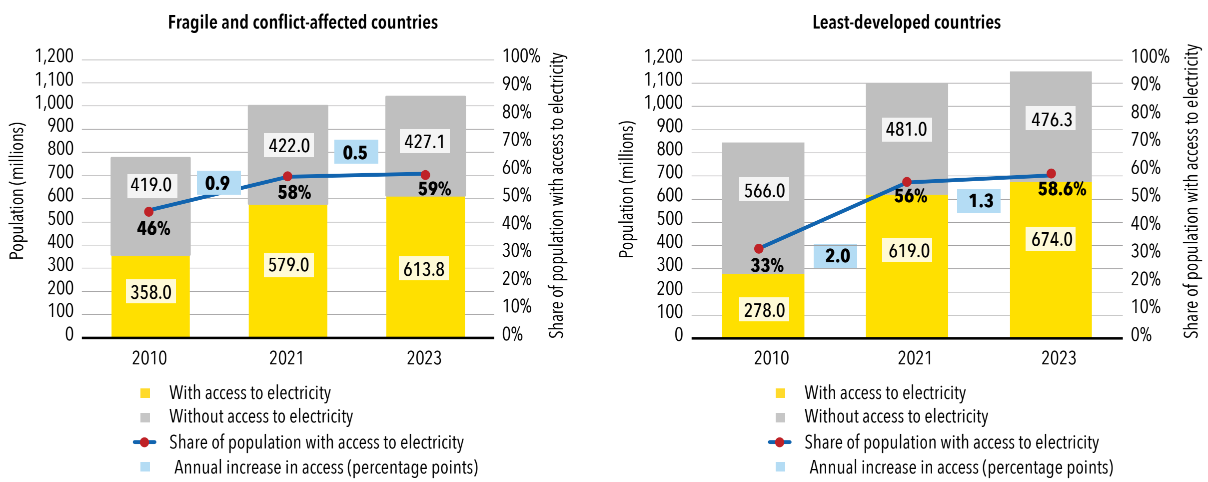
FIGURE 1.7 • SUBREGIONAL ACCESS DEFICITS IN AFRICA (IN MILLIONS OF PEOPLE WITHOUT ACCESS), 2010, 2021, 2023



Source: World Bank 2025.

Of the globe's 44 least-developed countries (LDCs), 32 are in Sub-Saharan Africa. Similarly, of the 15 countries facing situations of fragility, conflict, and violence, only two (Haiti and Afghanistan) lie outside Sub-Saharan Africa. As shown in figure 1.8, after a period of significant progress between 2010 and 2021, the number of people without access to electricity in LDCs decreased slightly from 481 million in 2021 to 476.3 million in 2023. Over the same period, for FCV-affected countries, the access gap increased from 422 million to 427 million. In LDCs, low incomes and capacity levels pose challenges in implementation. These challenges are exacerbated in FCV situations, curbing incomes and imposing higher costs and risks of servicing customers (ESMAP 2024).

FIGURE 1.8 • INCREASES IN GLOBAL ACCESS TO ELECTRICITY IN LDCs AND FCV-AFFECTED AREAS, 2010, 2021, 2023

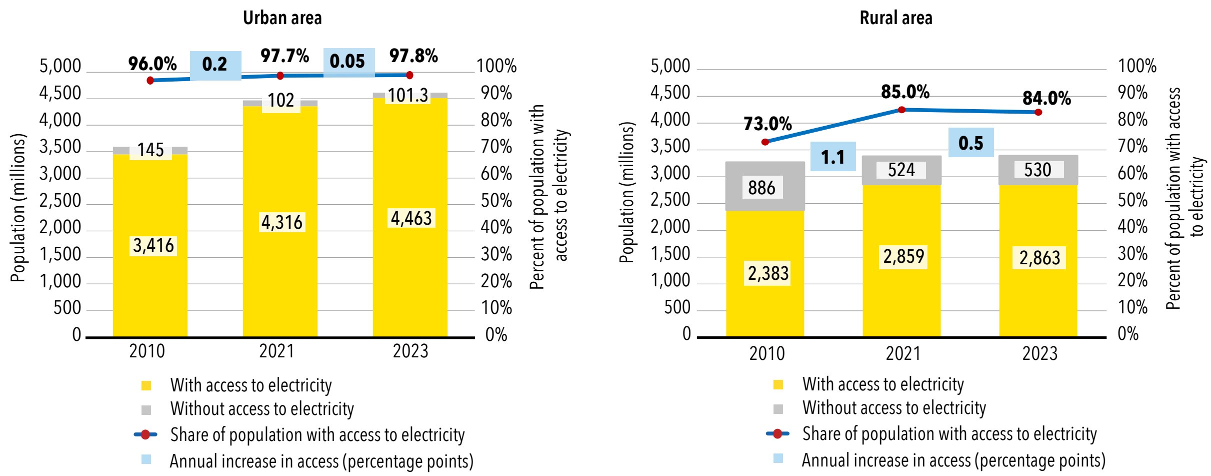


Source: World Bank 2025.

The urban-rural divide

Globally, electricity access in urban areas rose slightly from 96 percent in 2010 to 97.8 percent in 2023, while electricity access in rural areas grew from 73 percent to 84 percent (figure 1.9). During the period, the urban population with access swelled by 1 billion, while the rural population with access expanded by 480 million. The contrast between percentage gains and absolute numbers reflects the fact that adding grid connections in more densely populated urban areas expands access at scale, while in rural settings a new connection reaches fewer people. Fortunately, decentralized solutions have become increasingly feasible for dispersed populations, though granular, case-specific geographic analyses are needed to accurately assess potential impact of any contemplated expansion plan.

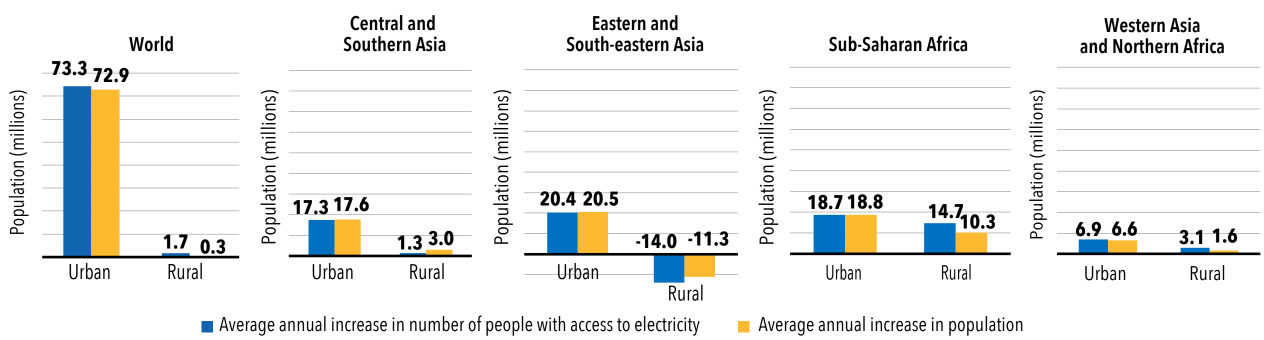
FIGURE 1.9 • INCREASES IN GLOBAL ACCESS TO ELECTRICITY IN URBAN AND RURAL AREAS, 2010, 2021, 2023



Source: World Bank 2025.

Between 2021 and 2023, the net gain in global electricity access in rural areas (~4 million) was much smaller than the gain in urban electricity access (147 million). The imbalance is broken down regionally in figure 1.10. Over the period in Central and Southern Asia, the annual access increase in rural areas was 1.3 million people, while in Sub-Saharan Africa an average of 14.7 million new connections were added each year. However, in Eastern and South-eastern Asia, there was a decrease in rural connections to the tune of 14 million/year. The data may indicate a greater deployment of off-grid and mini-grid technologies in Sub-Saharan Africa, but more data and analysis are needed to determine the pace at which these technologies can be deployed in countries with the greatest access deficit in Sub-Saharan Africa. It is also important to note that the figures reflect the starting points and patterns of urbanization in each region.

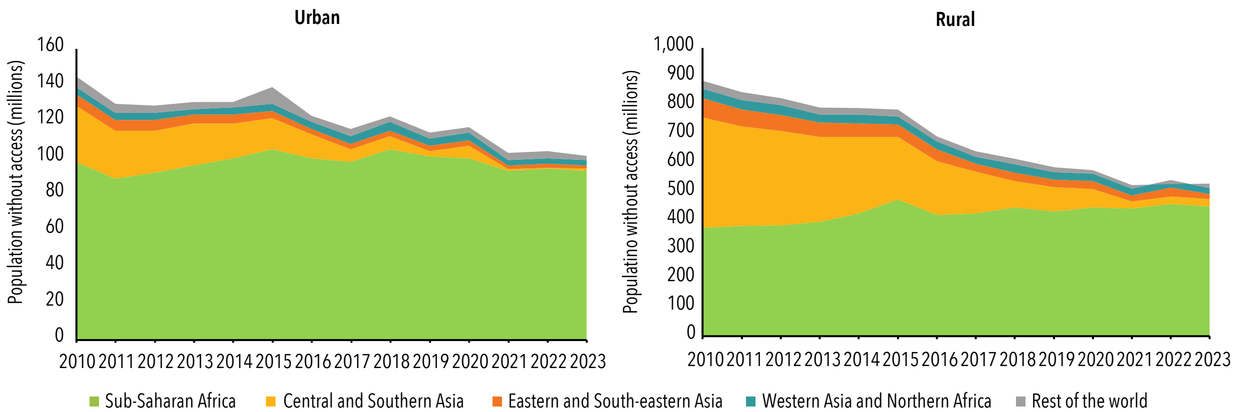
FIGURE 1.10 • ANNUAL GROWTH IN ELECTRICITY ACCESS AND POPULATION IN URBAN AND RURAL AREAS, BY REGION, 2021–23



Source: World Bank 2025.

Between 2010 and 2023, access deficits in rural areas shrank from 886 million to 530 million (figure 1.11). The steepest decline was seen in Central and Southern Asia (from 383 million to just 25.6 million). In contrast, Sub-Saharan Africa's rural deficit grew from 376 million to 451.1 million, though there was a slight decrease between 2022 and 2023 (from 459 million to 451 million). Globally, urban access gaps narrowed, starting from a much lower deficit number of 145 million in 2010 and falling to 101 million in 2023. As with rural areas, progress was uneven, driven primarily by Central and Southern Asia, where the urban deficit moved from 31 million in 2010 to 1 million in 2023.

FIGURE 1.11 • ACCESS DEFICITS IN URBAN AND RURAL AREAS, IN SELECTED REGIONS, 2010 AND 2023



Source: World Bank 2025.

Access to energy services through decentralized renewable energy

The off-grid solar (OGS) sector served 561 million people in 2023, of whom 385 million (~69 percent) were served by Tier 1 or higher products (Tier 1+ beneficiaries) (ESMAP 2024), as defined by the Multi-Tier Framework (MTF). OGS contributed 55 percent of new connections in Sub-Saharan Africa from 2020 to 2022.

The use of the MTF framework for target setting, alongside demand and affordability assessments, has enabled governments to pursue least-cost electrification strategies that combine grid, mini-grid, and off-grid solutions to accelerate progress.

The MTF bases access on seven attributes and six service tiers. Solar home systems typically provide partial Tier 1, Tier 1, or Tier 2 access, whereas mini-grids and grid electricity generally offer Tiers 3, 4, or 5 levels of service. Previous editions of this report have considered Tier 1 as the minimum level of service to constitute "electricity access," aligned with the International Energy Agency's (IEA's) "basic bundle" threshold, and the standard used by most governments in countries with access deficits (IEA 2023).[1]

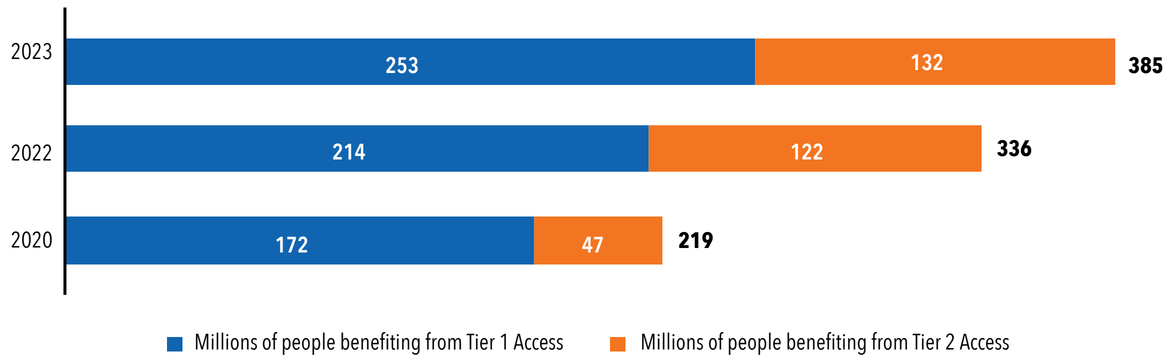
Tier 1 provides at least four hours of daily electricity (including one hour in the evening) with a system capable of generating 12 watt-hours per day. This level supports basic devices like lights and phone chargers, offering an entry point for remote or low- income households through OGS solutions.[2] For low-income households in off-grid areas, Tier 1's 50–100 kilowatt-hours (kWh) of electricity per year often meets their basic needs.

1 The MTF methodology is described at https://mtfenergyaccess.esmap.org/methodology/electricity.

2 Product lifespans are conservatively assumed to be 1.5 times the warranty period, at 18 months for solar lanterns and three years for solar home systems. For more information, see ESMAP (2024).

The number of Tier 1+ beneficiaries in off-grid households grew steadily from 219 million in 2020, to 385 million in 2023 (figure 1.12). In 2023, Tier 1 beneficiaries represented 65.9 percent of off-grid households; while Tier 2 made up 34.4 percent—and a growing share. The steady increase in Tier 2 customers indicates that Tier 2 access is increasingly meeting the affordability and level-of-service requirements. Tier 3+ beneficiaries were negligible. Thus, almost all households using off-grid systems (>200-watt [W] capacity) were receiving fewer than 8 hours of electricity per day for basic lighting and entertainment purposes.[3] More analysis of this point is needed in the context of Sub-Saharan Africa and the implementation of Mission 300.

FIGURE 1.12 • NUMBER OF PEOPLE BENEFITING GLOBALLY FROM OFF-GRID SOLAR ENERGY KITS BY TIER OF ELECTRICITY ACCESS, 2020–23 (MILLIONS)



Source: ESMAP 2024.
SHS = solar home system.

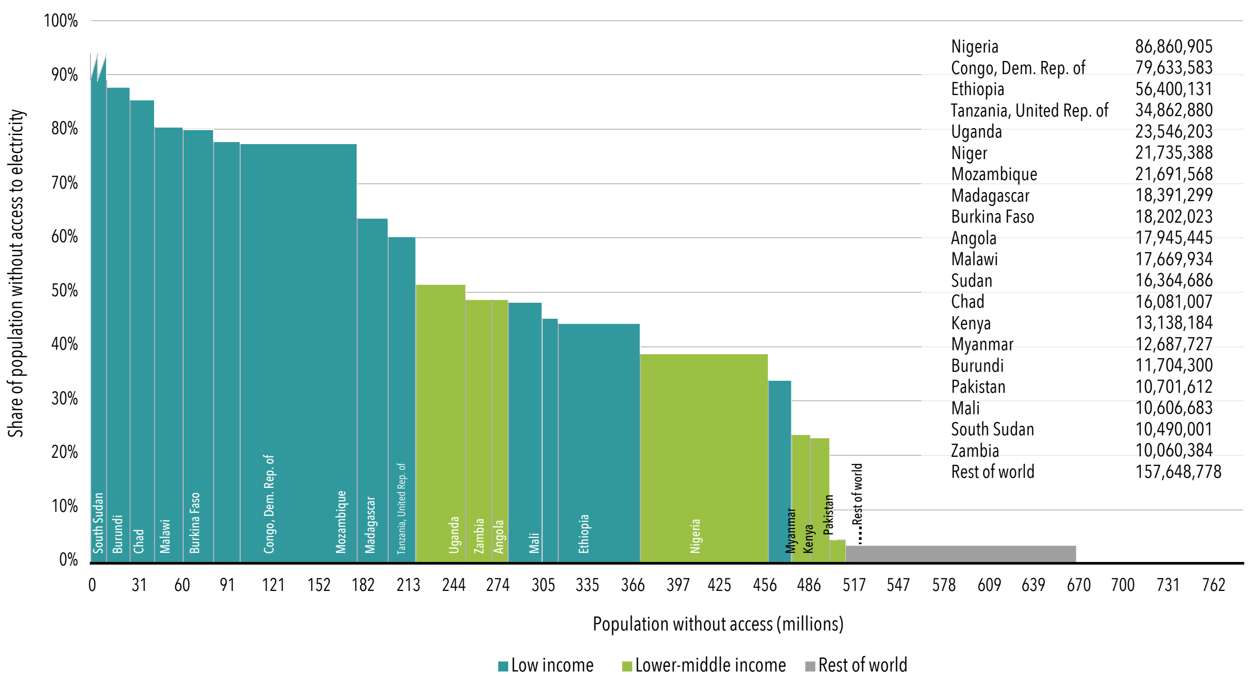
Figure 1.12 indicates the near zero market penetration of Tier 3+ service levels. Thus almost all households using off-grid systems (>200W capacity) were receiving less than 8 hours of electricity per day for basic lighting and entertainment. Only households with Tier 3+ service levels (>800W capacity) have access to 8–16 hours of electricity per day. These higher tiers would support energy services such as air conditioning, refrigeration, and space heating, which are not getting much traction currently. More investments in off-grid renewable energy solutions are required to improve the level of access and lessen the inequality in standard of living for first-time off-grid households (Tier 1) while keeping the goal of universal access in sight.

3 Only households with Tier 3+ service levels (>800 W capacity) have access to 8 to 16 hours of electricity per day. These higher tiers would indicate energy services such as air-conditioning, refrigeration, and space heating. More investments in off-grid renewable energy solutions would be required to improve the level of access and bridge the inequality in the standard of living for first-time off-grid households (Tier 1) while keeping the goal of universal access in sight.

Country trends

In 2022, the 20 countries with the largest electricity access deficits accounted for 76 percent of the global total, up from 75 percent in 2022.[4] Once again, 18 of these countries are in Sub-Saharan Africa. For the third consecutive edition of this report, Nigeria (86.8 million), the Democratic Republic of Congo (79.6 million), and Ethiopia (56.4 million) topped the list, together accounting for roughly a third of the entire global access deficit (figure 1.13). The lowest national access rates were observed in South Sudan (5 percent) followed by Chad and Burundi (12 percent), all three of which have shown low annualized increases in access since 2010 (figure 1.14).

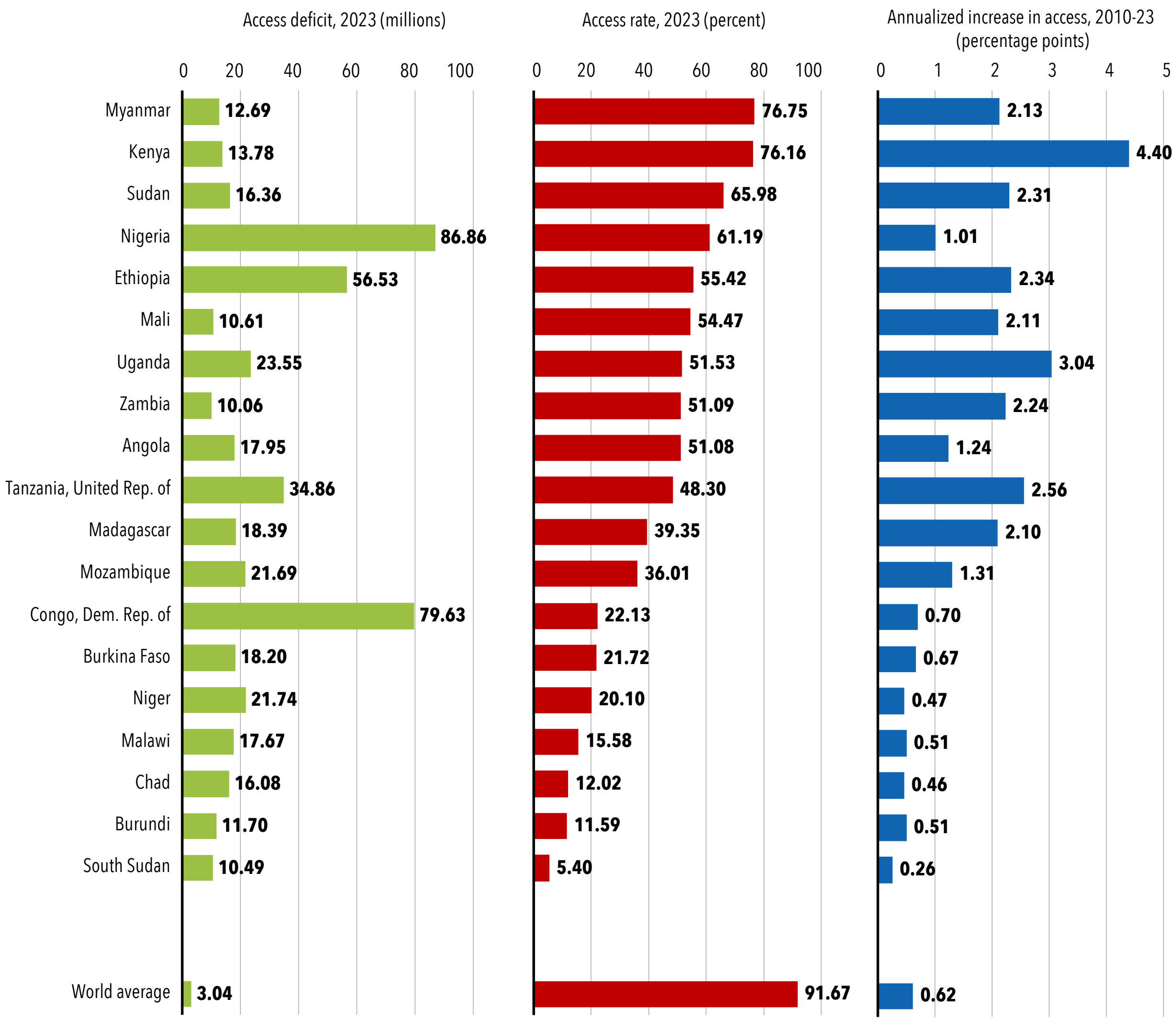
FIGURE 1.13 • SHARE AND ABSOLUTE SIZE OF POPULATION WITHOUT ACCESS TO ELECTRICITY IN THE TOP 20 ACCESS-DEFICIT COUNTRIES, 2023



Source: World Bank 2025.

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

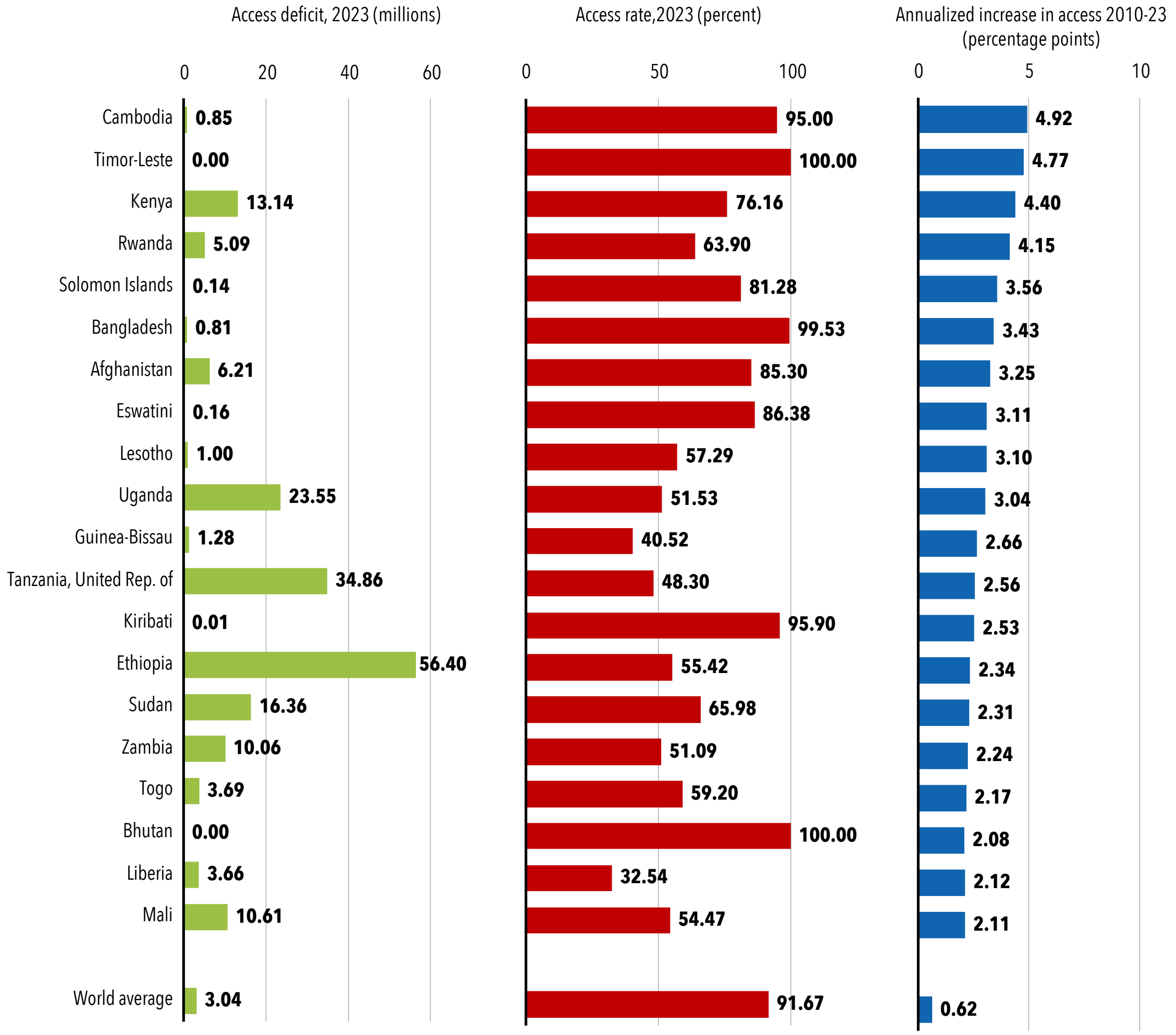
FIGURE 1.14 • ACCESS TO ELECTRICITY IN COUNTRIES WITH THE LOWEST RATES OF ELECTRIFICATION, 2023



Source: World Bank 2025.

Multiple countries were able to increase their access rates between 2010 to 2023, the most notable being Timor Leste and Bhutan, both of which achieved universal electrification starting from low levels. Kenya was among the fastest-electrifying countries, showing an impressive annual growth rate of 4.4 percent to reach 76 percent access by 2023 (figure 1.15). Rwanda also made impressive progress between 2021 and 2023 (from 48.7 to 63.9 percent), driven by aggressive grid expansion, increased investment in off-grid solutions, and strong government commitment to electrification targets. Bangladesh nearly closed its remaining access gap, reaching 99.5 percent access, with an annual growth rate of 3.4 percent.

FIGURE 1.15 • ACCESS TO ELECTRICITY IN THE 20 FASTEST-ELECTRIFYING COUNTRIES, 2010–23



Source: World Bank 2025.

Policy insights

Harmonizing definitions of access and moving beyond households

SDG 7 does not define "electricity access," and no single internationally accepted or adopted definition exists. However, since 2015, a growing number of governments have used the Multi-Tier Framework (MTF) to define levels of electricity access, set targets, and measure progress (ESMAP n.d.).

A key limitation of the current MTF approach is its exclusive focus on household electricity, omitting businesses, public institutions, and other settings. According to the IEA, only 26 percent of global electricity consumption is residential. Hence, it is important to consider electricity use in industry, agriculture, commerce, and other sectors. In the past decade, there has been growing interest in promoting the productive use of electricity by farmers, in particular. According to estimates from the Food and Agriculture Organization, about 30 percent of the world's total end-use energy is consumed by the agrifood sector.

Box 1.1 presents a new method for estimating the least-cost path to universal residential access to electricity.

BOX 1.1 • REFINING ESTIMATES OF ELECTRICITY ACCESS

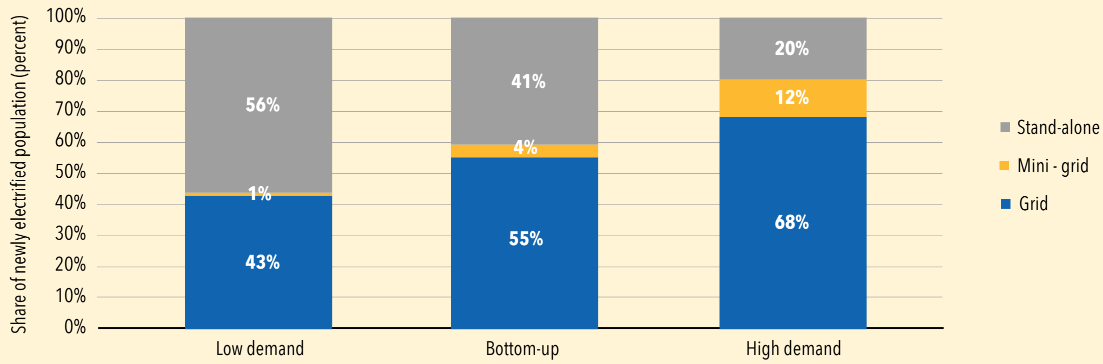
An updated least-cost electrification analysis based on the Global Electrification Platform—an open access, interactive, online platform—makes it possible to estimate the most cost-efficient path to universal access by 2030 in the top access-deficit countries under three demand scenarios. The model runs reported below used data from 58 countries. Residential electricity demand scenarios are based on projected population growth rates, a target tier of electricity access, and the associated electricity consumption level.

- *"Bottom-up" scenario*. A unique demand target is set for each settlement, based on the local poverty rate and the level of gross domestic product in the country.
- *"Low-demand" scenario*. Urban demand is estimated based on 2020 levels of electricity consumption in electrified parts of the country, translated to the nearest equivalent access tier. Rural demand is set to Tier 1.
- *"High-demand" scenario*. Urban demand targets are raised by one tier above 2020 consumption (unless already Tier 5), while rural demand is set to Tier 3.

In the bottom-up scenario, out of a total of 956 million people provided with new access to electricity from 2025 to 2030, 526 million are projected to be served by the grid (55 percent), 389 million (41 percent) by stand-alone photovoltaic (PV) power, and a further 40 million (4 percent) by mini-grids. In the low-demand scenario, stand-alone PV plays a more prominent role (56 percent); in the high-demand scenario, mini-grids provide 12 percent of new connections. In this latter scenario, there would also be greater productive use of electricity in commercial settings (figure B1.1.1).

BOX 1.1 • REFINING ESTIMATES OF ELECTRICITY ACCESS *(cont.)*

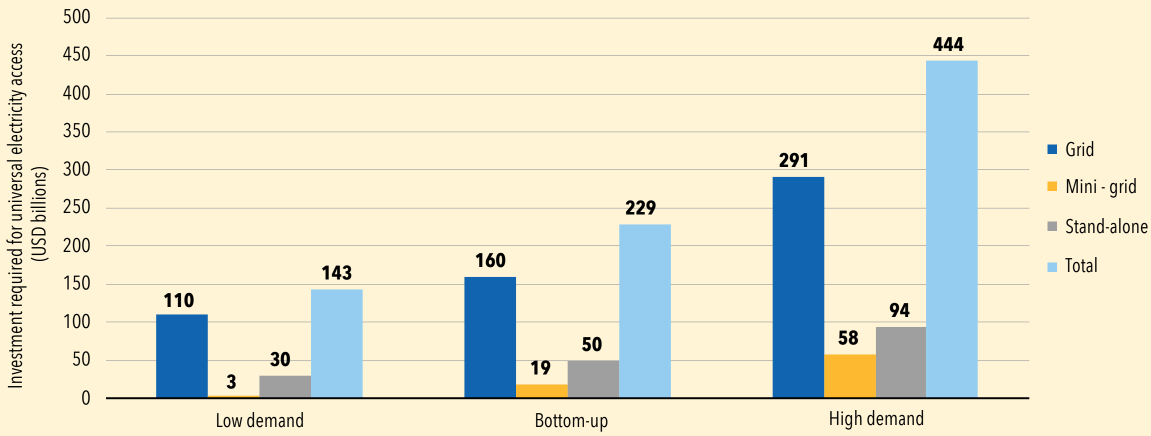
FIGURE B1.1.1 • NEWLY ELECTRIFIED POPULATION, BY SCENARIO, 2025–30



Source: World Bank 2025.

The bottom-up scenario would require a total investment of USD 235 billion, with USD 164 billion invested in the grid, USD 51 billion in stand-alone PV, and a further USD 19 billion in mini-grids. The low-demand scenario would need about two-thirds as much (USD 147 billion), whereas the high-demand scenario would require a significantly higher total investment (USD 455 billion) (figure B1.1.2). These calculations are based on estimated up-front capital costs of each electrification solution and do not include ongoing operation and maintenance costs.

FIGURE B1.1.2 • GLOBAL INVESTMENT REQUIRED FOR UNIVERSAL ELECTRICITY ACCESS, BY SCENARIO (USD, BILLIONS)



Source: World Bank 2025.

Data and customer awareness needs for implementing distributed renewable energy options

Mission 300 recognizes the crucial role of DRE solutions, which are transforming the energy landscape in Africa's poorest and most isolated regions. These technologies provide reliable, clean, and affordable power, offering faster deployment and supporting local economic development. For instance, Nigeria's mini-grid projects have connected nearly 6 million people through more than 170 mini-grids and almost 1.2 million stand-alone solar systems. Box 1.2 probes the use of DRE to advance rural electrification in Sub-Saharan Africa.

Improving data quality, frequent monitoring of progress, and a willingness to revisit priorities are crucial to successful DRE implementation, particularly as the access gap shrinks and implementation efforts move to more remote and difficult-to-reach demographic groups. The Global Electrification Database, ESMAP's MTF surveys, and Night-Time Light Satellite Imagery are some of the sources currently used. However, challenges persist in data consistency, collection frequency, and accuracy, particularly in remote areas.

Data and analytics are also needed to discover what drives consumer decisions. A newly announced partnership between the Energy Sector Management Assistance Program (ESMAP) and the Living Standards Measurement Study to conduct surveys in 15 countries over five years is driven by a focus on improving data quality and understanding consumers' needs and preferences—as well as their knowledge about the options available to them. Increasing consumer awareness of DRE technologies can fuel the growth of a self-help culture, encouraging consumers to become drivers and active participants in the electrification process.

BOX 1.2 • SUCCESS STORIES FROM SUB-SAHARAN AFRICA: KENYA, RWANDA, AND UGANDA

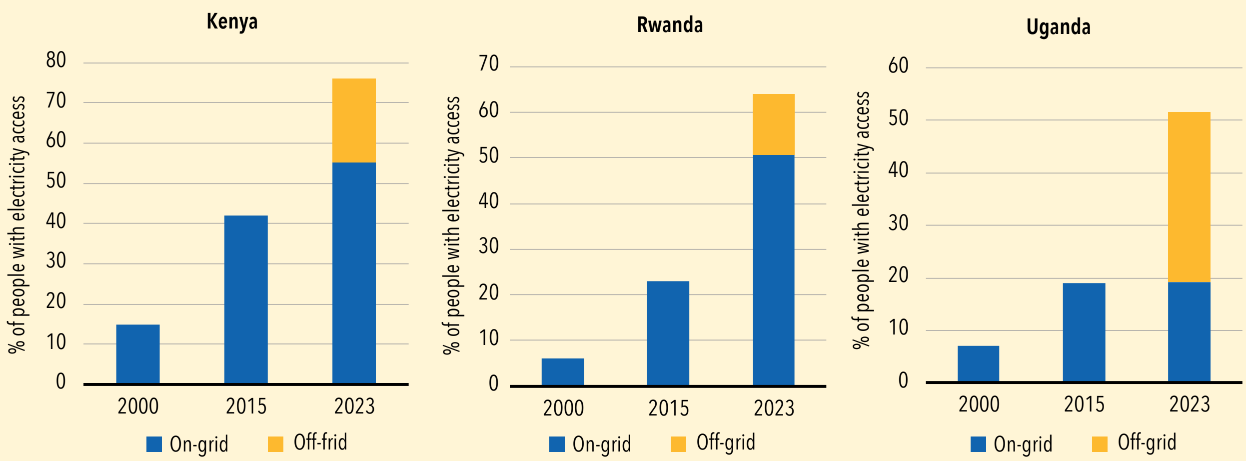
While grid extension is needed in more than a few countries of the region, budgetary and capacity constraints limit rapid extension, especially where per capita load is low and locations are remote. Here solutions based on decentralized renewable energy (DRE) are the fastest and most cost-effective way to expand electricity access. Over the past decade, DRE has been used for nearly 20 percent of all new electricity connections, nearly half of which were realized in East Africa alone.

In contexts characterized by fragility, conflict, and violence, where centralized grid expansion is even more challenging, DRE may frequently be the only option. Beyond household electrification, DRE is increasingly delivering targeted services that power productive uses for farmers and small businesses, as well as providing reliable electricity to health facilities, schools, and other essential public institutions.

Countries making significant strides in electrification—among them Kenya, Rwanda, and Uganda, are adopting a mix of grid and DRE options in their energy access strategies (figure B1.2.1). While grid extension has a more traditional path, scaling of DRE systems requires innovative customer outreach and financing mechanisms that foster consumer finance, entrepreneurship in the sector, and private sector financial flows.

BOX 1.2 • SUCCESS STORIES FROM SUB-SAHARAN AFRICA: KENYA, RWANDA, AND UGANDA *(cont.)*

FIGURE B1.2.1 • FAST PROGRESS IN ELECTRIFICATION ASSISTED BY DRE IN THREE COUNTRIES, 2000–20



Source: World Bank 2023. For Uganda, the grid-off-grid proportion is from "Energy Policy for Uganda 2023."

Off-grid solar: An example of a consumer-driven process

OGS is a cost-effective, rapidly scalable solution to meet electricity demand, especially in remote, low-income areas where demand is low and grid or mini-grid connections are impractical, as in areas beset by conflict or violence. In 2022 and 2023, over 50 million OGS products were sold, surpassing pre-COVID levels. Market turnover reached an estimated USD 3.9 billion in 2022 and USD 3.8 billion in 2023, surpassing the previous record of USD 3.3 billion in 2019. Pay-as-you-go (PAYG) models, which allow customers to pay in small instalments, accounted for 39 percent of sales in 2023, up from 24 percent in 2018.

Unelectrified households in such areas, especially those caught in FCV situations, have limited purchasing power and few opportunities to generate income, making subsidies or other forms of support a key ingredient in attaining market penetration. Only 22 percent of unelectrified households can afford a Tier 1 solar energy kit even on PAYG terms, while 49 percent might be able to afford it at a stretch. (Productive use appliances on PAYG terms remain largely out of reach.) Affordability is further exacerbated by logistical challenges in remote areas, especially in FCV situations. Extending services to remote or conflict-affected areas raises Tier 1 PAYG system prices by ~57 percent, affecting 82 percent of those lacking electricity (ESMAP 2024).

Fortunately, public and private investments in OGS are growing, reaching USD 1.2 billion during the 2022–23 period, up from USD 773 million in 2020–21. Since 2017, OGS funding has grown at an average annual rate of 6 percent, largely driven by debt financing. Of the USD 425 million invested in 2023 (excluding results-based financing), USD 285 million came in the form of debt (66 percent), USD 128 million as equity (30 percent), and USD 16 million as grants (4 percent). Large international and vertically integrated companies captured 70–80 percent of the total amount invested, broadly in line with their market share.

Public funding is also expanding, with the World Bank lending a record USD 660 million to governments in fiscal 2024 to scale up proven off-grid solar solutions, alongside active involvement from a range of development partners. Results-based financing, too, has gained traction, with USD 350 million disbursed since 2018 and USD 733 million committed under newly approved projects to be implemented over the next five years. Finally, the Mission 300 initiative led by the World Bank and African Development Bank (AfDB) should enable governments to secure financing from multilateral development banks for new programs investing in off-grid solar solutions.

All told, an estimated USD 21 billion is needed to electrify the 398 million people who would be most efficiently connected through OGS by 2030.[5] An additional USD 2.4 billion would electrify more than a million schools and health-care facilities. USD 74 billion would be needed to address the total market for solar water pumps, cold storage solutions, and Tier 2+ OGS products for micro, small, and medium-sized enterprises. Governments would only need to cover 30–40 percent of the cost to unlock an additional 60–70 percent in public and private co-investment (ESMAP 2024).

The case for governments to invest in OGS is profound—with such investments delivering significant social and economic returns. Achieving universal Tier 1 access for households could save USD 15.5–16.7 billion annually, or USD 142 per household, by reducing inefficient lighting costs and boosting incomes. Replacing diesel generators with OGS for businesses could save USD 6.3–12.5 billion in fuel costs and eliminate 8.3–16.6 million metric tons of carbon dioxide (CO2) emissions per year. Electrifying social infrastructure could reduce fuel generator costs by USD 10,000 per school and USD 30,000 per health center annually, while avoiding 0.9 million metric tons of CO2 equivalent globally each year. Finally, expanding the OGS sector generates tax revenue and reduces fossil fuel subsidies, in some cases enabling governments to make a net profit from OGS programs (ESMAP 2024).

The unexploited potential of mini-grids

Mini-grids—electric power generation and distribution systems that can supply electricity to households, businesses, and social institutions in a discrete area—come in various sizes and serve remote communities that lack access to electricity from the main grid. The overall value proposition of mini-grids as an electrification strategy is that they can be deployed faster than main grid extensions, often at a lower cost per connection; they tend to provide better-quality electricity and customer service than utility companies; they can support more productive uses at lower cost than solar home systems; and they can attract both private and public sector finance.

While electrification programs have traditionally focused on extending the national grid, recent experience in high-deficit countries in Sub-Saharan Africa shows that grid supply is often unreliable and grid extension costs prohibitive for areas with dispersed or remote populations. Compared to off-grid solar systems that can also serve these populations, mini-grids can offer 24/7 electricity and support larger productive loads. Additionally, distribution infrastructure built for the mini-grid can still be utilized if and when the main grid arrives. Therefore, in denser, larger communities with productive loads located away from the main grid, mini-grids will often be the least-cost, best electrification solution and can accelerate the provision of affordable access to high-quality electricity to millions of people.

Over the past decade, mini-grid installations have surged globally, with numbers now more than six times higher than in 2018. Growth has been especially prominent in Sub-Saharan Africa (SEforALL 2024). Mini-grids already serve 48 million people connected to 21,500 mini-grids, half of which are solar PV mini-grids. Another 29,400 mini-grids are currently planned, 95 percent of them in Africa and South Asia. Ninety-nine percent of these planned mini-grids use solar PV technology and are estimated to connect more than 35 million people at an investment cost of USD 9 billion.

5 The GEP bottom-up demand scenario estimates that the total cost of connecting all households for which off-grid solar is the least-cost option is USD 50 billion, based on assigned tiers corresponding to the relative affluence of households. In contrast, the USD 21 billion estimate assumes Tier 1 access for all. For more information, see Annex 6 of ESMAP (2024).

The Africa Mini Grid Developers Association has highlighted six key trends and opportunities in the sector (AMDA 2025).

- Mini-grids are growing in size and gravitating toward markets with an enabling financial and regulatory framework. The average number of connections per mini-grid has grown from 244 per site reported in 2022 to 458 in 2024. During this same period, mini-grid developers have flocked to markets with enabling ecosystems for mini-gid development, especially Nigeria.
- Mini-grids are significant contributors to job creation in Africa. Just 27 mini-grid developers surveyed created more than 6,000 jobs over the past four years, with the majority of them in the communities where the mini-grids are located.
- While mini-grid costs have decreased globally, capital expenditure for deployment in Sub-Saharan Africa remains stubbornly high compared to other regions. This regional discrepancy reflects factors like high logistics costs and low population density, but improved supply chain efficiency, economies of scale, and more favorable tax treatment can help reduce costs.
- Although more than USD 9 billion of concessional capital has been committed to the sector over the past five years, disbursement of donor funds has been slow, adversely affecting the rollout of mini-grids. The sector needs fewer, larger financing windows with harmonized reporting requirements to enable swifter disbursements.
- Gaining traction are new financing mechanisms, such as blended finance, escrowed grant payments to derisk commercial lending, and monetization of environmental benefits to attract corporate and institutional investors.
- The slow pace of regulatory approvals threatens to delay or halt the scale-up of mini-grid deployment, and streamlining regulatory processes and addressing bureaucratic bottlenecks will be critical to timely deployment.

Although mini-grids are estimated to be the least-cost electrification solution for 40 million people under a uniform bottom-up scenario for all countries considered in the analysis of the Global Electrification Platform (GEP) presented in box 1.1—and for 115 million people under the high-demand scenario—there is ample reason to expect that the addressable market for mini-grids is significantly larger. In fact, an earlier World Bank analysis found that, when adjusting the parameters in the GEP study on a country-by-country basis to reflect conditions favorable for mini-grid development, mini-grids could be the least-cost option for connecting up to 430 million people (ESMAP 2022).[6]

While mini-grids are not a new phenomenon—all existing centralized power grid systems started as small, isolated power systems and mini-grids that eventually interconnected—generation technologies, ownership models, and other attributes have evolved over time. The mini-grids being deployed today usually rely on modular technologies, especially solar PV and batteries, combined with sophisticated digital solutions like smart metering and remote monitoring. They are often developed and operated by private companies (with support from the public sector).

A geospatial assessment for the GEP study determined that 291,000 communities across Sub-Saharan Africa have the profile, in terms of settlement size and population density, that favors the deployment of solar mini-grids. Many of these communities, particularly those located closer to existing grid infrastructure, may be candidates for least-cost electrification via grid extension. However, most utilities in Sub-Saharan Africa face constraints that limit their capacity to raise financing, invest in infrastructure, improve service, and generate adequate revenue. Thus, counting on expansion of the main grid to connect 526 million people at least-cost would be unrealistic in the near to medium term. A good part of the population will have to be served instead by more agile, tech-enabled mini-grid operators, unburdened by the legacy obligations of distribution utilities.

6 Given the acceleration in the technology learning curve observed for mini-grid systems and components—especially for PV panels, battery storage, energy management systems, geospatial planning tools, and advanced metering solutions—along with operational efficiencies achieved from scale, least-cost assessments will probably point to a growing role for mini-grids.

BOX 1.3 • ACCESS EMPOWERS: THE GENDER-ENERGY NEXUS

Access to electricity empowers women and girls (Vidart 2014; Dutta, Koojiman, and Ceceleski 2017). Time saved from traditional energy tasks allows women to focus on income-generating activities and human capital development. The long-term benefits of access to electricity on girls' education and future employment are well documented. Moreover, access to electricity serves as a gateway to vital information, empowering women and girls to make informed decisions about health, education, and overall well-being.

Despite the benefits of energy access for women and girls, challenges persist in addressing the gender-energy nexus—whether approached from a lens of vulnerability or opportunity. Data from the MTF surveys show that households headed by women in Africa and South Asia are less likely to have off-grid access, with affordability being among the top constraints. Closing this gap requires increasing incomes or improving affordability, as exemplified by the Yemen Emergency Electricity Access Project supported by the World Bank (World Bank 2022, 2023). The project expanded electricity access for women in rural and peri-urban areas and promoted financial inclusion. Targeting women through microfinance institutions, the project helped increase sales to women from 5 to more than 20 percent, with 44 percent of total credit sales going to women, 16 percent of whom were first-time borrowers.

Employment opportunities for women in the energy sector remain limited, with women representing only 16 percent of the global energy workforce, compared to 40 percent economywide (IEA 2022). Senior leadership roles are even rarer, with women filling only about 17 percent of leadership slots. Although the clean energy sector is more promising, challenges remain. The International Renewable Energy Agency estimates that while women represent about a third of the renewable workforce, most are found in administrative and clerical positions. Additionally, only 7 percent of climate venture capital goes to women founders (Tech Crunch 2023).

To fulfill the promise of the Beijing Declaration and Platform for Action, policy makers must implement policies and regulations that foster women's participation and leadership in the energy sector. Investments should prioritize gender equity by directing financial resources toward initiatives that equip women with financial tools, such as access to financing, and business support services for women-led energy projects. Additionally, markets must be more inclusive by promoting women's involvement at all levels of the value chain, from design and production to distribution and decision-making. Projects should also address structural barriers and offer skills development while fostering cultural shifts toward gender equality. Finally, improving gender data in the sector is an opportunity to better identify the gaps that disadvantage women and to design solutions that can better support their ability to benefit fully from electricity access across the value chain.

By working together, governments, private sector players, civil society, and international organizations can pave the way for a just and equitable energy transition.

CHAPTER 2
ACCESS TO CLEAN FUELS AND TECHNOLOGIES FOR COOKING

Photo: © @danpope - CLEAN-Air(Africa)

Main messages

- **Global trend.** In 2023, an estimated 74 (70–77)[7] percent of the global population relied primarily on clean cooking fuels and technologies. Although this represents notable progress since 2010, roughly a quarter of the world's population—around 2.1 (1.9–2.5) billion people—remains dependent on polluting fuels and technologies for cooking.
- **Target for 2030.** At current rates, only 78 (74–81) percent of the global population will have access to clean cooking by 2030. This shortfall would leave nearly 1.8 (1.6–2.2) billion people still without clean cooking solutions. Sub-Saharan Africa is projected to account for the largest portion of this gap, underscoring the urgent need for more targeted interventions in the region.
- **Regional highlights.** Access deficits have continued to shrink in Eastern Asia and South-eastern Asia, as well as in Central Asia and Southern Asia—thanks largely to policy measures and rising incomes. However, in Sub-Saharan Africa, the number of people lacking access is still growing at a level of 14 million people yearly, with gains in access overshadowed by rapid population growth.
- **The urban-rural divide.** Access rates in urban areas remain significantly higher than in rural areas. Urban access is around 89 (85–90) percent globally, while rural access is closer to 55 (50–60) percent. Sub-Saharan Africa continues to show a notably wider gap between urban and rural access, with 42 (37-46) percent of the urban population having access compared to just 7 (5-8) percent in rural areas, a difference of 35 percentage points. These lower access levels in Sub-Saharan Africa influence the global averages considerably. If excluded, the global access rate would increase to 95 (91-96) percent in urban areas and 67 (61-73) percent in rural areas.
- **The 20 countries with the largest access deficits.** Collectively, the "top 20" account for more than 70 percent of people without clean cooking globally, including several countries in Sub-Saharan Africa and Southern Asia. Many have seen only marginal progress over the last decade and require urgent policy and financing support to meet global goals.
- **Global and regional fuel trends.** In 2023, the dominant cooking fuels in low- and middle-income countries (LMICs) were liquefied petroleum gas (LPG), natural gas, and electricity. Solid biomass, such as wood, dung, and agricultural residues, remains significant in rural and peri-urban areas. Meanwhile, coal and kerosene use has shrunk and now accounts for less than 1 percent globally.
- **Clean cooking and equity.** The lack of access to clean cooking affects the poor and vulnerable disproportionately. Wealthier households consistently have greater access, especially in Sub-Saharan Africa. The lack of access places a particularly heavy burden on women and girls, who spend hours collecting fuel and cooking on inefficient stoves, exposing them to household air pollution and limiting their educational and economic opportunities.
- **Policy insights.** Urgent action is needed to achieve universal access to clean cooking by 2030. Governments and stakeholders across sectors must scale up investments, prioritize vulnerable populations, and integrate clean cooking into broader energy access efforts to ensure a just and inclusive energy transition that maximize health, equity, and climate benefits.

7 Throughout the chapter, parenthetical figures appearing after estimates are 95 percent uncertainty intervals, as defined in annex 1. 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.

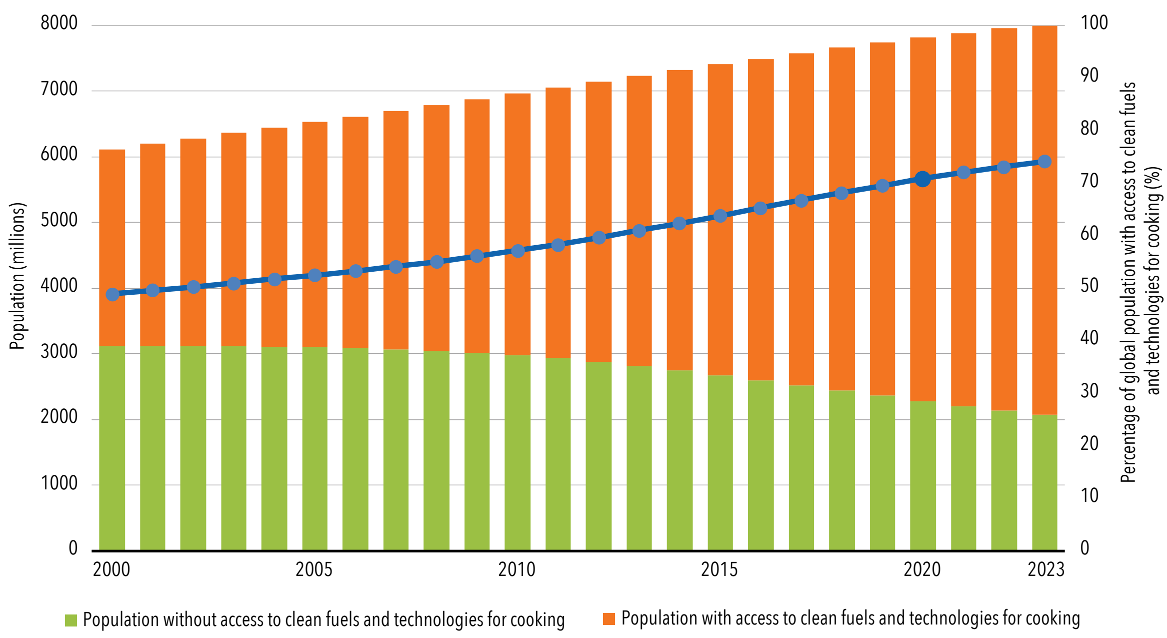
Are we on track?

In 2023, an estimated 74 (70–77) percent of the global population had access to clean cooking fuels and technologies such as electricity, LPG, natural gas, biogas, solar, and alcohol-based stoves. This figure represents an increase of 17 percentage points from 2010. Despite this steady progress, an estimated 2.1 (1.9–2.5) billion people continue to use polluting fuels—such as firewood, charcoal, crop waste, kerosene, and coal—for most of their cooking. The repercussions extend beyond household air pollution, putting women's and children's health, and people's livelihoods, at risk and undermining efforts to achieve global environmental goals.

The current trajectory suggests that only 78 (74–81) percent of the global population will have access to clean cooking by 2030, leaving 1.8 (1.6–2.2) billion people still dependent on polluting fuels—far short of the Sustainable Development Goal (SDG) 7 goal of universal access. This estimate would represent only a modest improvement in the aggregate numbers, as population growth, weak policy frameworks, inadequate infrastructure, lagging innovation, and limited affordability of clean cooking solutions in some regions continue to hinder progress and, in some areas, reverse prior gains.

Figure 2.1 illustrates these trends, showing that while global access to clean cooking climbed from around 57 (53–61) percent in 2010 to 74 (70–77) percent in 2023, the absolute access deficit remains stubbornly high globally, and the world is far from reaching the universal target in 2030.

FIGURE 2.1 • ABSOLUTE NUMBER OF PEOPLE (LEFT AXIS, BARS) AND PERCENTAGE OF THE GLOBAL POPULATION (RIGHT AXIS, LINE) WITH ACCESS TO CLEAN COOKING, 2000–23

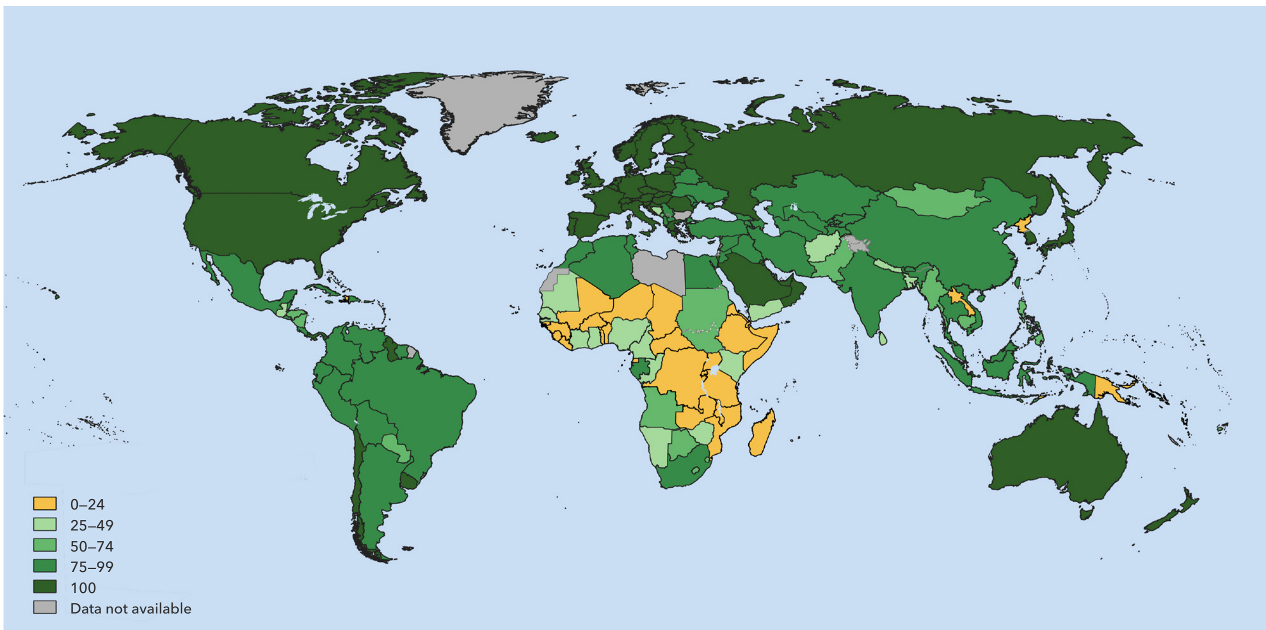


Source: WHO 2025.

The situation is especially urgent in Sub-Saharan Africa, which remains the only region where the absolute number of people without access continues to grow. In 2023, only 21 (19–24) percent of the region's people had access to clean cooking fuels and technologies (figure 2.2), leaving 955.3 (920.0–986.0) million people relying on polluting cooking fuels and technologies. Although some countries in the region have introduced policies to promote improved and clean fuels and technologies, overall progress continues to be outpaced by rapid population growth (0.87 percent annually, or around 70 million people[8]). Without accelerated action, the region risks falling further behind.

Moreover, population growth in Sub-Saharan Africa continues to outstrip incremental improvements in access, causing the number of people without clean cooking to rise by roughly 14 million each year. This further exacerbates the challenges faced by nearly 1 billion people already affected by polluting cooking, with severe consequences for their health, well-being, and quality of life. If this trend persists, it could slow or even reverse the global progress made so far.

FIGURE 2.2 • SHARE OF POPULATION WITH ACCESS TO CLEAN COOKING FUELS AND TECHNOLOGIES, 2023 (PERCENT)



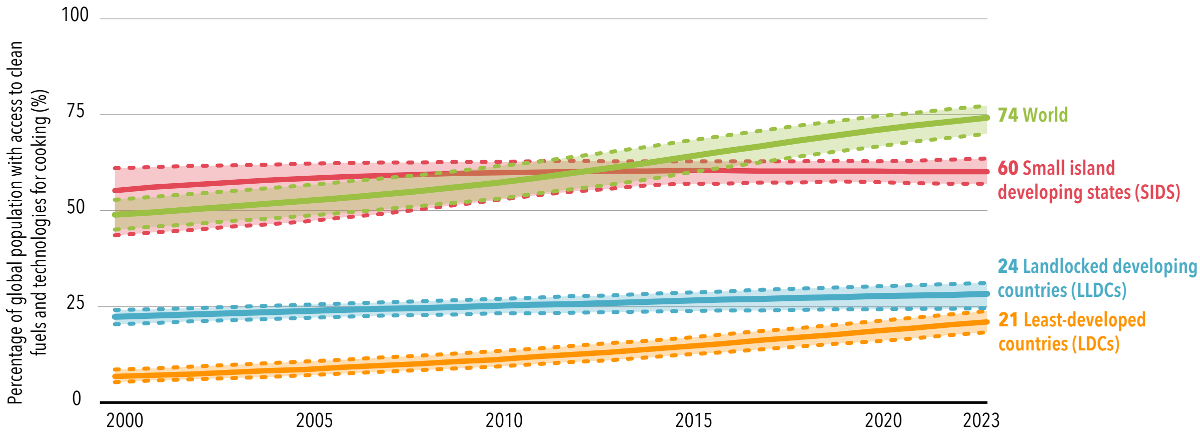
Source: WHO 2025.

Of equal concern is the picture in certain other country groupings. Least-developed countries (LDCs), landlocked developing countries (LLDCs), and small island developing states (SIDS) together comprise 92 countries, including 38 in Sub-Saharan Africa. Many of the countries in these groups are vulnerable and fragile. In 2023, only 21 (18–24) percent of LDCs, 28 (25–31) percent of LLDCs, and 60 (57–64) percent of SIDS had access to clean cooking fuels and technologies, figures that lag significantly behind the global average, as shown in figure 2.3.

In some cases, progress has slowed. In 2012, the share of the population in SIDS with access to clean cooking was close to the global average 60 (67-64) percent. That share has since stagnated, remaining unchanged through 2023. This stagnation underscores the urgent need for targeted efforts to help these countries meet global goals for clean energy access.

8 In line with UN Population Division (2024).

FIGURE 2.3 • ACCESS TO CLEAN COOKING FUELS AND TECHNOLOGIES IN LDCs, LLDCs, SIDS, AND WORLDWIDE, 2000–23



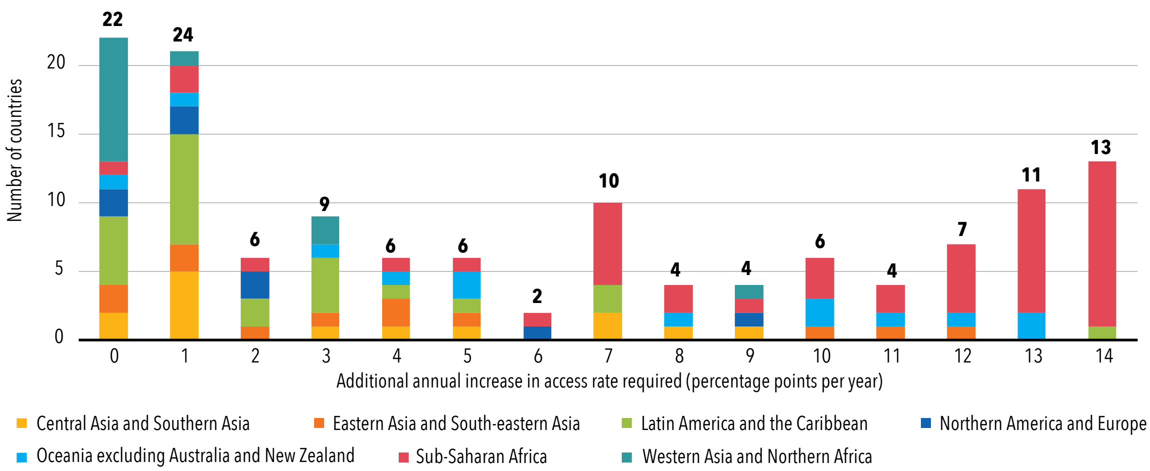
Source: WHO 2025.

Note: Dashed lines are 95 percent uncertainty intervals.

Substantial barriers still impede progress toward universal access to clean cooking, including rapid population growth in the areas facing the greatest deficits, insufficient financing to scale up clean cooking solutions, and gaps in policies and regulations that could otherwise promote equitable access.

Without stronger commitments and new policies, most LMICs will fall short of universal access by 2030. Over the past decade, global progress has averaged just 1.3 percentage points per year, slowing further to 1.2 points over the last five years—far too slow for SDG indicator 7.1.2. Achieving this goal required drastic acceleration, particularly in 41 countries—including 31 in Sub-Saharan Africa, where annual increases of 10–14 percentage points beyond current trends are needed between 2023 and 2030 (figure 2.4).

FIGURE 2.4 • NUMBER OF COUNTRIES REQUIRING STEEPER ANNUAL INCREASES IN ACCESS TO ACHIEVE UNIVERSAL ACCESS TO CLEAN COOKING BY 2030



Source: WHO 2025.

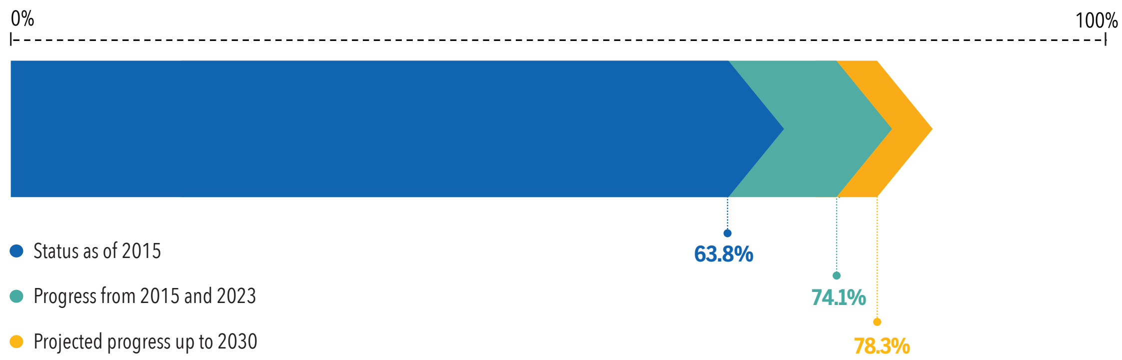
Note: The additional increases required to achieve universal access are calculated over the period 2023–30 and rounded to the nearest percentage point. The number displayed above each bar represents the count of countries.

Looking beyond the main indicators

In 2023, the global share of people relying primarily on clean cooking fuels reached 74 (70–77) percent. This represents a notable jump from just over 57 (53–61) percent in 2010. While the global progress over the last decade is considerable—lifting tens of millions of people annually out of reliance on polluting fuels—it masks the reality in smaller, less-developed countries, including LDCs, LLDCs, and SIDS, where adoption of clean cooking has stagnated. Most gains are heavily concentrated in a few populous countries (such as China, India, Indonesia, Nigeria, and Pakistan), while many smaller countries have seen only minimal improvements.

Urgent steps must be taken to close existing gaps, especially in areas with persistent deficits, if equitable access to clean cooking fuels and technologies is to be achieved by 2030 and beyond. Even with ongoing improvements, only about 78 (74–81) percent of the world's population is expected to have access by 2030, which means that around 22 (19–26) percent—which translates to approximately 1.8 (1.6–2.2) billion people—will not have access (figure 2.5).

FIGURE 2.5 • PROGRESS TOWARD UNIVERSAL ACCESS TO CLEAN COOKING, 2015-30



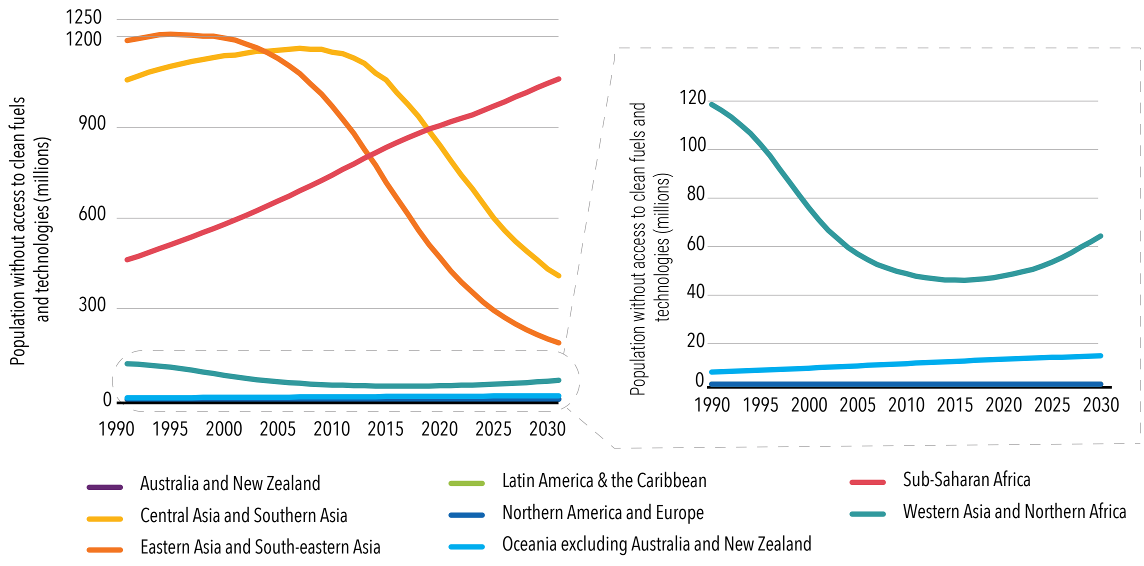
Source: WHO 2025.

The access deficit

Even as more people transition to clean cooking, some 2 billion still lack consistent access. Some regions—such as Eastern Asia, South-eastern Asia, and, more recently, Central Asia and Southern Asia—have made major strides and demonstrated how government-led programs, infrastructure investment, and economic growth can reduce deficits in a relatively short period. Conversely, in Sub-Saharan Africa, the convergence of rapid population growth, limited economic resources, and weak enforcement of energy policies continues to offset many local or national initiatives. This regional imbalance means that gains in some regions risk being offset by backsliding or stagnation in other parts of the world, jeopardizing overall progress toward SDG 7.

Despite substantial growth in some parts of the world, nearly 2.1 (1.9–2.5) billion people continue to cook primarily with polluting fuels, such as traditional biomass, charcoal, and kerosene. In Sub-Saharan Africa, the number of people lacking access continues to rise, potentially reaching 1 billion by 2030 if current trends persist and no action is taken (figure 2.6). Large national programs in several countries in Central Asia and Southern Asia have accelerated access in both urban and rural areas, although disparities persist within countries. Rapid urbanization and stable LPG and electricity supply in Eastern Asia and South-eastern Asia have driven a broad uptake of clean cooking in multiple countries.

FIGURE 2.6 • NUMBER OF PEOPLE WITHOUT ACCESS TO CLEAN FUELS AND TECHNOLOGIES, BY REGION, 1990-2030

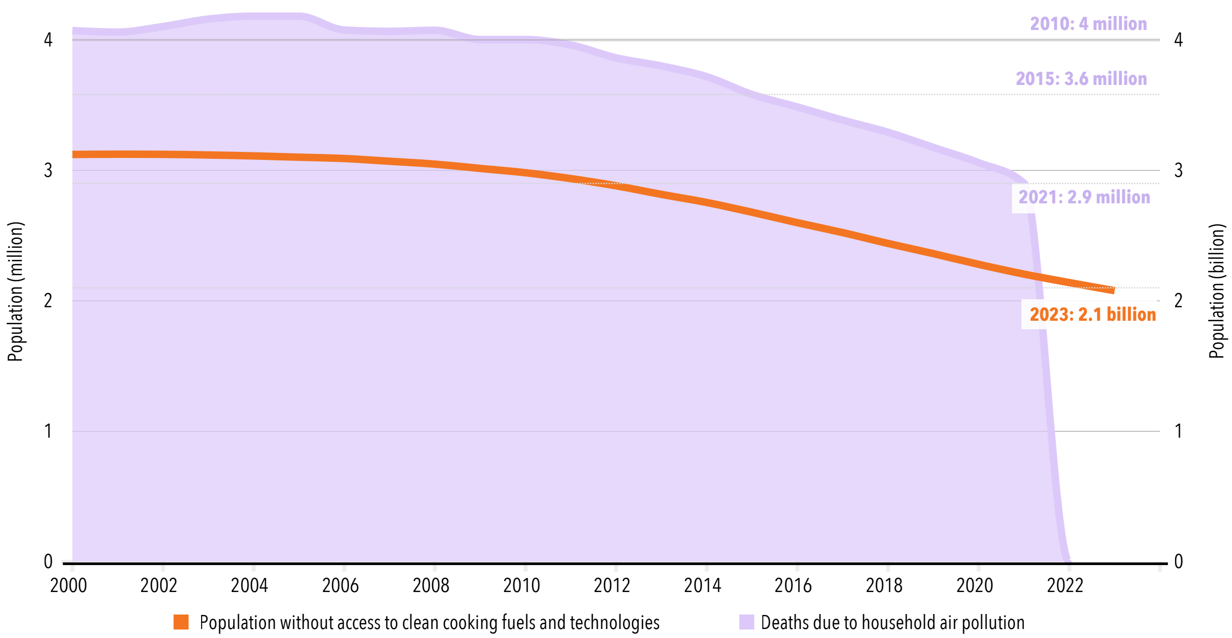


Source: WHO 2025.

While progress in clean cooking access continues, adoption and sustained use remain challenging, as households often engage in fuel and technology stacking—using multiple methods for cooking, heating, and lighting rather than switching entirely to a single clean option. This behavior is widespread and not inherently negative, occurring in both LMIC and high-income contexts. However, cost fluctuations and irregular fuel supply can lead to reliance on more polluting options within the stack, limiting the effectiveness of clean cooking solutions in reducing household air pollution. Supporting households transition toward the cleanest possible stack is essential to fully realize the associated benefits for health, social equality, gender equity, and climate change mitigation.

In an effort to measure the impact of household air pollution, the World Health Organization (WHO) estimated that, in 2021, household air pollution was linked to an estimated 2.9 million yearly deaths (figure 2.7), including more than 329,000 among children under the age of five (WHO 2025). When examining trends in deaths from household air pollution and the number of people relying on clean cooking fuels and technologies, we observe a steady decline in mortality over the past decade. However, as illustrated in the figure, many people continue to face serious health risks. In 2023, of the 2.1 (1.9–2.5) billion people who still lacked access to clean cooking, many were likely exposed to toxic cooking smoke. This exposure contributes to millions of premature deaths each year, particularly among women and children.

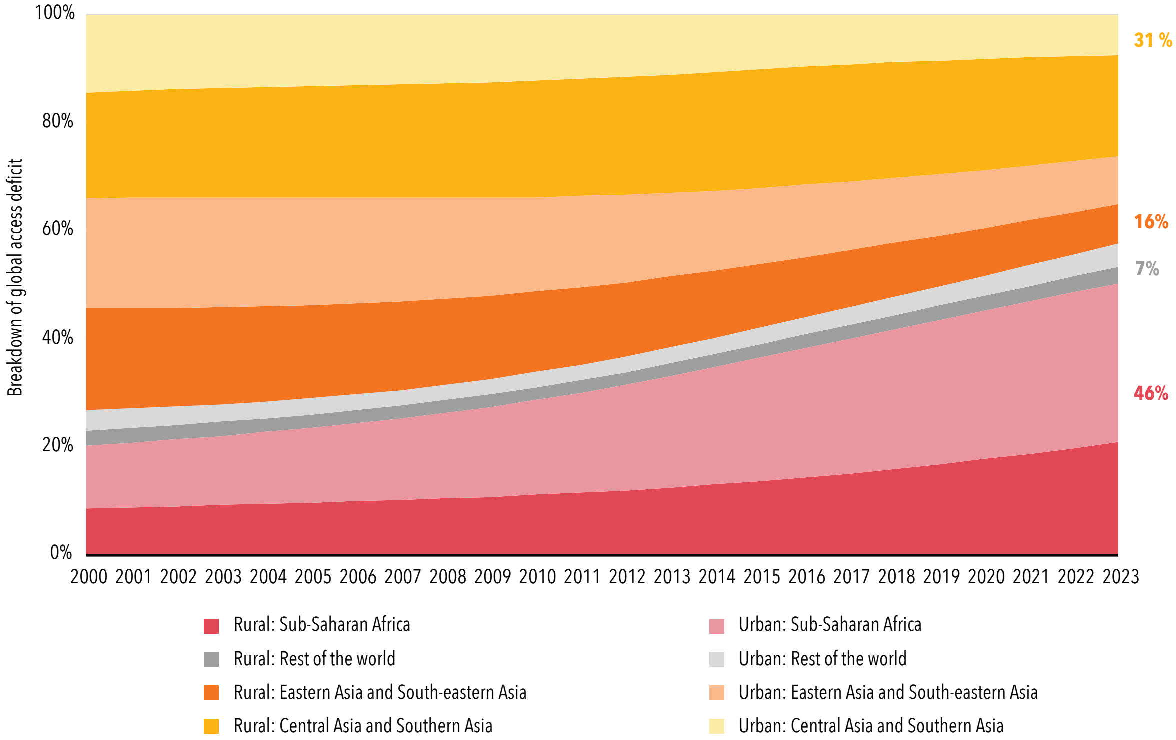
FIGURE 2.7 • TRENDLINE OF ESTIMATED DEATHS FROM HOUSEHOLD AIR POLLUTION, 2000–21; AND PEOPLE LACKING ACCESS TO CLEAN COOKING FUELS AND TECHNOLOGIES, 2000–23



Source: WHO 2025.

Figure 2.8 highlights how the regional makeup of people without access to clean cooking shifted from 2000 to 2023. In 2000, 40 percent were in Central and Southern Asia, 40 percent in Eastern Asia and South-eastern Asia, and 20 percent in Sub-Saharan Africa. By 2023, half of the global population without access lived in Sub-Saharan Africa, reflecting marked declines in the Asian deficits but a significant increase in the Sub-Saharan Africa region. If this pattern continues, nearly 60 percent of people lacking access will be found in Sub-Saharan Africa by 2030. Achieving progress in these settings requires calibrating efforts to local conditions, including levels of economic development, infrastructure, and the availability of clean household energy sources to ensure that solutions are both appropriate and sustainable.

FIGURE 2.8 • PROPORTION OF THE TOTAL GLOBAL ACCESS DEFICIT IN THE THREE LARGEST ACCESS-DEFICIT REGIONS AND THE REST OF THE WORLD, 2000–23



Source: WHO 2025.

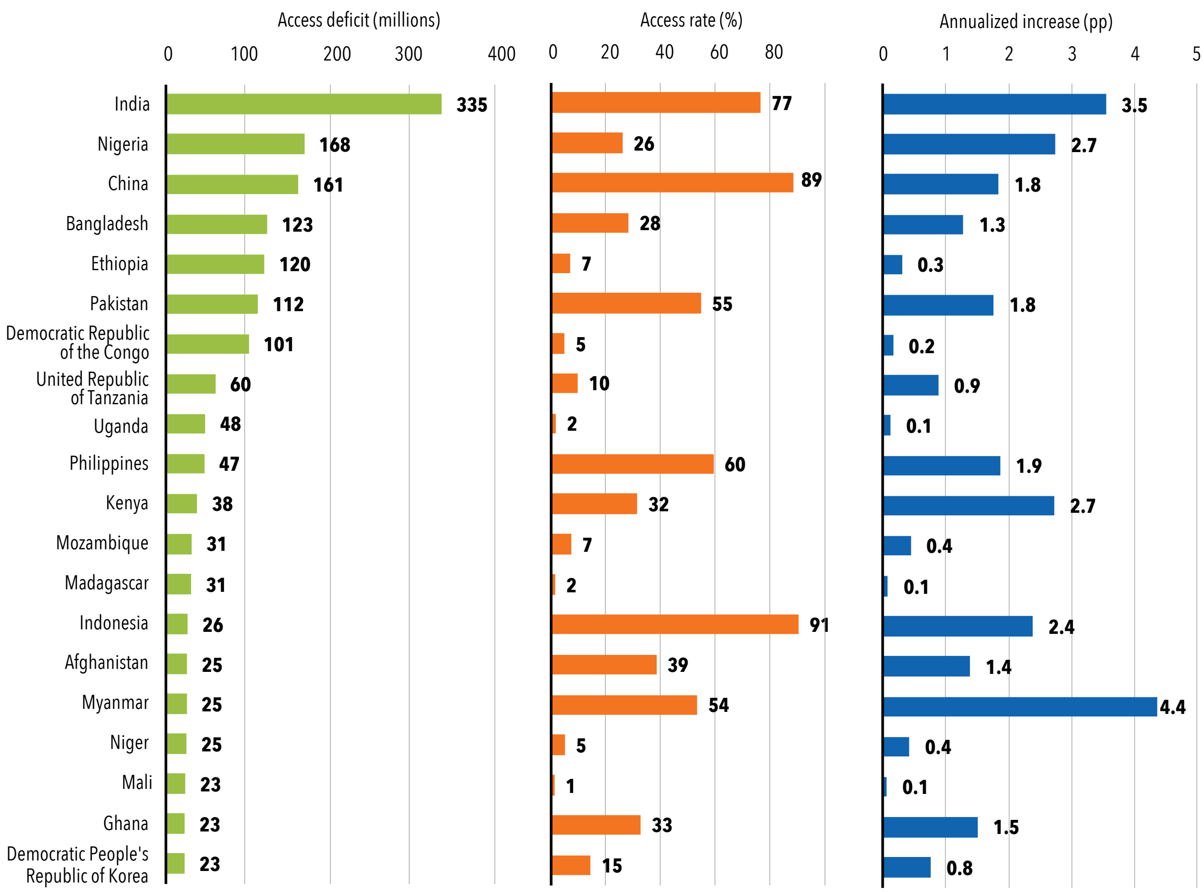
The top 20 access-deficit countries

Access deficit is an indicator that measures the total (absolute) number of people who rely primarily on polluting fuels and technologies to do their cooking. These populations are bearing the harmful health and socioeconomic consequences of such fuels and technologies.

Over the past decade the number of people lacking access declined from 2.8 (2.4–3.1) billion in 2014 to 2.1 (1.8–2.4) billion in 2023. Just 20 countries account for 70 percent of the global access deficit in absolute numbers, with most of them in Sub-Saharan Africa and the remainder scattered across Asia (figure 2.9).

In eight of these countries, all of them LDCs housing large numbers of displaced populations, fewer than 10 percent of households use clean fuels, reflecting severe infrastructure gaps that exacerbate socioeconomic effects and heighten the vulnerabilities of these populations. These countries are the Democratic Republic of the Congo, Ethiopia, Madagascar, Mali, Mozambique, Niger, Uganda, and the United Republic of Tanzania. Moreover, 14 of the top 20 show access rates below 50 percent, and only one—Indonesia—exceeds 90 percent, despite being the country with the 14th-highest access deficit by absolute population. India continues to have the largest absolute population without access, yet both India and Myanmar have recorded some of the most significant gains in overall clean cooking coverage over the past five years, with annualized increases of 4 and 5 percentage points, respectively.

FIGURE 2.9 • THE 20 COUNTRIES WITH THE LARGEST ACCESS DEFICIT BY ABSOLUTE POPULATION (BLUE), ACCESS RATE (ORANGE), AND ANNUALIZED INCREASE IN ACCESS (GREEN), BASED ON THE 2018–23 AVERAGE



Source: WHO 2025.

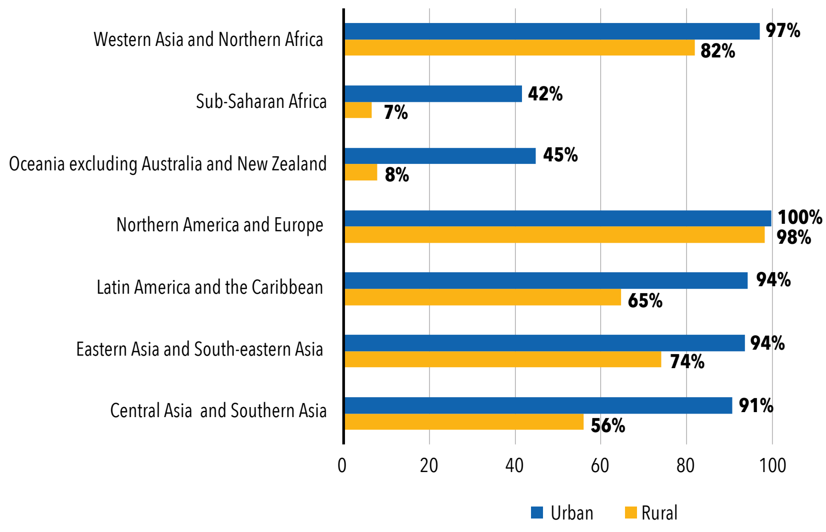
pp = percentage point.

The urban-rural divide

In 2023, 89 (85–90) percent of people in urban areas worldwide had access to clean cooking, compared with 55 (50–60) percent in rural areas (figure 2.10).

While incremental progress in rural areas has helped narrow the urban-rural gap since 2010, the difference in absolute numbers remains significant. An estimated 1.5 (1.4–1.7) billion people residing in rural areas still lack access to clean cooking, compared with 529 (455–675) million urban residents. Reducing inequalities requires decentralized approaches—for example, small LPG depots, household biogas plants, mini-grids that facilitate electric cooking, and financing models that accommodate variable incomes and vulnerability. Such strategies can help remove the barriers that leave rural communities spending time collecting fuel and urban communities that often rely on expensive, inefficient charcoal.

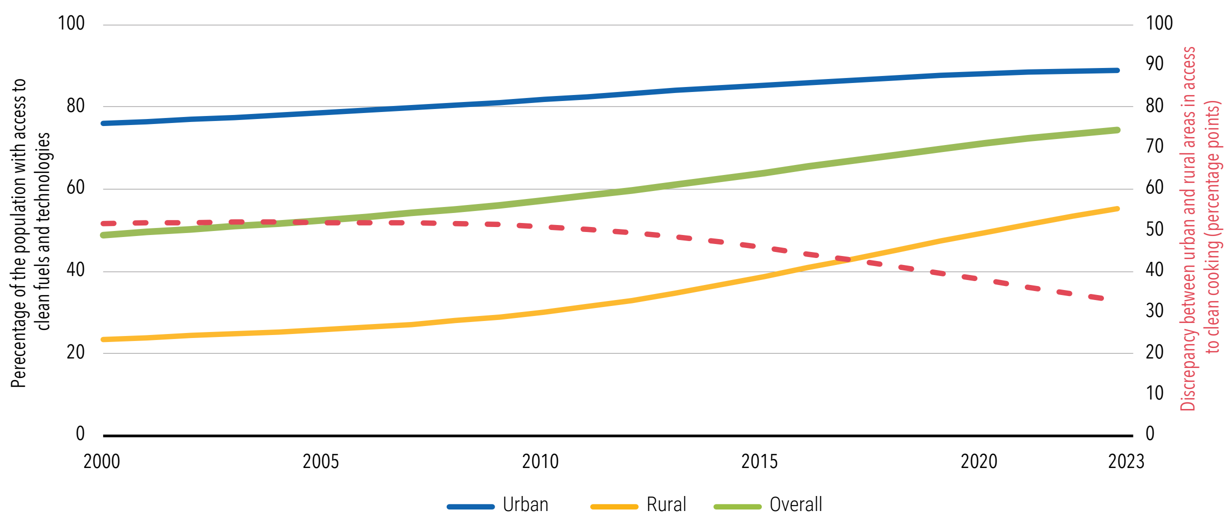
FIGURE 2.10 • POPULATION WITH ACCESS TO CLEAN FUELS AND TECHNOLOGIES FOR COOKING BY REGION (PERCENT)



Source: WHO 2025.

Urban households adopt clean cooking fuels and technologies at a higher rate than rural households, likely because of stronger infrastructure (such as roads), more reliable energy supplies, and higher incomes. Over the last decade, urban clean cooking coverage edged up from 84 (81–87) percent to 89 (85–90) percent, whereas coverage in rural areas jumped from 37 (33–41) percent to 55 (50–60) percent. The past five years have seen a significant shrinkage in the access gap between urban and rural areas, changing from 40 percentage points in 2019, to 33 in 2023, as shown in figure 2.11.

FIGURE 2.11 • 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), 2000–23



Source: WHO 2025.

Across most LMICs, urban households are more likely to own gas stoves and electric appliances, and to have more reliable access to fuels such as LPG. Even so, not all urban households benefit from these advances; low-income urban neighborhoods can struggle with unpredictable pricing or limited supply and distribution of specific cooking fuels.

In the meantime, rural communities, especially in Sub-Saharan Africa (where only 7 [5–8] percent of the population has access to clean cooking fuels and technologies), face even more formidable challenges: they often lack the infrastructure and market base for large-scale fuel distribution, and the installation costs of clean cooking technologies (e.g., stoves and appliances) remain prohibitive for many low-income households and other vulnerable populations such as refugees and internally displaced people.

Additionally, LDCs, LLDCs, and SIDS present a notable example of urban-rural inequality. In these country groups, urban residents are two to four times more likely to use clean cooking fuels and technologies than those in rural areas. In LDCs, just 10 (8–13) percent of the rural population uses clean cooking fuels and technologies, while that number rises to 40 (36–44) percent in urban areas—four times higher. In LLDCs, clean cooking access in urban areas—at 53 (45–57) percent—is more than triple that in rural areas (15 [12–18] percent). In SIDS, the share of urban residents relying on clean cooking fuels (76 [72-80] percent) is twice that of rural residents (35 [30–42] percent).

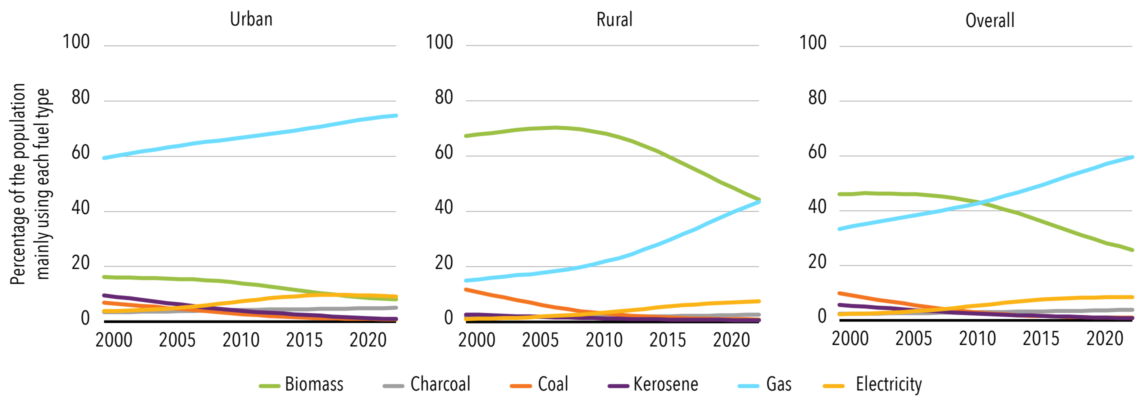
Changes in the fuel mix

A detailed look at fuels and technologies used in LMICs in 2023 shows that gaseous fuels—LPG, natural gas, and biogas—remained the primary energy source for 60 (54–66) percent of the population, accounting for nearly 4 billion people overall.

Although gaseous fuels command center stage overall (figure 2.12), biomass (wood, dung, agricultural waste) and charcoal remain highly prevalent in rural areas, where supply chains are more fragile. In 2023, biomass remained the primary cooking fuel for almost half of the population living in rural areas: 44 (39–49) percent; or 1.4 billion people, slightly exceeding gas (44 [38–49] percent).

With the use of unprocessed biomass declining in both urban and rural areas, the share of households using charcoal is growing, particularly in urban areas of Sub-Saharan Africa, where 30 (26–34) percent, or nearly 157 million people, depended on charcoal in 2023. A similar share of urban residents in the region used gaseous fuels (30 [26–35] percent), while 24 (21–28) percent continue to rely on biomass.

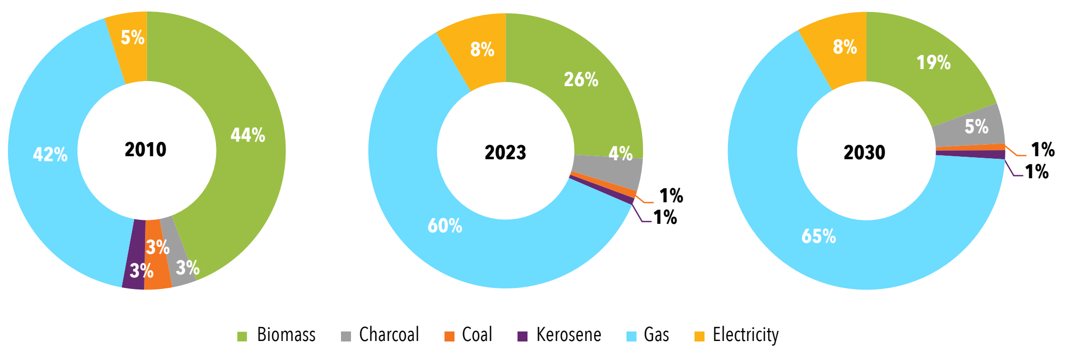
FIGURE 2.12 • PERCENTAGE OF PEOPLE IN LOW- AND MIDDLE-INCOME COUNTRIES RELYING PRIMARILY ON EACH TYPE OF COOKING FUEL: URBAN, RURAL, AND OVERALL



Source: WHO 2025.

Globally, electricity was the main fuel for 8 (6–12) percent of people (nearly 560 million), with little variation between urban (9 [6–14] percent) and rural (7 [4–12] percent) areas (figure 2.13). However, its use remained lowest in rural areas of Central and Southern Asia, where it accounted for less than 1 (0.5–2) percent of primary cooking fuels. Meanwhile, coal and kerosene use declined significantly, representing less than 1 percent of global primary cooking fuels in 2023, with 0.5–1.8 percent (58 million people) using coal and 0.4–1.8 percent (54 million people) using kerosene.

FIGURE 2.13 • COMPARISON OF THE PERCENTAGES OF PEOPLE IN LOW- AND MIDDLE-INCOME COUNTRIES USING VARIOUS FUEL TYPES IN 2010 AND 2023, WITH PROJECTIONS FOR 2030



Source: WHO 2025.

These evolving fuel trends highlight the need for cohesive policies and complementary measures. Expanding access to clean cooking fuels and technologies requires more than just stove distribution; it must be accompanied by a reliable fuel supply, public communication, user-centered solutions to stimulate demand and support adoption and sustained use, and complementary policies focusing on affordability. Approaches should also consider sociocultural contexts, job creation along the energy value chain, and the role of women as critical agents of change. Without such integrated efforts, clean cooking solutions may go underused, with families reverting to wood or charcoal.

Box 2.1 offers a closer look at the association between wealth and access to clean cooking fuels and technologies.

BOX 2.1 • COUNTRY AND REGIONAL DISPARITIES THROUGH THE LENS OF WEALTH

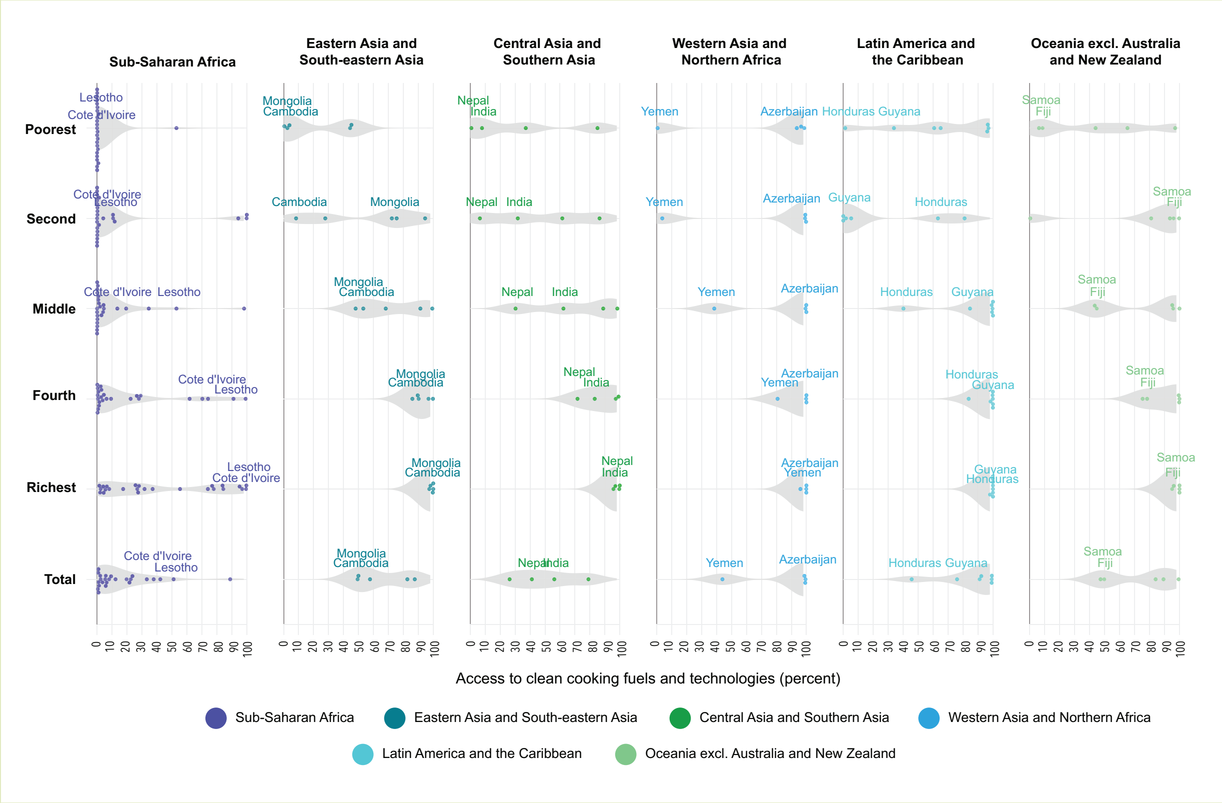
Disaggregating clean cooking data by wealth is vital for revealing economic barriers, devising equitable policies, and ensuring that improvements in energy access benefit every segment of society.

Examining data from two major household surveys—Demographic and Health Surveys (DHS) and the Multiple Indicator Cluster Survey (MICS)—disaggregated by wealth quintile and conducted recently (since 2018), sheds light on patterns across 51 LMICs and uncovers disparities and equity dimensions, revealing the patterns of potential impacts of wealth on access to clean cooking solutions, affordability more generally, and health outcomes.

The survey data reveal a clear positive association between wealth and access to clean cooking fuels and technologies (figure B2.1.1). In almost all countries represented, households in the richest wealth quintile consistently exhibit much greater access than those in the poorest quintile. This trend indicates that economic resources play a crucial role in determining the ability to adopt cleaner energy solutions, likely reflecting differences in infrastructure, affordability, and perhaps, policy focus on energy access.

BOX 2.1 • COUNTRY AND REGIONAL DISPARITIES THROUGH THE LENS OF WEALTH *(cont.)*

FIGURE B2.1.1 • COUNTRY ACCESS TO CLEAN COOKING FUELS AND TECHNOLOGIES, BY WEALTH QUINTILE AND REGION



Source: Data extracted from DHS and MICS.

Note: The figure presents country-level data, where each dot represents a single country value for each wealth quintile within a region. Grey-shaded areas indicate the distribution of all values. Two countries with the highest disparities (measured as the ratio of the richest to the poorest wealth quintile) in each region are labeled.

In Sub-Saharan Africa, the disparities in access to clean cooking fuels are often extreme. For example, in Kenya, the difference is pronounced, with poorer quintiles (poorest and second) showing less than 1 percent access and the wealthiest reaching 84 percent. Other countries in the region exhibit comparable patterns. In Lesotho and Côte d'Ivoire, the poorest quintile has access lower than 1 percent, while the richest can achieve access levels exceeding 90 percent, again indicating a significant disparity.

These examples from Sub-Saharan Africa underscore the urgent need for policies that address both economic and infrastructural barriers if inequities in access to clean cooking technology are to be reduced. Such policies should also consider context-specific barriers to the clean cooking transition and promote actions and investments in appropriate fuels and technologies suited to local needs.

Conversely, in the Western Asia and Northern Africa region, countries such as Jordan exhibit a more moderate wealth gradient. In Jordan, even the poorest households enjoy high access levels (above 98 percent), with the richest households showing only a modest increase over the rest of the wealth quintiles. This suggests that regional policies, infrastructure investments, and broader economic factors contribute to more uniform access to clean cooking fuels and technologies, reducing the disparity between wealth groups.

Policy insights

Clean cooking and its role in health and gender equality

Achieving universal access to clean cooking remains a critical challenge with profound implications for public health and gender equality, two SDGs to be reviewed at the High-Level Political Forum in 2025. While the proportion of the global population with access to clean cooking has steadily increased over the past few decades, progress remains insufficient. Our estimates indicate that by 2030, approximately 1.8 (1.6–2.2) billion people—most of whom live in Sub-Saharan Africa—will still be cooking with polluting fuels and technologies unless more ambitious actions are taken.

The health impacts of household air pollution from burning polluting fuels such as wood, charcoal, and agricultural residues are well documented. In 2021, exposure to household air pollution was estimated to contribute to 2.9 million premature deaths annually, including over 329,000 deaths of children under the age of five (WHO 2025). Long-term exposure to fine particulate matter (i.e., PM2.5[9]) emitted from inefficient combustion of these fuels is linked to noncommunicable diseases, such as stroke, ischemic heart disease, chronic obstructive pulmonary disease, and lung cancer. In children under five, exposure to household air pollution is responsible for nearly half of all pneumonia deaths. The burden of disease due to household air pollution is particularly high in rural and low-income communities, as well as among displaced populations such as refugees and internally displaced persons, where access to clean cooking alternatives is limited by economic constraints, inadequate infrastructure, and poor policy implementation.

Beyond health, the lack of access to clean cooking also poses a barrier to gender equality. In many communities, women and girls bear most of the responsibility for household cooking and fuel collection. They spend hours each day gathering wood, charcoal, or dung—time that could otherwise be spent on education, income-generating activities, or personal well-being. This burden frequently extends to children, particularly girls, who may miss school to assist with fuel collection or care for ill family members suffering from exposure to household air pollution. The burden of fuel collection over long distances also exposes women and girls to risks of physical injury and gender-based violence. These risks can be even greater in settings marked by fragility or displacement, where basic protections are limited and it may not be safe to move about freely. Cooking with biomass takes significantly longer, including time spent tending the fire. One study estimated the extra time needed for collecting and cooking with biomass at 650 hours per year per household (Troncoso and others, 2025, under review).[10] These two extra hours per day could make the difference for women's and girls' opportunities and quality of life. When children are involved, these lost hours can also limit their educational progress and long-term development, further reinforcing cycles of poverty and inequality.

Achieving universal access to clean cooking requires strong and inclusive policies, sustained financial commitments, and solutions that consider both health and gender equality. Governments need to make clean cooking affordable by providing subsidies, grants, and accessible credit programs, ensuring that these solutions are not only available but also financially feasible for low-income households. Women's participation in clean cooking businesses—from stove distribution to fuel supply chains—can create sustainable economic opportunities while driving wider adoption of clean cooking fuels and technologies. Inclusive approaches should also extend to vulnerable populations in humanitarian and fragile settings, where tailored solutions are needed to close persistent gaps in access to energy. Beyond national efforts, stronger global cooperation and expanded financing (made available through a wider range of mechanisms) are essential to accelerate progress. International climate finance, such as carbon markets and development aid, can

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9 Fine particulate matter with a diameter of 2.5 micrometers or less.

10 For other estimates, see Jeuland, Tan Soo, and Shindell (2018); Das and others (2025); and Krishnapriva and others (2021).

be leveraged to scale up clean cooking initiatives, recognizing their far-reaching benefits for health, gender, equity, and climate mitigation.

Ensuring clean energy at home: Cooking, heating, and lighting

While clean cooking has been a major focus of the energy transition in many countries, other household uses of energy—notably heating and lighting—also play significant roles in health and climate outcomes. In many parts of the world, especially in cold-climate regions, inefficient heating systems that rely on coal, wood, or other solid fuels contribute to both household and ambient air pollution, increasing health risks and climate emissions (box 2.2). Many communities, particularly in Eastern Europe, Central and Eastern Asia, and parts of Northern America, still rely on polluting heating fuels, resulting in severe wintertime air pollution. In other parts of Europe, biomass heating has made a comeback, partly owing to subsidies for wood stoves and a growing trend for stoves and open fires—even in some big cities. To maximize health and climate co-benefits, policy makers must take an integrated approach to household energy transitions, addressing all forms of energy use.

BOX 2.2 • GLOBAL AND REGIONAL ESTIMATES FOR POLLUTING HEATING

Unlike household cooking, for which data over the past few decades is well documented, global and regional estimates for polluting heating have been lacking. The World Health Organization has now developed the first estimates of populations primarily using heating technologies producing high carbon emissions.

Using the WHO Global Household Energy Database and a custom statistical model, estimates were generated for the proportion and number of people relying on high-emission and low- to medium-emission heating at the global, regional, and national levels. High-emission fuels and technologies are defined as heaters/stoves burning solid fuels (including all types of wood), kerosene/paraffin, or gasoline/diesel. Low- to medium-emission fuels and technologies, by contrast, include all central heating systems, boilers, heat pumps, heat recovery systems, and stoves/heaters using electricity or gaseous or liquid fuels that meet WHO guidelines.

In 2022, an estimated 26 percent of the world's population (1.8 billion) relied primarily on high-emission heating, while 33 percent (2.5 billion) relied on low- to medium-emission fuels. The remaining 41 percent (3.1 billion) had no household heating. Although the global share of the population using high-emission heating had declined slightly from 2000, population growth offset this progress, resulting in stagnant or rising absolute numbers. Rural populations remained more reliant on high-emission heating, with 39 percent using it in 2022, compared with just 15 percent in urban areas.

The overlap between polluting cooking and high-emission heating has not yet been quantified at the household level. However, combining WHO's new heating estimates with cooking data suggests that at least 3.1 billion people relied on polluting household energy in 2022, with an upper estimate of 3.7 billion. While reliance on polluting cooking has been steadily declining, high-emission heating is on the rise. Sub-Saharan Africa has the highest reliance on polluting cooking; however, 72 percent of its population uses no household heating at all. In contrast, the number of people using high-emission heating in Eastern and South-eastern Asia nearly doubled between 2000 and 2022, despite significant transitions to clean cooking. High-income countries, where clean cooking is nearly universal, still face significant challenges with polluting heating.

Expanding tracking mechanisms to include heating is essential for accelerating the transition to clean household energy and reducing health and environmental risks.

Urgent policy and investment actions to accelerate the transition to clean household energy

With just five years left to achieve universal access to clean cooking under SDG 7, urgent action is needed to rapidly scale up investments, strengthen policies, and integrate clean household energy into national development strategies. Governments, international organizations, and other key stakeholders must significantly increase investments in clean household energy infrastructure and technologies, ensuring that solutions are widely accessible, affordable, and tailored to specific regional and local energy needs. Financing strategies can play a key role in supporting these efforts through greater public and private investment and international financial support where appropriate. Policies and actions must balance immediate health needs with longer-term environmental and climate goals.

A just and inclusive transition is essential, especially for women and girls, who disproportionately bear the burden of household air pollution. Their active involvement in decision-making and the implementation of clean energy solutions is crucial. Moreover, rural and low-income households—as well as refugees, internally displaced persons, and those living in fragile settings—must be prioritized to prevent further deepening of energy poverty. High-income countries, in addition to supporting global efforts, should also prioritize their own transitions to sustainable household energy—phasing down fossil-fuel-based cooking and heating systems through electrification, energy efficiency, and renewables-based solutions that align with net-zero targets.

Policy makers should also enhance public awareness and invest in user-centered approaches that promote the adoption and sustained use of clean cooking, heating, and lighting, helping households recognize the wide-ranging health, social, and economic benefits. The health sector can play a significant role in driving such change. Clean household energy is as much a health intervention as it is an energy solution. Health ministries and health-care workers, including clinical and public health professionals, must be equipped to recognize and communicate the health risks of household air pollution and prescribe clean household energy solutions. By identifying and promoting effective policy and intervention options to communities, the health sector can drive greater public awareness and demand for clean air at home and clean household energy solutions.

Beyond clean cooking, ensuring clean household energy access for heating and lighting is equally critical. Without addressing all forms of household energy use, millions will remain exposed to harmful pollutants, undermining progress in health, gender equality, and climate mitigation. This is particularly true for people in settings characterized by conflict and displacement, where energy access is often overlooked but urgently needed for safety and well-being.

The next five years will be pivotal. Governments must act decisively to increase investments, implement transformative policies, facilitate access to a range of financing options, and strengthen cross-sector collaboration to accelerate the clean household energy transition. The success of SDG 7 will not only determine energy access for billions but will also have lasting implications for global health, gender equality, child development, and climate resilience.

Photo: © Masdar Official

CHAPTER 3
RENEWABLES

Main messages

- **Global trend.** In 2022, renewables represented 17.9 percent of the world's total final energy consumption (TFEC), including traditional uses of biomass, and 13 percent excluding them. TFEC, which had doubled in the preceding 15 years, continued to increase despite the disruption caused by the COVID-19 pandemic and the ensuing energy crisis. Renewables' share of TFEC remained relatively steady over the previous three decades, increasing slowly over 2012–22 (+2.8 percentage points), despite their increased use in electricity generation. The electricity sector continues to lead in the growth of renewables' share, while progress in transport and heat remains limited.
- **Target for 2030.** Ensuring access to affordable, reliable, sustainable, and modern energy for all requires swifter expansion of renewable energy's use in generating electricity and heat, and for transport. Target 7.2 of Sustainable Development Goal (SDG) 7 calls for a substantial increase of the share of renewable energy in the global energy mix by 2030. 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 SDG target or other international climate and development objectives. Significant action to expand the adoption of renewable energy and boost energy efficiency 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, with 585 GW of renewable capacity added in 2024. Under current policies and market conditions, global power capacity is expected to increase another 2.7 times, by 2030. But even this expansion is not sufficient to triple global renewables' capacity by 2030—an objective endorsed by the Parties to the UNFCCC at the United Nations Climate Change Conference (COP28) in 2023.
- **Electricity.** The use of renewables-based electricity grew almost 8 percent from 2021 to 2022, and by 56 percent from 2015. As of 2022, almost 30 percent of all energy consumed to generate electricity was renewable—the largest share among all end uses of renewables. Renewables-based electricity, in turn, represented more than a third of global renewable energy consumption and half of modern uses of renewable energy. Continuous new capacity additions—mainly in wind and solar photovoltaics (PV), for which the combined generation more than tripled in 2022 relative to 2015—is rapidly increasing renewables' share in electricity. Hydropower remains the predominant source of renewables-based electricity in the world, meeting 15 percent of global demand.
- **Heat.** In 2022, renewable sources accounted for about 21 percent of the world's use of energy for heat. Notably, almost half of this renewables-based heat took the form of the traditional use of biomass (19 exajoules [EJ]), of which more than 90 percent was concentrated in Sub-Saharan Africa and Asia. The share of modern renewable energy use in global heat consumption increased marginally. The share was just 11 percent in 2022, only 2.1 percentage points higher than a decade earlier. This is in large part because of the simultaneous increase in global annual heat demand, despite the 2022 energy crisis.

- **Transport.** Final energy consumption for transport grew 4 percent (+4 EJ) in 2022, while remaining below 2019 levels. The share of renewable energy in transport TFEC rose to 4 percent in 2022, up from 3.1 percent in 2015. Biofuels, primarily crop-based ethanol and biodiesel, continued to dominate renewable energy use in transport, growing 5 percent year-on-year in 2022. Remarkably, the amount of renewables-based electricity used in vehicles and trains almost doubled from 2015—due to higher electric vehicle (EV) sales and a greater share of renewables in electricity for transport.
- **Regional highlights.** The widespread use of traditional biomass for heating and cooking in Sub-Saharan Africa places it first among the regions where renewables constitute the largest share of energy supply. When considering only modern uses of renewable energy, the share of renewables in TFEC was the highest in Latin America and the Caribbean, reflecting hydropower generation and the consumption of bioenergy in industrial processes and biofuels for transport. In 2022, almost half of the global year-on-year increase in modern uses of renewable energy came in Eastern Asia, essentially China, where wind and solar PV dominated growth, followed by Northern America and Latin America and the Caribbean.
- **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 largest shares of modern uses of renewables in 2022 (respectively, 45 percent and 24 percent of TFEC), due to their considerable reliance on hydropower for electricity, biofuels for transport, and biomass for extracting heat, specifically, in industry. Also in that year, Korea and Türkiye recorded the largest year-on-year increase in the share of modern uses of renewables (+16 and +15 percent, respectively),[11] followed by China and Germany (+9 percent). China alone accounted for more than a fifth of global modern uses of renewable energy. Between 2010 and 2022, the United Kingdom, Germany, and China led in the growth of the share of modern uses of renewables in TFEC (+10, +8, and +8 percentage points, respectively), followed by India, Indonesia, and France (with shares increasing between +5 and +6 percentage points). This growth was mostly possible thanks to the development of wind and solar PV, as well as a significant decrease in TFEC in the United Kingdom, Germany, and France in 2010–22, and a significant shift from traditional to modern uses of biomass in China, Indonesia, and India.
- **Indicator for installed renewable energy generating capacity in developing countries.** Installed renewables-based capacity reached an all-time high in 2023, both globally at 478 watts per capita and in developing countries at 341 watts per capita. Yet significant disparities among countries and regions remain, with developed countries having 3.4 times more renewable power per capita than developing countries. Oceania and Northern America and Europe lead in installed renewables-based capacity per capita, with over 1,100 watts installed, while Sub-Saharan Africa remains critically behind, at only 40 watts per capita. While least-developed countries (40 watts per capita), landlocked developing countries (105 watts per capita), and small island developing states (110 watts per capita) have gradually added renewables-based capacity, deployment remains well below levels in both developing countries and the world overall. Given the energy access gaps in many of these countries as well as persistent inequality between developed and developing countries, continued efforts are needed to overcome these inequities, to reach target 7.b, "expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries."

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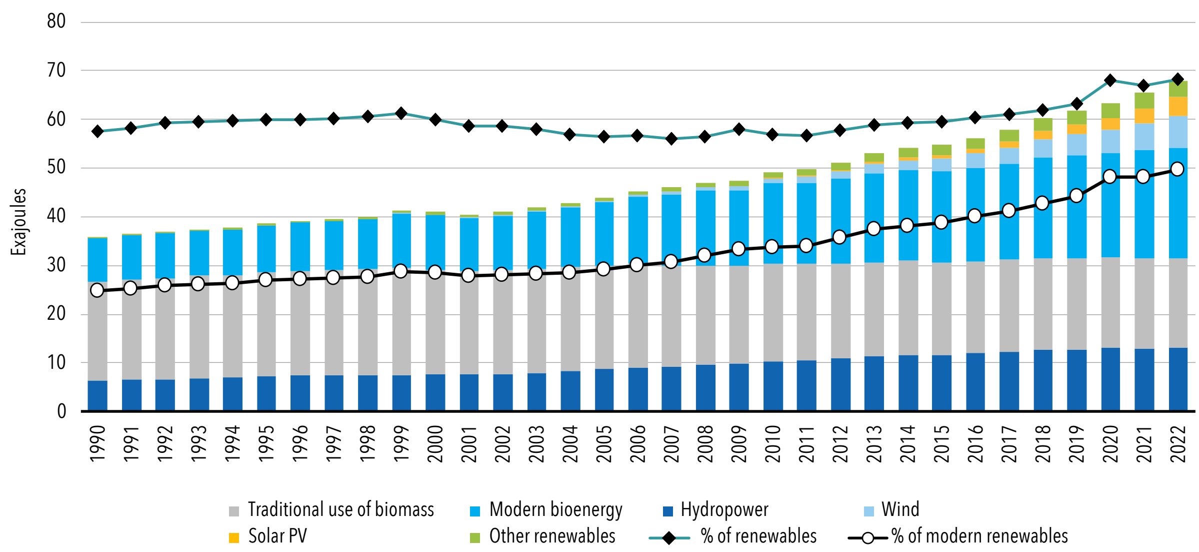
11 The Kingdom of Saudi Arabia more than doubled its share of modern uses of renewables on a year-on-year basis. The share remains marginal, however (0.15 percent in 2022).

Are we on track?

Globally, renewables have maintained a relatively steady share of TFEC over the past three decades; their share grew slowly in the most recent decade (+2.8 percentage points), despite their accelerated deployment in electricity generation.[12]

Global final energy consumption grew 1.8 percent year-on-year in 2022, but this increase was not as significant as the rebound (5 percent) following the worldwide COVID-induced disruptions in 2021. Global renewable energy consumption, including traditional uses of biomass,[13] reached 67.8 EJ in 2022, bringing renewables' share of global TFEC to 17.9 percent. This share was slightly higher than the 17.6 percent[14] of the year before but at the same level as observed in 2020 (figure 3.1).

FIGURE 3.1 • RENEWABLE ENERGY CONSUMPTION AND SHARE OF TFEC BY TECHNOLOGY—MODERN AND TOTAL RENEWABLES, 1990–2022



Source: International Energy Agency and United Nations Statistics Division.

Note: EJ = exajoule; PV = photovoltaic; TFEC = total final energy consumption.

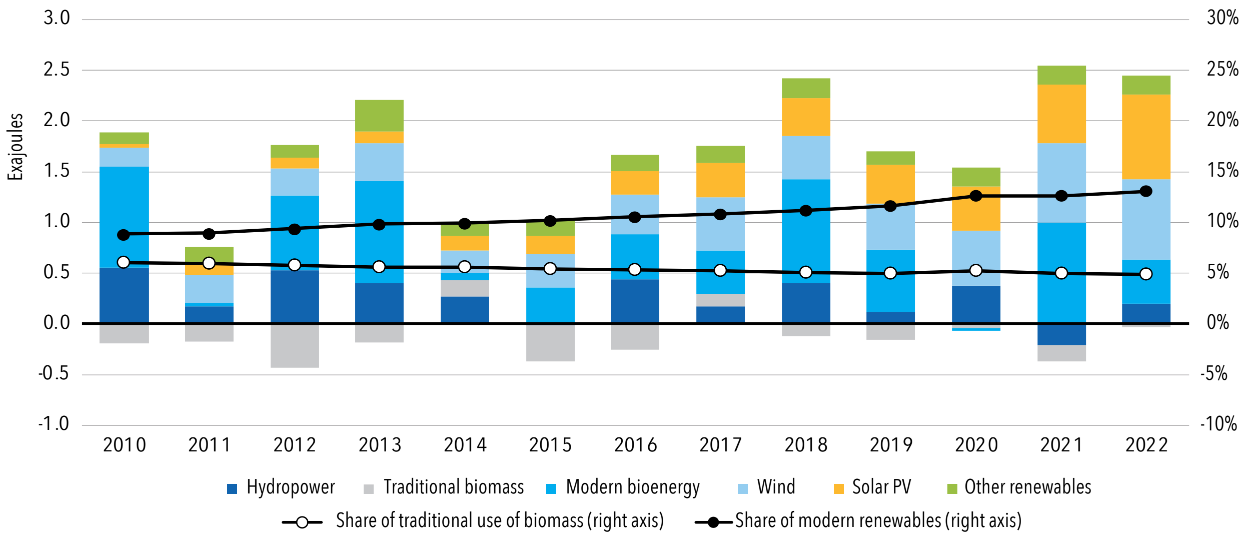
12 If not referenced otherwise, all data in this chapter come from the IEA World Energy Balances database (IEA 2024a), UNSD Energy Balances 2022 (UNSD 2024a), Energy Statistics Database 2022 (UNSD 2024b), and IRENA Renewable capacity statistics 2025 (IRENA 2025).

13 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, for example, traditional open cookstoves and fireplaces. The low conversion efficiency of such solutions can generate adverse environmental effects, including indoor pollution, which poses health hazards. Because of their informal and noncommercial nature, it is difficult to estimate the energy consumed in such practices, 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 also used with low efficiency in OECD countries (e.g., in fireplaces burning split logs), it is 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.

14 The 2021 share of renewables in TFEC has been revised downward from 18.7 percent (as stated in last year's report) to 17.6 percent. This is because solid biofuels consumption in 2021 in the residential sector was revised downward for Nigeria, South Africa, and Zimbabwe in the 2024 edition of the IEA World Energy Balances database, due to the adoption of a more accurate bottom-up methodology for estimating consumption per capita. Residential solid biofuel consumption in 2021 was also revised downward for China, to reflect trends in population with a primary reliance on biomass for cooking, as reported by the World Health Organization. The figures for Ethiopia and Indonesia underwent similar downward adjustments based on the latest official statistics.

From 2021 to 2022, growth in renewable energy use came predominantly from solar PV, wind, and modern uses of bioenergy, followed by hydropower and geothermal and solar thermal, whereas traditional uses of biomass declined slightly (figure 3.2). The shares of solar PV and wind power in TFEC grew about 27 percent and 14 percent year-on-year, respectively, and together were responsible for three-quarters of the increase in renewables-based electricity.

FIGURE 3.2 • GROWTH IN RENEWABLE ENERGY CONSUMPTION BY TECHNOLOGY AND THE SHARES OF MODERN USES OF RENEWABLE ENERGY AND TRADITIONAL USES OF BIOMASS IN TFEC, 2010–22

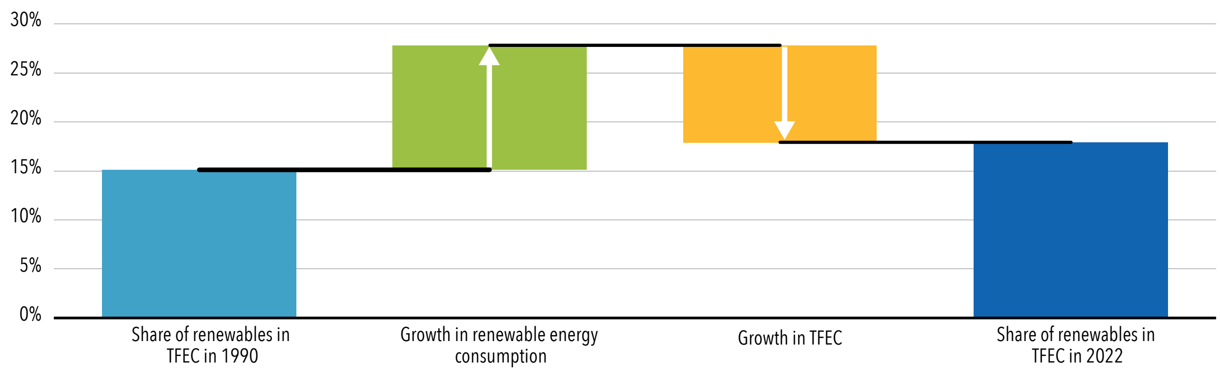


Source: International Energy Agency and United Nations Statistics Division.

Note: EJ = exajoule; PV = photovoltaic.

From 1990 to 2022, global renewable energy consumption grew 89 percent while TFEC grew 60 percent. As a result, the share of renewable energy in TFEC remained relatively steady (figure 3.3). Two trends coexisted in that period: The share of modern uses of renewables (excluding traditional uses of biomass) in TFEC progressively increased, from 6.5 percent in 1990 to more than 13 percent in 2022, with the strongest growth in the electricity sector. Meanwhile, the share of traditional uses of biomass declined, from 8.6 percent to less than 5 percent.

FIGURE 3.3 • IMPACT OF TFEC GROWTH ON THE GROWING SHARE OF RENEWABLES IN TFEC GLOBALLY, 1990–2022



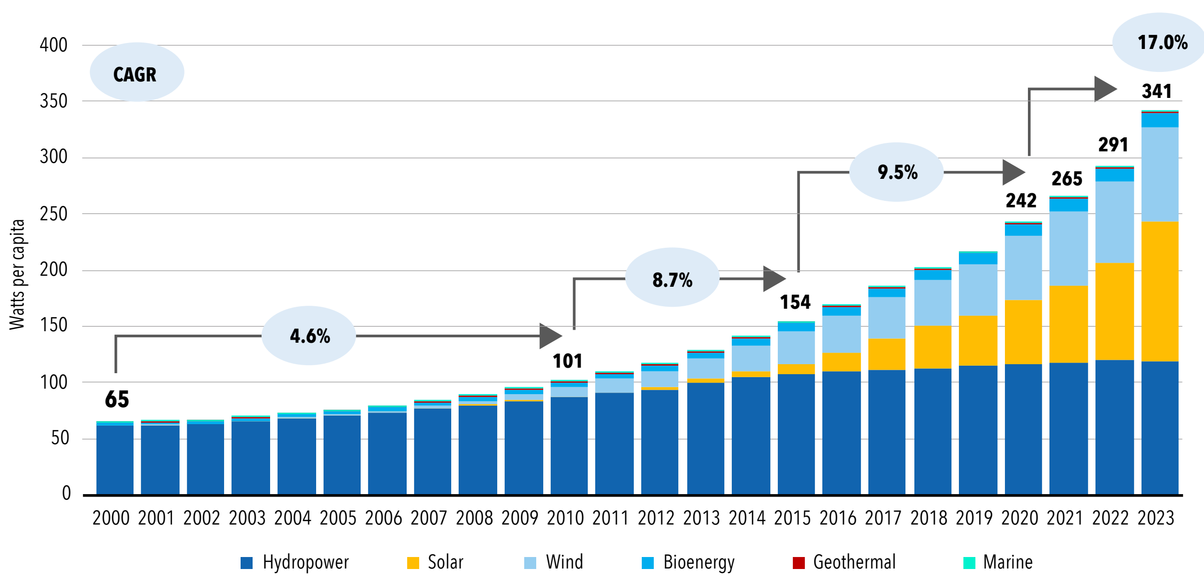
Source: International Energy Agency and United Nations Statistics Division.

Note: TFEC = total final energy consumption.

In 2012–22, modern uses of bioenergy accounted for almost one-third (+5.3 EJ) of the increase in modern uses of renewable energy—the largest absolute increase among renewable sources, although closely followed by wind (+4.9 EJ). Solar PV and wind grew at an average of about 29 percent and 15 percent, respectively—the fastest growth, despite starting from a smaller base. Overall, bioenergy, including traditional uses of biomass, remained the largest source of renewable energy, representing almost 11 percent of the global final energy consumption and almost two-thirds of the renewable portion in 2022, followed by hydropower, wind, and solar PV.

Renewable energy generating capacity continues to grow globally, reaching 478 watts per capita in 2023. Notable disparities remain between countries, with 1,162 watts installed in developed countries compared with 341 watts in developing countries. Hydropower, solar, and wind technologies continue to drive the expansion of renewables in developing countries (see figure 3.4 and table 3.1). These figures reflect progress toward SDG target 7.b—"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 land-locked developing countries." Progress is tracked through Indicator 7.b.1, which measures the installed renewable energy generating capacity per capita—the metric presented here.

FIGURE 3.4 • INSTALLED RENEWABLES-BASED CAPACITY PER CAPITA FOR DEVELOPING COUNTRIES (2000–23) AND CAGR IN SELECTED YEARS



Source: International Renewable Energy Agency.

Note: CAGR = compound annual growth rate.

Globally, renewable energy capacity per capita more than doubled (from 215 watts per capita) between 2013 and 2023 (table 3.1). This sustained growth reflects a compound annual growth rate (CAGR) of 9.4 percent over five years, accelerating from a CAGR of 8.1 percent in 2012. The last decade's highest annual increase in renewable energy capacity per capita in global terms was in 2023 (13 percent). A record high CAGR, of 11.1 percent, was also observed in developing countries over the same period.

Developing countries—including China, Brazil, and India—are leading the charge in global renewable energy generating capacity per capita.[15] Their year-on-year growth of 17 percent in 2023, and a five-year CAGR of 11.1 percent, outpaced developed countries' annual growth and 5-year CAGR. This growth is driven by public policies and investments that have enabled lower technology costs (IRENA 2024a), as global policies and strategies increasingly prioritize renewable energy (IRENA et al. 2024).

TABLE 3.1 • GLOBAL INSTALLED RENEWABLE ENERGY GENERATING CAPACITY PER CAPITA, ANNUAL GROWTH, AND 5-YEAR CAGR, 2010–23

	GLOBAL			DEVELOPED			DEVELOPING		
Year	Renewables per capita (watts)	Annual growth (%)	5-year CAGR (%)	Renewables per capita (watts)	Annual growth (%)	5-year CAGR (%)	Renewables per capita (watts)	Annual growth (%)	5-year CAGR (%)
2010	174	6.3	5.0	499	6.5	4.7	101	7.0	6.1
2011	187	7.2	5.8	537	7.7	5.7	109	7.5	6.7
2012	200	7.1	6.4	580	7.9	6.5	116	7.1	7.0
2013	215	7.2	6.8	610	5.3	6.7	128	9.9	7.8
2014	230	7.2	7.0	644	5.5	6.6	140	9.6	8.2
2015	248	7.8	7.3	687	6.7	6.6	154	9.5	8.7
2016	267	7.5	7.3	728	5.9	6.3	168	9.6	9.2
2017	286	7.2	7.4	764	5.0	5.7	185	9.8	9.7
2018	305	6.8	7.3	803	5.1	5.6	201	8.8	9.5
2019	326	6.8	7.2	857	6.7	5.9	216	7.4	9.0
2020	358	9.6	7.6	920	7.4	6.0	242	11.9	9.5
2021	388	8.4	7.8	991	7.6	6.4	265	9.6	9.5
2022	423	9.1	8.1	1,074	8.5	7.1	292	10.0	9.5
2023	478	13.0	9.4	1,162	8.1	7.7	341	17.0	11.1

Source: International Renewable Energy Agency.

Note: CAGR = compound annual growth rate.

Despite sustained progress in renewable energy deployment, the levels achieved remain insufficient. Developing countries are struggling to meet growing energy demand, foster sustainable development, and reduce energy poverty. Notable disparities in renewable energy-generating capacity per capita exist also within developing countries (as discussed in more detail in the next section), further underscoring the need for support to reach target 7.b, "expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries."

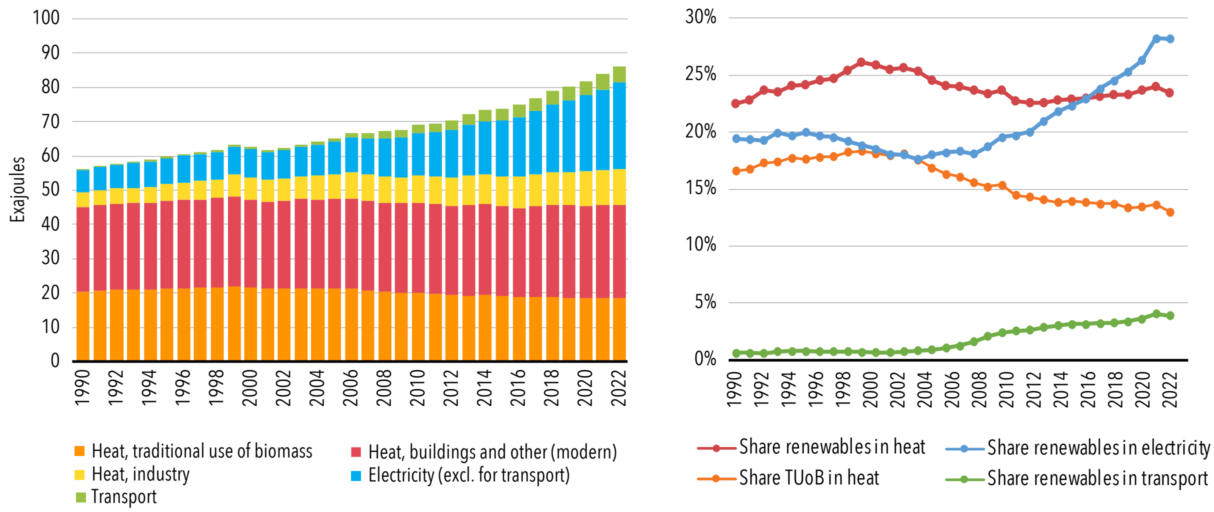
15 The full list of developed and developing countries can be found in Annex 1.

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, heat, transport, and electricity, which made up 46, 31, and 23 percent, respectively, of TFEC in 2022 (figure 3.5).

Electricity has seen the largest and the most dynamic increase in renewables' share in final consumption. Renewables' share in electricity grew from 23 percent in 2015 to almost 30 percent in 2022. In the **heating** subsector, renewable sources represented about 21 percent of energy used; almost half of this corresponded to traditional uses of biomass, which decreased 0.2 percent in 2022. Including the use of renewables-based electricity, the **transport** sector accounts for only 9 percent of global modern uses of renewable energy. It is the end-use sector with the lowest penetration of renewable energy, which represented only 4 percent of the sector's final energy consumption in 2022.

FIGURE 3.5 • RENEWABLE ENERGY CONSUMPTION AND SHARE BY END USE, 1990–2022



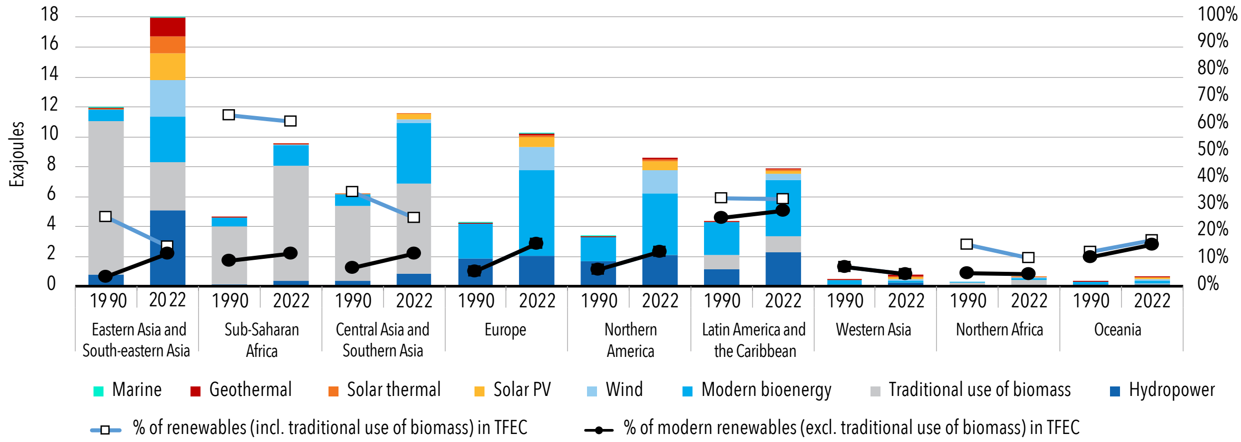
Source: International Energy Agency and United Nations Statistics Division.

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 about two-thirds of TFEC in Sub-Saharan Africa, modern uses of renewables, excluding traditional uses of biomass, represent only 12 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 2022), 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 2022



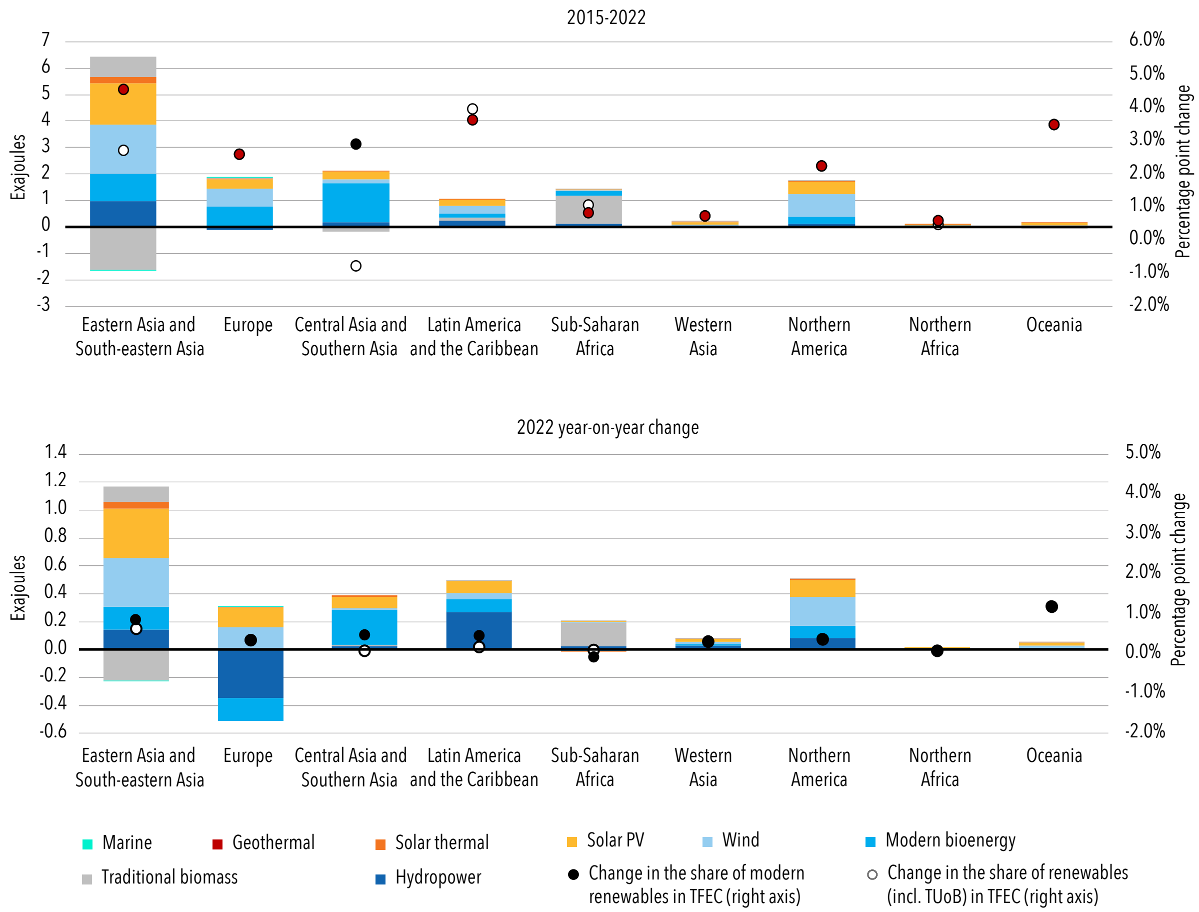
Source: International Energy Agency and United Nations Statistics Division.

Note: "Traditional uses of biomass" refers to the residential consumption of primary solid biofuels and charcoal in countries outside the OECD. Although biomass is used with low efficiency in OECD countries as well, such use is reported here under "modern bioenergy."

In 2022, significant additions of wind and solar PV, and, to a lesser extent, geothermal capacity, in Eastern Asia and South-eastern Asia led the region to represent almost half of the global year-on-year increase in modern uses of renewable energy, while traditional uses of biomass continued to decline significantly (figure 3.7). Europe ranked second for solar PV and wind capacity additions in 2022 (IEA 2022a).

After a strong rebound in 2021, TFEC increased only moderately in 2022 (+1.8 percent year-on-year). Nonetheless, this made the use of renewable energy more noticeable as a share of TFEC. Renewables' share in TFEC grew for all regions, led by Oceania and Eastern and South-eastern Asia (respectively, +1.2 and +0.6 percentage points in 2022 year-on-year). Growth in modern uses of bioenergy was the largest in Central Asia and Southern Asia (+0.3 percentage points year-on-year). Globally, traditional uses of biomass declined slightly; while they increased in Sub-Saharan Africa, this growth was offset by decreased consumption in Eastern and South-eastern Asia.

FIGURE 3.7 • CHANGE IN RENEWABLE ENERGY CONSUMPTION AND RENEWABLES' SHARE IN TFEC BY REGION, 2015–22, AND YEAR-ON-YEAR CHANGE, 2022



Source: International Energy Agency and United Nations Statistics Division.

Note: "Traditional uses of biomass" refers to the residential consumption of primary solid biofuels and charcoal in countries outside the OECD. Although biomass is used with low efficiency in OECD countries as well, such use is reported under "modern bioenergy."

At the 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. After a strong rebound in 2021, TFEC grew moderately in 2022, in line with previous years. Only 11 of the top 20 energy-consuming countries recorded a higher TFEC in 2022 than in 2021.[16] In the remaining nine countries, TFEC decreased,[17] most likely due to energy conservation measures amid the energy crisis.

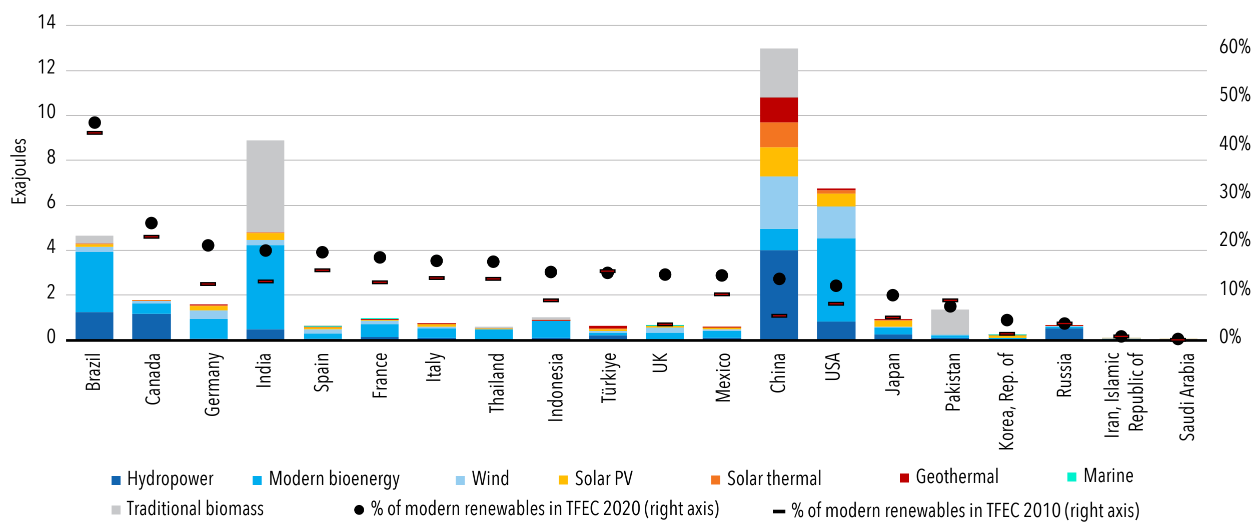
16 Countries that saw an increase in TFEC include Brazil, Canada, China, India, Indonesia, the Islamic Republic of Iran, Mexico, Pakistan, Saudi Arabia, Thailand, and the United States.

17 Countries that saw a decrease in TFEC include France, Germany, Italy, Japan, Korea, the Russian Federation, Spain, Türkiye, and the United Kingdom.

In 2022, year-on-year growth in modern uses of renewables was the largest in the Republic of Korea (+16 percent), followed by Türkiye (+15 percent).[18] Brazil and Canada continued to lead the top 20 energy-consuming countries in the share of modern uses of renewables in 2022 (45 and 24 percent of TFEC, respectively), owing to their considerable reliance on hydropower for electricity, biofuels for transport, and biomass for extracting heat, specifically in industry. China alone accounted for over a fifth of the global modern uses of renewable energy, despite its TFEC having a less than 13 percent share of modern renewables.

Between 2010 and 2022, the United Kingdom, Germany, and China achieved the largest increases in the share of modern uses of renewables in TFEC (+10, +8, and +8 percentage points, respectively), followed by India, Indonesia, and France (with shares increasing between +5 and +6 percentage points). This growth was mostly possible thanks to the development of wind and solar PV, as well as a significant decrease in TFEC in the United Kingdom, Germany, and France between 2010 and 2022 and a significant shift from traditional to modern uses of biomass in China, India, and Indonesia (figure 3.8).

FIGURE 3.8 • RENEWABLE ENERGY CONSUMPTION, 2022, AND SHARE OF MODERN USES OF RENEWABLES IN TFEC, 2010 AND 2022, FOR THE TOP 20 ENERGY-CONSUMING COUNTRIES



Source: International Energy Agency and United Nations Statistics Division.

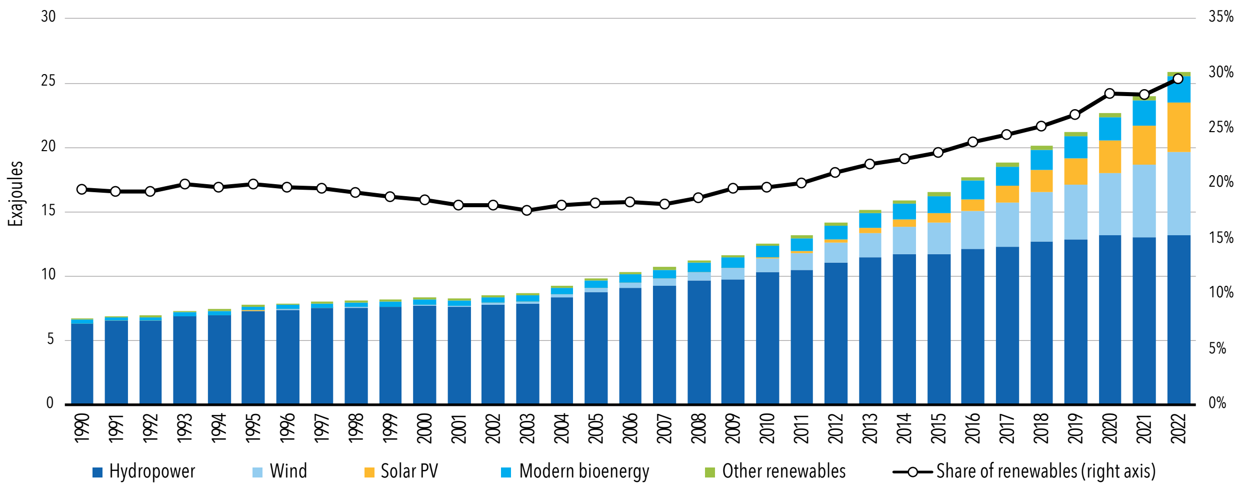
Note: "Traditional uses of biomass" refers to the residential consumption of primary solid biofuels and charcoal in countries outside the OECD. Although biomass is used with low efficiency in OECD countries as well, such use is reported under "modern bioenergy."

18 It should be noted that Saudi Arabia more than doubled its share of modern uses of renewables on a year-on-year basis. The share remains rather marginal, however (0.15 percent in 2022).

Electricity

Electricity accounted for 23 percent of TFEC globally in 2022. It is the fastest-growing end use: electricity consumption almost doubled over the past 22 years and grew 37 percent since 2010.[19] Although global annual electricity consumption increased slightly, by 3 percent, to 86 EJ in 2022, global renewables-based electricity consumption grew almost 8 percent (+1.8 EJ) year-on-year in 2022. The share of renewables in electricity generation increased to almost 30 percent in 2022—the greatest share among all end uses (figure 3.9).

FIGURE 3.9 • GLOBAL RENEWABLES-BASED ELECTRICITY CONSUMPTION BY TECHNOLOGY, 1990–2022



Source: International Energy Agency and United Nations Statistics Division.

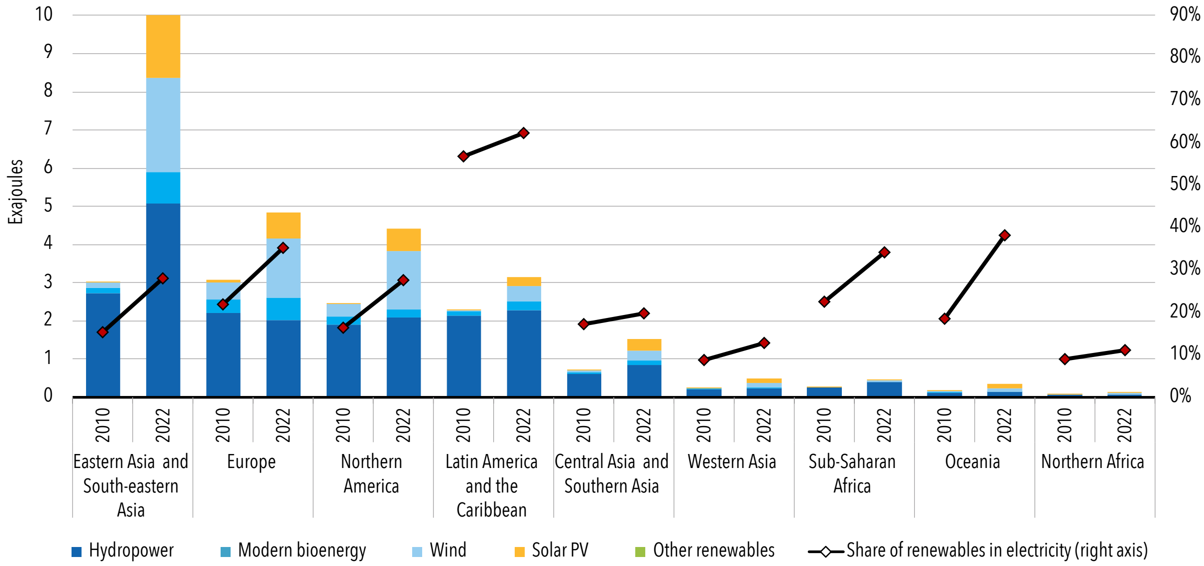
PV = photovoltaic.

In 2022, wind and solar PV made the largest contributions to the annual increase in renewables-based electricity consumption, with hydropower and electricity from combustible bioenergy and other technologies (geothermal, concentrating solar power, marine energy) contributing the remaining growth. Hydropower remained the largest source of renewables-based electricity globally and for each region, representing in many cases more than half of renewables-based electricity consumption in 2022. After extreme drought conditions in 2021, hydroelectricity consumption grew 1.5 percent year-on-year in 2022, rebounding to the levels seen in 2020.

Eastern Asia and South-eastern Asia recorded the largest absolute year-on-year increase of renewables in electricity consumption in 2022. Almost half of the growth in global renewables-based electricity consumption came from this region, chiefly in China, followed by Indonesia and Japan. This growth was led by rapid developments of wind and solar PV. The share of renewable sources in electricity consumption was the largest in Latin America and the Caribbean, where hydropower alone accounted for almost half of electricity consumption in 2022. Oceania and Europe ranked second and third, respectively, for their shares of renewable sources in electricity consumption, followed by Sub-Saharan Africa. Rapidly declining costs and policy support contributed to wind and solar PV together representing almost 70 percent of the increase in global renewables-based 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 • RENEWABLES-BASED ELECTRICITY CONSUMPTION AND RENEWABLES' SHARE IN ELECTRICITY BY REGION, 2010 AND 2022

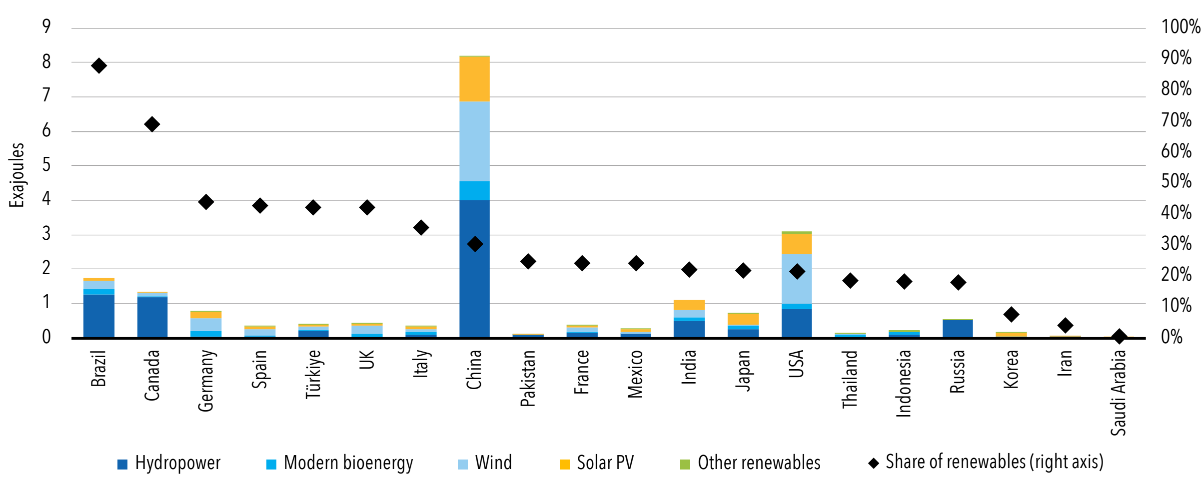


Source: International Energy Agency and United Nations Statistics Division.

PV = photovoltaic.

Trends in renewables' share in electricity consumption vary among the top 20 energy-consuming countries, from about 1 percent to nearly 90 percent. Brazil and Canada are by far the leaders, due to large hydropower capacities (figure 3.11). Wind and solar PV, that is, nondispatchable renewables, together are the largest sources of renewables-based electricity in India, the United States, Germany, France, Italy, Japan, Spain, Mexico, the United Kingdom of Great Britain and Northern Ireland, the Republic of Korea, and Saudi Arabia, and they supply more than three-fifths of the total renewable electricity consumption in these countries. Between 2021 and 2022, China contributed about 43 percent of the global annual increase in renewables-based electricity consumption, more than 90 percent of it from wind and solar PV.

FIGURE 3.11 • RENEWABLES-BASED ELECTRICITY CONSUMPTION IN THE TOP 20 ENERGY-CONSUMING COUNTRIES, BY SOURCE AND COUNTRY, 2022



Source: International Energy Agency and United Nations Statistics Division.

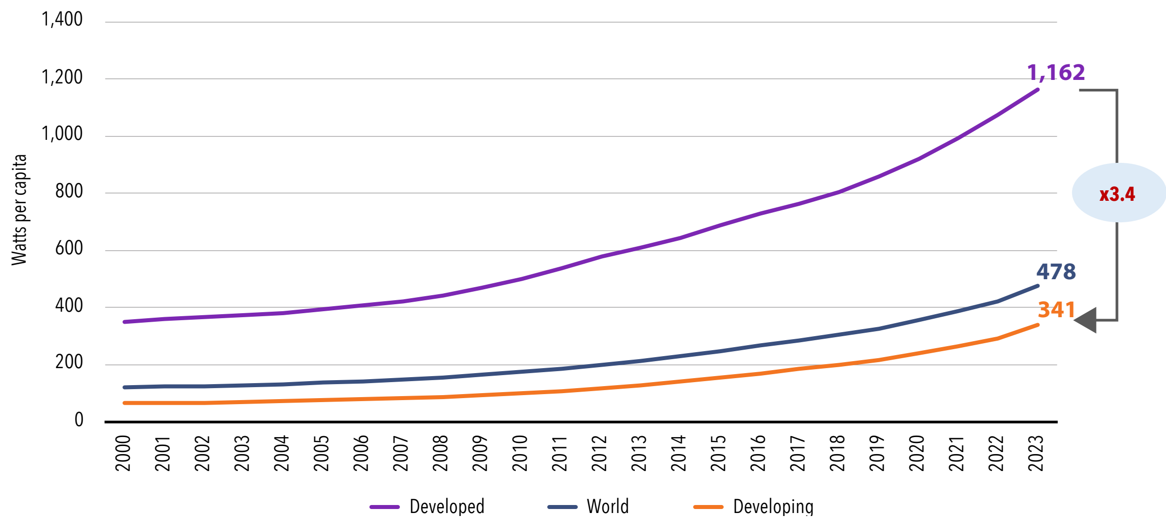
PV = photovoltaic.

Installed renewable energy generating capacity per capita

Despite substantial progress in indicator 7.b.1, developed and developing regions still show significant disparities. Developed countries had 1,162 watts of renewable energy capacity per capita in 2023, while the average person in a developing country was limited to only 341 watts. This means that people in developing countries met their energy needs using less than a third of the renewables-based power available to the average person in a developed country (figure 3.12). If Brazil, China, and India are excluded from the developing country category, the category average drops to only 126 watts per capita for 2023, showing the outsized impact of some of the larger countries owing to the uneven distribution of renewable energy capacity.

While the disparity has narrowed in the past 10 years (in 2013, developed countries had 4.8 times more renewable energy capacity per capita), developed countries still possess 3.4 times more renewable energy capacity per capita. Renewable energy must be deployed at a faster pace in developing countries to accomplish SDG 7 and fulfill the overall SDG agenda by the end of the decade, especially given their critical role in helping ensure universal access for all (see chapter 1).

FIGURE 3.12 • ANNUAL GROWTH OF RENEWABLE ENERGY GENERATING CAPACITY PER CAPITA IN DEVELOPING AND DEVELOPED COUNTRIES, AND THE WORLD, 2000–23

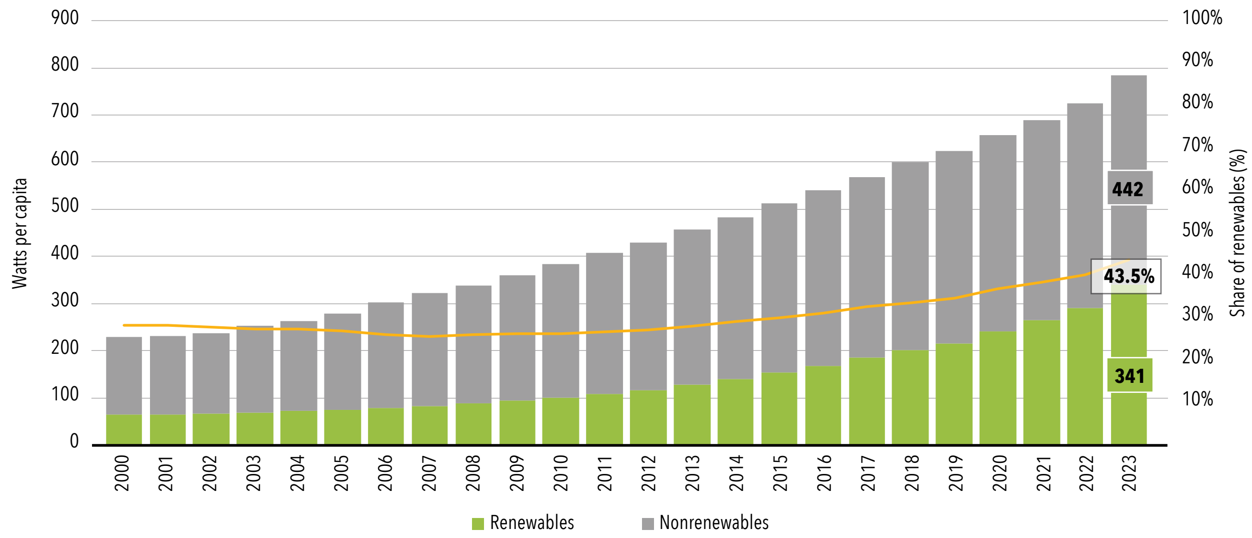


Source: International Renewable Energy Agency.

Developing countries have steadily increased their renewable shares in the past two decades, peaking at 43.5 percent of total energy generating capacity in 2023. But nonrenewable sources continue to dominate (figure 3.13). While many regions are exploring renewable energy technologies, particularly solar, as least-cost options for new power generation, unique challenges, in particular financial and capacity constraints (as also discussed in chapter 5), hinder renewables' deployment in developing countries (IRENA 2023a).

In 2023, developing countries had less renewable energy capacity installed per capita than in developed countries by a factor of 3.4, but a higher share of renewables in total installed capacity (43.5 percent, compared with 42.3 percent). This higher share of installed capacity, despite lower absolute levels, reflects progress and suggests an opportunity to continue leapfrogging carbon-intensive development pathways in favor of more sustainable energy systems (IRENA 2023b).

FIGURE 3.13 • ANNUAL GROWTH OF RENEWABLE ENERGY GENERATING CAPACITY IN DEVELOPING COUNTRIES, AND SHARE OF RENEWABLES, 2000–23



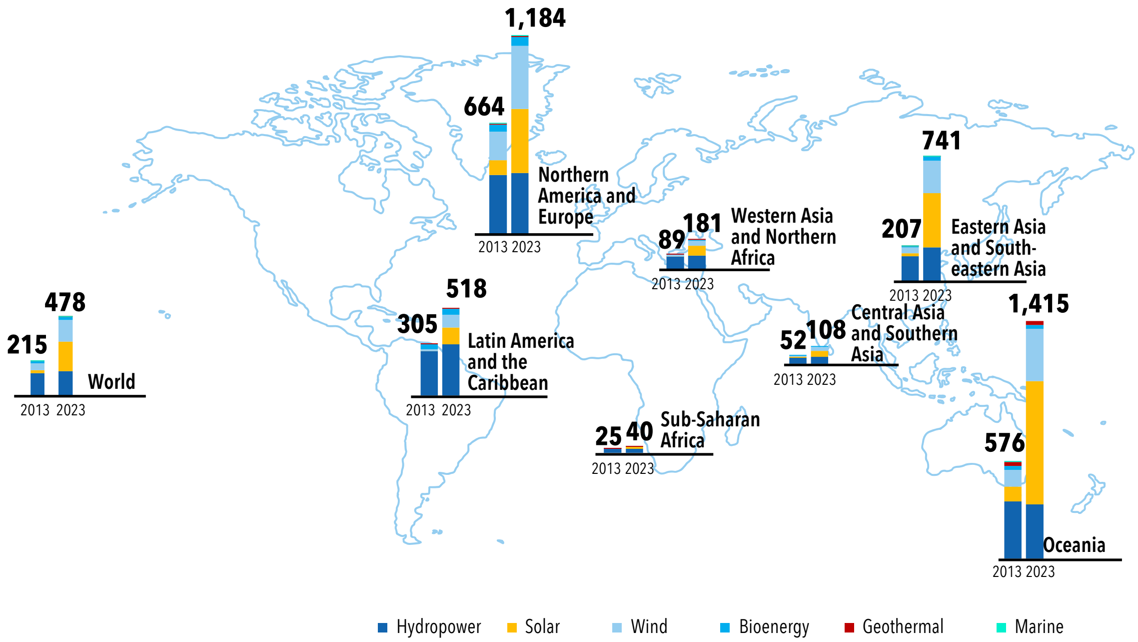
Source: International Renewable Energy Agency.

The largest growth of renewable energy generating capacity per capita in the past decade occurred in Eastern and South-eastern Asia, mainly driven by solar power, followed by hydropower and wind (figure 3.14). The region's installed renewable energy generating capacity per capita, which grew at a CAGR of 13.6 percent over the past decade, more than tripled in 2013–23, from 207 watts to 741 watts. Meanwhile, Oceania, Central and Southern Asia, and Western Asia and Northern Africa each more than doubled their installed renewable energy per capita in the same period. The lowest growth rates are attributed to Northern America and Europe, Latin America, and Sub-Saharan Africa, in that order.

Notably, Oceania has the highest ratio of renewables-based power to population, at 1,415 watts per capita, followed by Northern America and Europe, at 1,184 watts per capita, while the lowest is in Sub-Saharan Africa, at just 40 watts per capita. While growth was slower in Northern America and Europe, this is due in part to the fact that the region already possessed substantial renewable energy capacity in 2013, as well as the fact that further expanding renewables requires upgrading or replacing existing infrastructure rather than simply adding new capacity. New renewable installations in these regions have therefore been more incremental than in regions with lower starting capacity. In fact, with 664 watts per capita as of 2013, Northern America and Europe already had more renewable power per person 10 years ago than the average person did in 2023 in Latin America and the Caribbean, Western Asia and Northern Africa, Central and Southern Asia, and Sub-Saharan Africa. Yet there is still much scope for renewables' share of electricity supply to grow in Northern America and Europe.

A critical front in the global push toward achieving SDG 7 is Sub-Saharan Africa, which is at risk of being left behind in the global energy transition. Limited progress in installed renewable energy generating capacity per capita, from 25 watts in 2013 to only 40 watts in 2023, reflects ongoing struggles in achieving universal energy access and supporting sustainable development as population growth continues to outpace energy demand.

FIGURE 3.14 • GROWTH IN RENEWABLE ENERGY GENERATING CAPACITY PER CAPITA BY TECHNOLOGY ACROSS REGIONS, 2010–23



Source: International Renewable Energy Agency.

CAGR = compound annual growth rate.

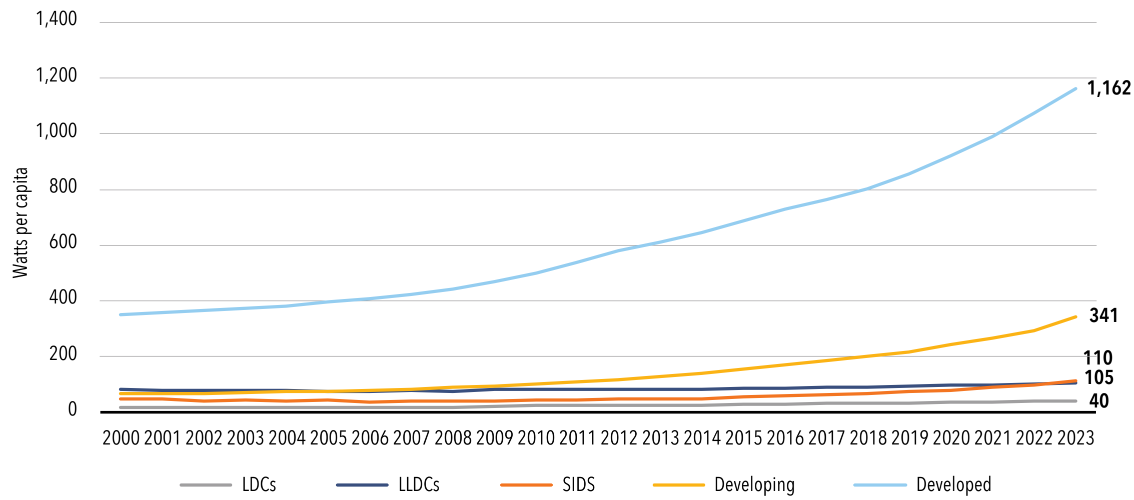
Disclaimer: This map is provided for illustration purposes only. Boundaries and names shown on this map do not imply any endorsement or acceptance by IRENA.

Target 7.b[20] emphasizes the specific needs of least-developed countries (LDCs), small island developing states (SIDS), and landlocked developing countries (LLDCs) by 2030. Figure 3.15 illustrates the status of renewable energy generating capacity per capita for this subset of developing countries. For all three groups, capacity is below that of developing countries as a whole (341 watts per capita), with 110 watts per capita for SIDSs, 105 watts per capita for LLDCs, and only 40 watts per capita for LDCs.

The sluggish growth of renewables in these country groups contrasts sharply with both the wider developing category and, even more so, with developed regions. It reflects systemic issues—including limited access to financing, inadequate infrastructure, and insufficient revenues—that hinder large-scale deployment of renewables. Dedicated efforts are thus needed to ensure that the 106 countries comprising the LLDCs, LDCs, and SIDS—home to 1.8 billion—are not left behind in the energy transition.

20 This target aims by 2030 to expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular LDCs, SIDS, and LLDCs,, in accordance with their respective programmes of support."

FIGURE 3.15 • RENEWABLE ENERGY GENERATING CAPACITY PER CAPITA BY COUNTRY GROUP, 2000–23



Source: International Renewable Energy Agency.

SIDS = small island developing state; LDC = least-developed country; LLDC = landlocked developing country.

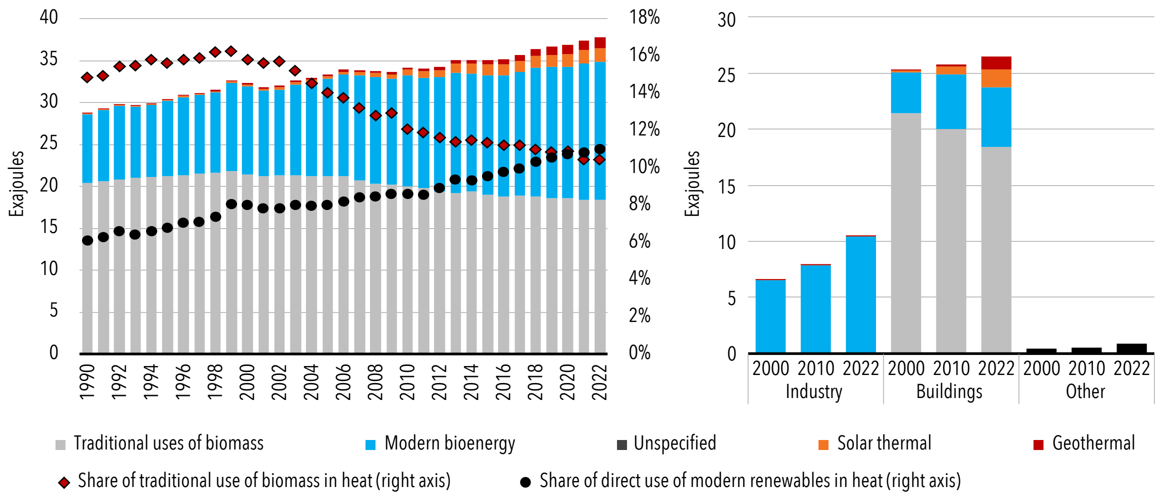
Heat

Heat is the largest energy end use worldwide, accounting for almost half of global TFEC (176 EJ). Worldwide, the total energy consumption for heat in 2022 was roughly the same as that in 2021. The global heat sector relies heavily on fossil fuels, meeting more than three-quarters of heat demand through coal, gas, and oil. Traditional uses of biomass for heat declined slightly, by 0.2 percent, in 2022 year-on-year, accounting for over 10 percent (18 EJ) of the global energy consumption for heat. Excluding traditional uses of biomass, as well as ambient heat harnessed by heat pumps[21] (on which data are limited), direct modern uses of renewables for heat increased 1.8 percent year-on-year to exceed 19 EJ in 2022. This represented 11 percent of the total energy consumed for heat, only 2.7 percentage points higher than in 2010 (figure 3.16).

Despite its dominant share in TFEC, the heating sector has received limited policy attention and support, until recently (IEA 2022a), with the development of renewable-heat-focused policies that include 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"). 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—must be combined with rapid deployment of renewable heat technologies to transition away from fossil fuels and inefficient and unsustainable uses of biomass.

21 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 the lack of data, this report does not account for it, although ambient heat (in excess of any electricity used to run the pumps) 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.

FIGURE 3.16 • RENEWABLE HEAT CONSUMPTION BY SOURCE AND SECTOR, 1990–2022



Source: International Energy Agency and United Nations Statistics Division.

Note: Indirect consumption of renewable heat through renewables-based electricity is not represented in this figure.

Bioenergy accounts for about 85 percent (16.4 EJ) of direct[22] modern use of renewables for heat globally. It accounts for about one-tenth (IEA 2021) of the energy consumed for industrial heat and one-twentieth of the energy consumed for heat in the buildings sector (IEA 2024b). Industry accounts for over two-thirds of modern uses of bioenergy, mostly in subsectors producing biomass residues on site, such as wood, pulp, and paper industries, as well as the sugar and ethanol industries. In 2022, industrial consumption of modern uses of bioenergy for heat grew 3 percent year-on-year—mostly due to increasing use in Brazil's and India's sugar and ethanol industries—but decreased 2.8 percent in the buildings sector.

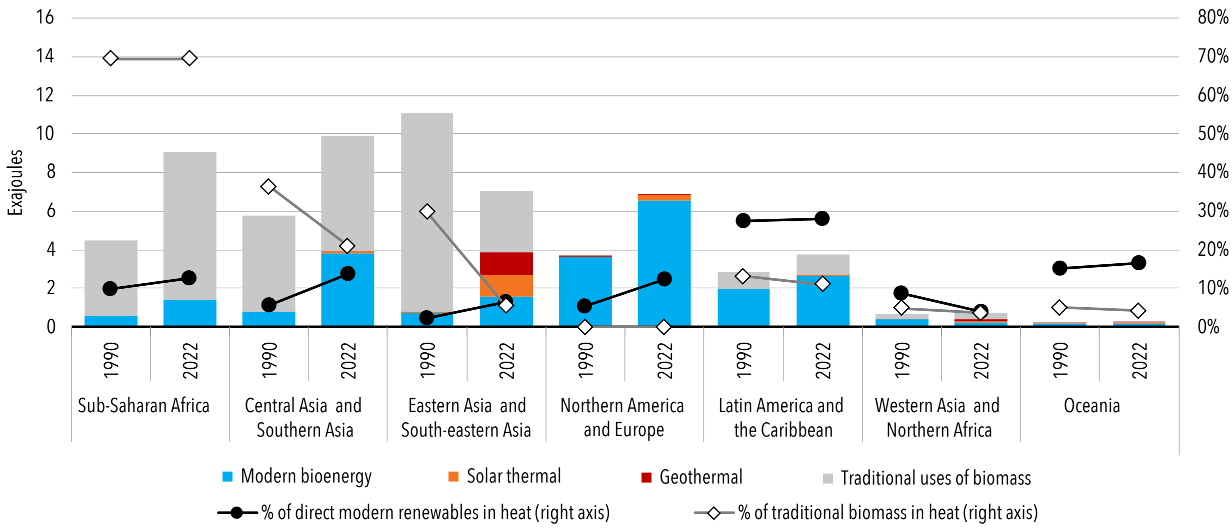
Global **solar thermal** heat consumption increased 5 percent between 2021 and 2022; it accounted for 8 percent (1.62 EJ) of modern uses of renewables for heat, yet met less than 1 percent of total final heat demand. New solar thermal installations in 2023 fell 7 percent, due to challenges in China's real estate market, as reduced rates of construction limited the demand for solar thermal systems. However, year-on-year growth occurred in the United Kingdom (+66 percent), India (+27 percent), Greece (+10 percent), Mexico (+5 percent), and Brazil (+3 percent).

Global **geothermal** heat consumption grew 9.3 percent in 2022. It was driven almost exclusively by China and represented over 6.5 percent (1.3 EJ) of modern uses of renewables for heat. About 60 percent of geothermal heat is harnessed by ground source heat pumps worldwide (Lund and Toth 2021). 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 accounts for over four-fifths of the global geothermal heat consumption, followed by Türkiye and the United States, which together account for almost one-tenth.

22 For the purposes of this report, the "heating" subsector encompasses all energy not used as electricity or for transport, even those energy uses that are not for heating purposes (e.g., diesel oil in a water pump). If we see heat strictly as an end use, renewables also contribute to heat supply indirectly through renewables-based electricity used for heating and district heat networks. If we account for these indirect uses, and exclude ambient heat harnessed by air source heat pumps, then renewables-based electricity makes the second-largest contribution to modern end use of renewables-based heat after bioenergy, and the fastest-growing one. Renewables-based electricity used for heating accounted for almost half of the increase in total (direct and indirect) modern use of renewable energy used for heat in 2018; this was due to the combination of increasing renewables penetration in power and heat electrification using electric heat pumps and boilers. The buildings sector is responsible for the majority of electricity consumption for heat.

Traditional uses of biomass are primarily concentrated in Sub-Saharan Africa and Asia (figure 3.17), with—in descending order—India, China, Ethiopia, the Democratic Republic of the Congo, Nigeria, 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 2022 were still at a level similar to that of 1990 at a global scale. Trends differed across regions and countries in 2012–22, 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 IN HEAT BY REGION, 1990 AND 2022



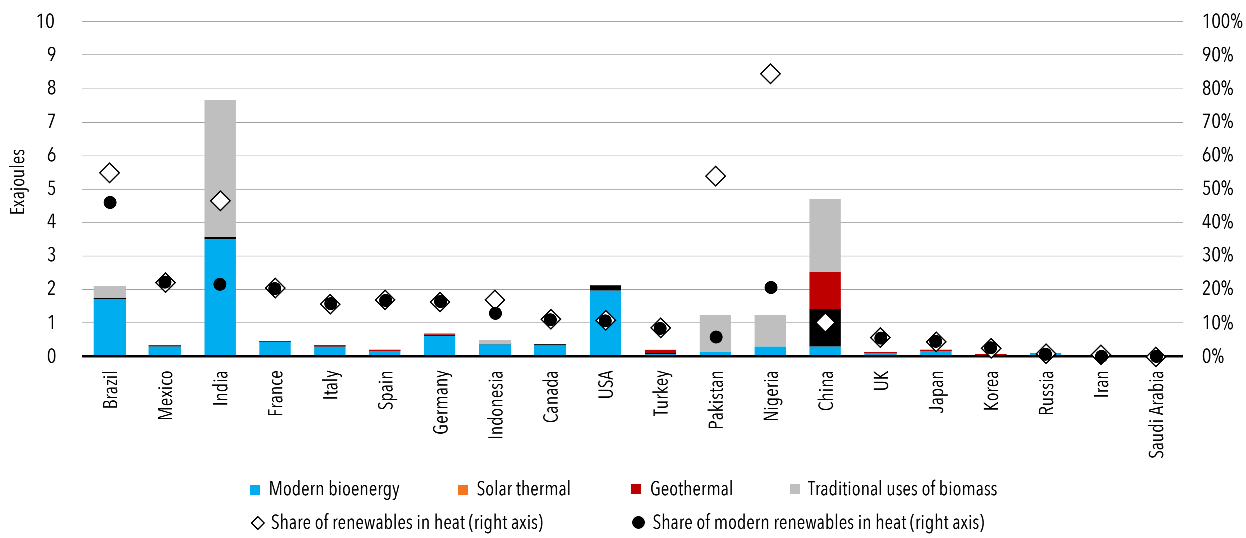
Source: International Energy Agency and United Nations Statistics Division.

Note: The statistical framework adopted for this figure does not account for the use of renewables-based electricity for heating. "Traditional uses of biomass" refers to the residential consumption of primary solid biofuels and charcoal in countries outside the OECD. Although biomass is used with low efficiency in OECD countries as well, such use is reported under "modern bioenergy."

EJ = exajoule.

China and India together represented over 70 percent of the global increase in modern use of renewable energy for heat in 2010–22. Together with the United States and Brazil, they represented 43 percent of the global heat demand and accounted for half of modern use of renewable heat globally in 2022 (figure 3.18). This is due to the significant consumption of bioenergy in the pulp and paper industry and for residential heating in the United States; extensive use of bagasse in Brazil's and India's sugar and ethanol industry; and notable deployment of solar thermal water heaters and geothermal heat in China. Europe accounts for another quarter of the 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 detailed in this report, renewable heat consumption was indirectly driven by the growing consumption of renewables-based electricity through electric heaters and heat pumps (accounted for in the electricity sector), as well as the use of heat pumps to harness ambient heat (not quantified in this report) in China, the United States, and the European Union (IEA 2024b).

FIGURE 3.18 • RENEWABLE HEAT CONSUMPTION AND THE SHARE OF RENEWABLES IN TOTAL HEAT CONSUMPTION, BY COUNTRY, FOR THE TOP 20 ENERGY-CONSUMING COUNTRIES, 2022



Source: International Energy Agency and United Nations Statistics Division.

Note: "Traditional uses of biomass" refers to the residential consumption of primary solid biofuels and charcoal in countries outside the OECD. Although biomass is used with low efficiency in OECD countries as well, such use is reported under "modern bioenergy." Indirect consumption of renewable energy through electricity for heat is not included in this figure.

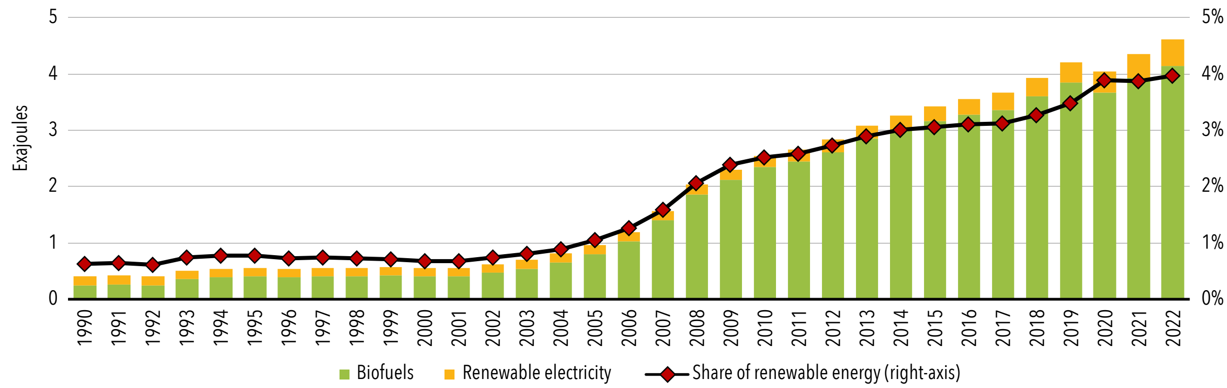
Transport

The share of renewable energy in transport TFEC rose to 3.9 percent in 2022, up from 3 percent in 2015. Global TFEC for transport increased 4 percent (+5 EJ) between 2021 and 2022. Biofuels, representing nearly 90 percent of the renewable energy consumed for transport, continued to dominate; their share grew 5 percent year-on-year in 2022 (+0.22 EJ), despite their overall share in transport TFEC remaining steady, at 3.5 percent. The shares of bio gasoline and other liquid biofuels (mostly bioethanol) grew 3 percent in 2022, over 2021. By comparison, in 2022, the shares of biodiesel and renewable diesel grew well beyond the levels seen in 2021. The combined demand for these fuels in 2022 was 6 percent more than in 2021.

Liquid biofuels, mainly crop-based ethanol and biodiesel blended with fossil transport fuels, represented nearly 90 percent of the renewable energy consumed for transport; most of the remainder came from renewables-based electricity used in vehicles and trains, which grew 14.5 percent from 2021.

This growth is partly due to an expanding EV fleet. The number of EVs on the road rose from 10.2 million in 2020 to 16.5 million in 2021 and then to more than 26.3 million in 2022 (IEA 2024c). The electricity powering these vehicles has increasingly come from renewable sources, with renewables' share of total electricity used in transport climbing from 20 percent in 2010 to 29.6 percent in 2022 (figure 3.19).

FIGURE 3.19 • GLOBAL SHARE OF RENEWABLE FUELS IN TRANSPORT AND TOTALS FOR RENEWABLES-BASED ELECTRICITY AND BIOFUELS, 1990–2022



Source: International Energy Agency and United Nations Statistics Division.

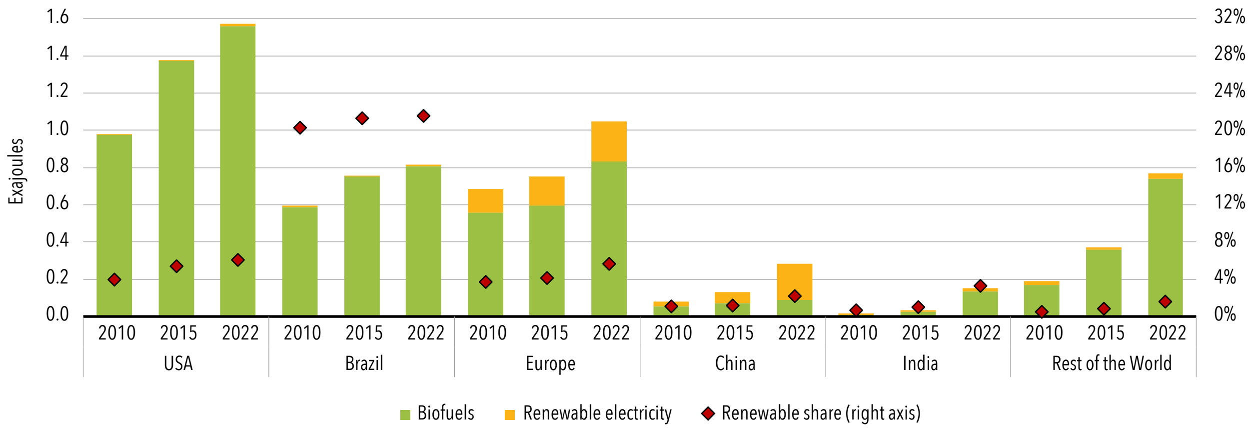
RES = renewable energy sources.

Over 2010–22, renewable energy in transport grew nearly 60 percent, but its share of TFEC increased only 1.5 percentage points. The growth is mainly due to country-level policies to expand biofuels, while increased use of renewable electricity (through electrification of transport, and increased renewable energy generation, among other things) has played a smaller, but growing, role. Despite many successes at the country level, supportive policies have only slightly outpaced growing fossil fuel demand, resulting in a modest overall increase in share.

While the United States, Brazil, and Europe account for nearly three-quarters of the renewable energy used in transport, other countries and regions are also increasing their shares (figure 3.20). In the United States and Brazil, biofuels (mainly ethanol and biodiesel) represent 99 percent of the renewable energy used in transport. In Europe, renewables-based electricity represents 20 percent of the renewable energy used in transport. China's use of renewable energy in transport more than doubled between 2015 and 2022; renewable electricity consumption for transport grew two times over this period. By 2022, renewable electricity represented over three-quarters of all renewable energy used in China's transport. This was due to increasing shares of renewables in power generation and efforts to electrify transportation. Biofuels received limited policy support, however. Also, by 2022, EV sales in China had more than doubled, reaching 5.9 million (IEA 2024c). Together, China and Europe represented nearly 85 percent of global electric car sales in 2022. In India, biofuel support policies tripled renewable energy use in transport between 2015 and 2022.

Increasing renewables' share in transport will require multiple policies, including to boost biofuels (while ensuring that feedstock meets stringent sustainability criteria), to electrify transport, and to increase renewable electricity generation; as well as to promote active mobility, support transit efficiency (by design), and phase out fossil fuels for transport. Such policies must be steadily strengthened where they exist and introduced where they do not.

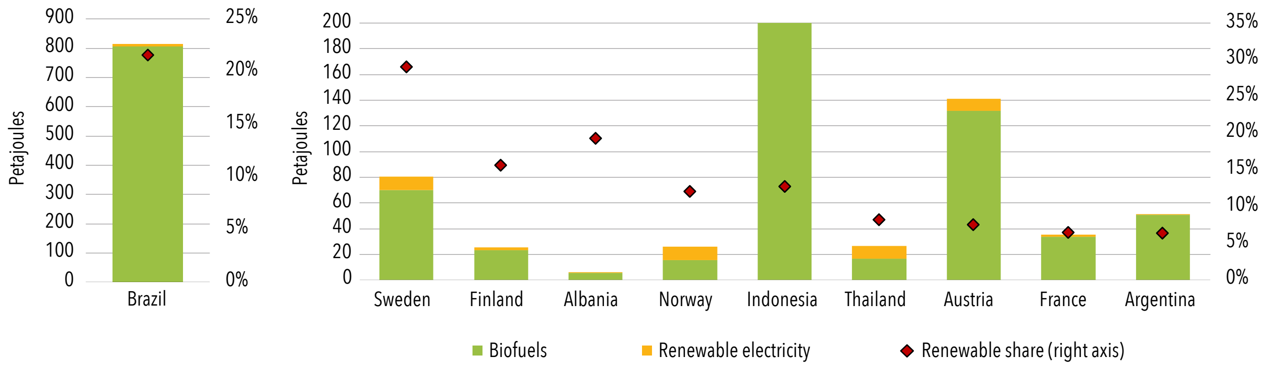
FIGURE 3.20 • RENEWABLE ENERGY SHARE AND TOTAL RENEWABLE ENERGY IN TRANSPORT ACROSS SELECTED COUNTRIES AND REGIONS, 2010, 2015, AND 2022



Source: International Energy Agency and United Nations Statistics Division.

The United States, Brazil, Europe, China, and India account for nearly 85 percent of the renewable energy used for transport, thanks to policy support for biofuels and electrification. In 2022, renewables' shares in transport TFEC were the highest in Brazil, Sweden, Finland, Albania, Norway, and Indonesia—all above 10 percent (figure 3.21).

FIGURE 3.21 • TOP 10 COUNTRIES BY SHARE OF RENEWABLE ENERGY IN TRANSPORT, 2022



Source: International Energy Agency and United Nations Statistics Division.

Policy insights

Since the adoption of SDG 7 in 2015, the share of renewable energy sources in TFEC, including traditional uses of biomass, increased modestly, from 16.7 to 17.9 percent in 2022. The increase remained modest despite record additions of renewable energy over the same period. In 2024 alone, an unprecedented 585 gigawatts of renewable power capacity were added, accounting for over 90 percent of the total power expansion globally (IRENA 2025). Global renewables-based power capacity is expected to grow by a factor of 2.7 in 2030, surpassing countries' current ambitions by nearly 25 percent (IEA 2024b, 2024d). Yet significant disparities remain in the installed renewable capacity of developing versus developed countries. The consensus reached at the climate summit COP28 in 2023 in the UAE to triple global renewable power capacity, double energy efficiency, and transition away from fossil fuels can help shift the needle on increasing renewables' share in the global energy mix—and support infrastructure expansion and technology upgrades for delivering modern and sustainable energy services to all, with adequate policy support and financing.

Renewable energy solutions remain a key enabler of the broader SDG agenda. As global policy makers consider progress toward SDG 8 on employment and economic growth, SDG 5 on gender equality, and SDG 3 on good health and well-being during the 2025 High-Level Political Forum, the recommendations below also emphasize the interlinkages and need for holistic policy making across these areas. The renewable component of SDG 7 is central to this effort since it addresses inequities in energy access and clean cooking (see chapters 1 and 2), while unlocking opportunities that drive progress across health, gender equality, job creation, and other SDGs.

Sustained action is needed to drive the uptake of renewable energy solutions in line with climate and development goals, including the goal to triple global renewables power capacity by 2030. Assessments by the International Renewable Energy Agency and International Energy Agency show that current ambitions are insufficient to meet the tripling goal, with an ambition gap of between 3.8 terawatts (TW) and 4.2 TW by 2030 (as discussed in more detail in the chapter 6). Last year's edition of this report referenced several essential policy measures—effective target setting, long-term planning, and policy support—for accomplishing SDG 7, as well as the tripling goal. Enabling policy and regulatory frameworks remains crucial. Market incentives, including carbon pricing mechanisms, that consider the externalities of fossil fuel use and well-designed procurement schemes should be put in place. Organizational structures of the power sector should be tailored to national contexts, such as institutional structure and the availability of renewable energy resources; those structures must ensure flexibility, reliability, and sustainability. Digital solutions, including advances in artificial intelligence, are offering new opportunities for how sustainable energy is produced, consumed, and financed. Overall, policies and public funds must drive investments in new transmission and distribution infrastructure. Across these measures, the socioeconomic impacts of different policies need to be considered to ensure that benefits and burdens are equitably distributed, both across and within countries, considering in particular the needs of vulnerable populations (IEA 2024b; IRENA 2024b).

Global efforts need to be scaled up to address the uneven deployment of renewable energy, specifically supporting LDCs, SIDSs, and LLDCs, which are at risk of being left behind. Sub-Saharan Africa as a region and LDCs as a group had respectively only 40 watts of renewable energy generating capacity per capita in 2023. Average capacity per capita across LLDCs and SIDSs was 10 times less than the global average. This is far from sufficient to support socioeconomic development in these regions, which are characterized by widespread energy poverty and inequities both within and across countries. Tripling as a global goal on its own does not ensure that equitable renewables deployment will occur in contexts where renewables can help close the energy access gap, support community development and productive uses, and foster sustainable industrialization. Tailored action spanning a wide range of policy interventions—including in technology and knowledge exchange, capacity building, and access to adequate financing (see also chapter 5)—is needed to enable equitable energy access and the ability to escape the cycles of poverty and exploitation that stifle economic development.

Integrated policy making is required to leverage SDG 7 to support SDG 8, which seeks to "promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all." Renewable energy offers employment opportunities for individuals with a range of skills along the value chain (IRENA 2024b). Rapid deployment of renewable energy is already translating into a growing workforce: 16.2 million in 2023 (IRENA and ILO, 2024). In the wider energy sector, clean energy remains the primary engine of job growth, while employment in fossil fuels grew 3 percent in 2023, driven by growth in the oil and gas sector (IEA 2024e).

Stimulating demand for renewable energy requires clear long-term targets and plans, with support from holistic policies, including industrial policies, as well as affordable financing, to promote renewable energy deployment and the development of domestic value chains. This in turn can help create jobs in procurement and manufacturing, installation, operation and maintenance, as well as end-of-life management (IRENA 2024b). However, most emerging and developing economies face structural barriers to creating new clean energy jobs, especially in manufacturing, because they struggle to attract clean energy investments, lack a robust existing manufacturing base, have a limited skill pool, and have inadequate infrastructure (IEA 2024e).

Job opportunities and the related policy priorities also depend on the context. For rural areas, where new electricity connections are expected to occur mostly through decentralized renewable energy, the electrification agenda must intentionally include productive uses of energy. Integrating productive uses of renewable energy in planning and design will ensure income-generating activities that advance sustainable development. Realizing this requires developing policy and regulatory frameworks conducive to cross-sectoral planning (e.g., between energy and agriculture sectors), tailoring delivery and financing models to rural markets' needs, promoting quality-certified appliances that are efficient and affordable for rural enterprises, and building the capacity of and training key actors involved in productive uses of energy (IRENA 2022a).

Continued attention is needed to ensure that the new jobs created are decent. Employment quality in the renewable energy sector varies widely, reflecting existing national standards and their implementation, the specific nature of the jobs, and unionization rates. Generally, labor standards tend to be higher in industries with formalized structures than in emerging and informal sectors. Improving job quality entails action beyond the energy sector, including in areas such as minimum wage legislation, collective bargaining rights, workplace safety regulation, and social protection, including unemployment and health insurance (IRENA and ILO 2022).

In turn, accomplishing SDG 7 also requires prioritizing inclusive workforce development and just transition policies. Skill shortages are already slowing down the energy transition. In this regard, proactive policy making and close coordination among different actors, including governments, educational institutions, trade unions, and the private sector, is crucial. There is also a need to gather more data on emerging jobs and skills, create new certifications, improve technical and vocational education and training opportunities, and integrate renewable energy into educational curricula. In some countries, targeting workers in related professions can also help ease the skilling needs (IEA 2023; IRENA 2024c; OECD 2024). Adult learning and support for fossil fuel workers and marginalized groups are vital for a just energy transition. This is especially true in the coal sector, which is in structural decline; fewer than 15 percent of the sector's workers were covered by coal-specific just transition policies as of 2023 (IEA 2024e).

Gender equality needs to be mainstreamed across international, national, and local energy policy making and decision-making. Access to affordable energy plays a critical role in women's economic and social empowerment, and supports greater health and well-being, as well as education. As the global community gathers at the 2025 High-

Level Political Forum, it will be important to commit to gender-inclusive policies that specifically address the energy needs of and health impacts on women and girls. This includes eliciting their voices through consultations, place in parens ensuring their active participation at all levels of planning and policy making, and ensuring adequate financing.

Importantly, fostering women's participation can expand the talent pool, reducing the skill gap (IRENA 2024d). Women represent 28 percent of the renewable workforce overall, with higher representation in solar PV (32 percent) but a stark underrepresentation in wind (14 percent) (IRENA 2019, 2020, 2022b). While this exceeds their 16 percent share in the energy sector overall (IEA 2022c), it falls far short of the aspiration for gender parity and fails to harness women's potential to contribute to accomplishing SDG 7. As discussed in chapter 1 (box 1.4), women have also emerged as leaders in accelerating the deployment of decentralized renewable energy solutions. Despite obstacles, they have increasingly been catalysts for change as entrepreneurs and innovators (IRENA 2024d).

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CHAPTER 4
ENERGY EFFICIENCY

Main messages

- **Global trend.** Primary energy intensity, defined as the ratio of total energy supply to gross domestic product (GDP), is the main global indicator for energy efficiency. It declined 2.1 percent in 2022—more than four times the weak 0.5 percent improvement rate of 2021. Global energy intensity was 3.87 megajoules per US dollar (MJ/USD[23]) in 2022, when a global energy crisis induced major shocks to energy demand across many regions, and led to a strong decline in energy intensity.
- **2030 target.** Sustainable Development Goal (SDG) target 7.3 calls for the world's rate of energy intensity improvement to double by 2030 relative to the 1990–2010 average. Sluggish global progress in recent years means that energy intensity needs to improve by 4 percent a year on average in 2022–2030 to reach the SDG 7.3 target. This is roughly consistent with the Net Zero Emissions by 2050 Scenario of the International Energy Agency (IEA) and with the goal to double the global average annual rate of energy efficiency improvement by 2030 agreed on during the 2023 United Nations Climate Change Conference (COP28).
- **Regional highlights.** As a result of economic growth outpacing energy demand, energy intensity improved in all major regions in 2022, albeit at different speeds. Energy intensity declined by over 4 percent in Northern America and Europe, and improved by almost 6 percent in Oceania. The slowest progress, under 1 percent, was in Eastern and South-eastern Asia. Energy intensity in other major regions improved at rates similar to the global average of around 2 percent.
- **Trends in the 20 countries with the largest total energy supply.** From 2010 to 2022, energy intensity improved rapidly (relative to 1990–2010) in 15 of the 20 countries with the largest total energy supply. The annual rate more than doubled in this period in Australia, France, Italy, Japan, the Republic of Korea, Mexico, Saudi Arabia, Thailand, and Türkiye. But the 2.6 percent progress rate[24] required to meet SDG target 7.3 was met only by China, France, Germany, and the United Kingdom.
- **End-use trends.** Progress in energy intensity across end-use sectors accelerated in 2010–2022 compared to 2000–2010. The average annual improvement rate for buildings rose from 1.2 to 1.3 percent, and for industry from 0 to 1.4 percent. Passenger vehicles' annual progress rate increased from 0.7 to 1.6 percent, while heavy-duty trucks saw a smaller change, from 0.4 to 0.5 percent.
- **Electricity generation trends.** In 1990–2010, electricity generation efficiency increased from 40 to 42 percent. This rose to about 46 percent in 2010–2022, meaning that generation efficiency improved twice as fast in nearly half the time—largely due to the integration of renewable energy.

23 Based on purchasing power parity (PPP) rates of 2021.

24 When target 7.3 and indicator 7.3.1 were defined, the annual average rate of global energy intensity reduction stood at 1.3 percent for the baseline period of 1990–2010. Based on this figure, the target of doubling this average was set at 2.6 percent per year. Due to data revisions, the baseline annual improvement stands at 1.2 percent, but to avoid variations in the numerical target, the custodians of this indicator—IEA and the United Nations Statistics Division—decided to keep the target fixed at 2.6 percent.

Are we on track?

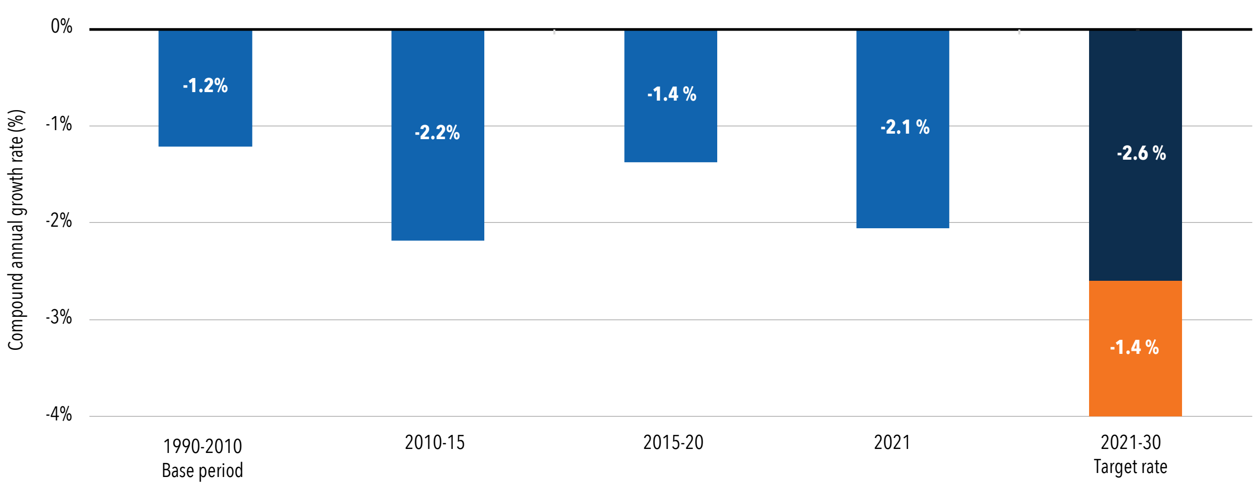
SDG 7 commits the world to ensuring universal access to affordable, reliable, sustainable, and modern energy. Target 7.3 calls for a doubling of the global rate of energy intensity improvement relative to the 1990–2010 average.

Energy intensity is the ratio of total energy supply to GDP, thus revealing the energy consumed per unit of wealth created. Energy intensity helps track changes in energy consumption and the factors influencing them, for example, changes in economic structure, weather, and behavior. All such factors 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 target 7.3. But given the slow pace of global progress in all years except 2015, energy intensity now needs to improve at an annual rate of 4.0 percent from 2022 onward. This figure is roughly consistent with the IEA's Net Zero Emissions by 2050 Scenario, under which the average rate of improvement is slightly over 4 percent in 2022–30. It is also in line with the goal of doubling the global average annual rate of energy efficiency improvement by 2030, as agreed on during COP28.

Global energy intensity improved by 2.1 percent in 2022, to reach 3.87 MJ/USD (2021 PPP), from 0.5 percent in 2021. This is in large part due to the global energy crisis, which triggered major disruptions in energy demand in many parts of the world. However, given the slower-than-required progress in previous years, the world is not yet on track to reach SDG target 7.3 by 2030 (figure 4.1).

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



Source: International Energy Agency (World Energy Balances) and United Nations Statistics Division (Energy Balances).

SDG = Sustainable Development Goal.

Looking beyond the main indicators

Component trends

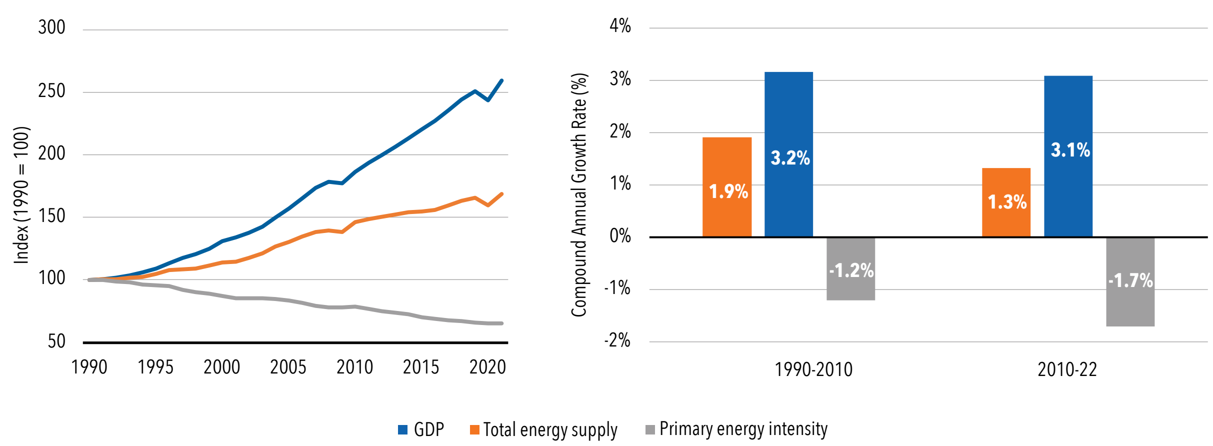
The year 2022 was marked by a global energy crisis, triggered by the onset of war in Ukraine. High energy prices and supply risks in many parts of the world slowed global energy demand, which grew by a mere 1.3 percent. This came after a more than 5 percent increase in 2021 following post-COVID rebounds—one of the largest single-year rises in the past 50 years. Globally, GDP growth was sluggish, at 3.4 percent, almost half the rate of 2021 (6.5 percent). Yet, since GDP grew faster than energy supply, energy intensity improved (decreased).

Over the longer term, the impact of improvements in energy intensity is revealed by trends in its underlying components (figure 4.2). Between 1990 and 2022, global GDP increased by a factor of 2.7, while total energy supply grew by 71 percent (or a factor of 1.71). This decoupling of energy use from economic growth yielded a consistent improvement in global energy intensity, which fell by over a third from 1990 to 2022.

Economic growth averaged 3.1 percent a year in 2010–22, very similar to the 3.2 percent average across 1990–2010. By contrast, energy demand grew notably slower in 2010–22 (1.3 percent a year on average) than in 1990–2010 (1.9 percent). This means that a similar level of GDP growth was achieved with less energy in 2010–22.

Much of the change in 2022 was due to severe shocks to the energy system, with high energy prices or supply risks compelling households and businesses to reduce their energy consumption. Given that consumers were under duress, the energy intensity improvement in 2022 cannot be viewed entirely as progress. Businesses were forced to close or curtail operations, and many people across the world struggled to afford basic energy needs. Sustained energy intensity improvement will require structural energy efficiency measures. The rate of improvement is estimated to have slowed down in 2023 and 2024 as some of the pressures of the energy crisis eased off.

FIGURE 4.2 • CHANGES IN THE COMPONENTS OF GLOBAL PRIMARY ENERGY INTENSITY, 1990–2022



Source: International Energy Agency (World Energy Balances) and United Nations Statistics Division (Energy Balances).

GDP = gross domestic product.

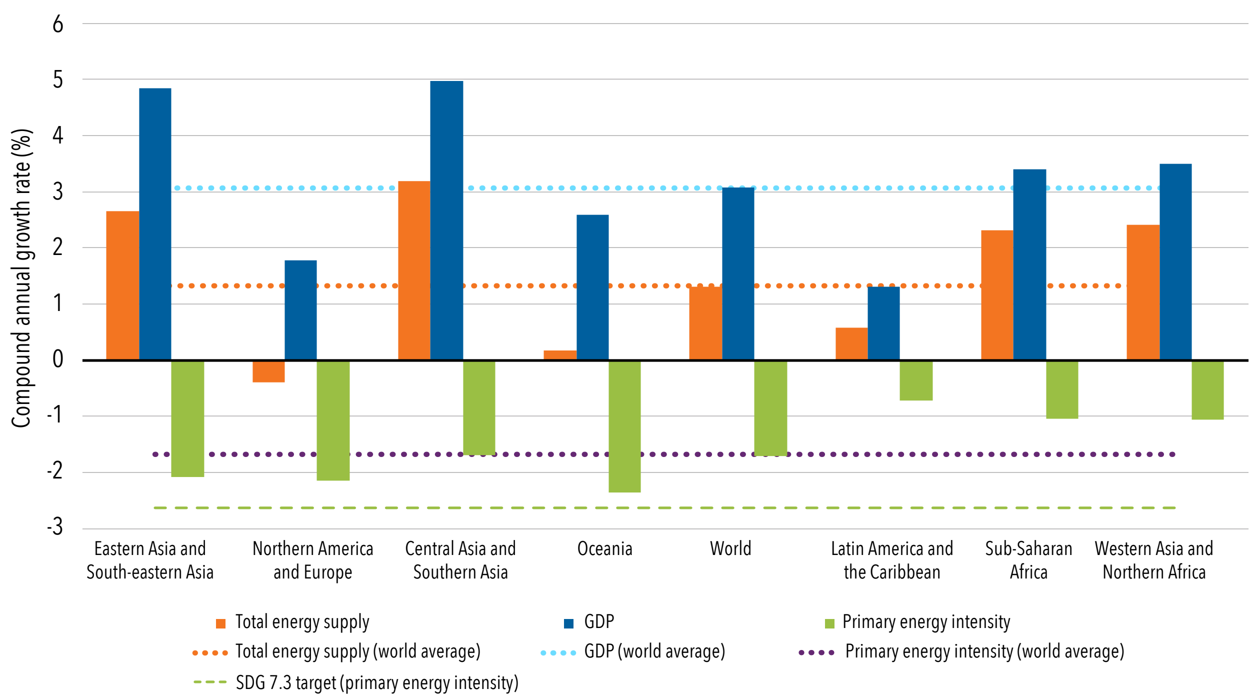
Regional trends

The global energy crisis in 2022 was a severe shock to energy markets around the world. In all major regions, total energy supply grew at a slower rate than GDP in 2022, and the energy supply even shrunk—by around 5 percent in Europe and 2 percent in Oceania. Northern America and Europe experienced the slowest GDP growth of any major region, at around 2 percent. Meanwhile, growth in both energy (4 percent) and GDP (6 percent) was the fastest in Central and Southern Asia.

Economic growth outpacing growth in energy demand resulted in energy intensity improving across all major regions, albeit at different speeds. Energy intensity improved by more than 4 percent over 2021–22 in Northern America and Europe, while it improved by nearly 6 percent in Oceania. Progress in 2022 was slowest in Eastern and South-eastern Asia, at a rate of less than 1 percent. Energy intensity in other major regions improved at a rate similar to the global average, approximately 2 percent. This is four times the global improvement rate of 2021.

Looking across a longer time period, on the other hand, average annual improvement in energy intensity between 2010 and 2022 was the lowest in Latin America, Sub-Saharan Africa, Western Asia, and Northern Africa, at around 1 percent each. In all other regions, an improvement rate of around 2 percent was recorded, pushing the global average annual rate to 1.7 percent for the period 2010–22 (figure 4.3). But this rate is insufficient to reach SDG target 7.3, which requires energy intensity to reduce (improve) by 2.6 percent between 2010 and 2030.

FIGURE 4.3 • AVERAGE ANNUAL CHANGES IN TOTAL ENERGY SUPPLY, GDP, AND PRIMARY ENERGY INTENSITY, BY WORLD REGION, 2010–22



Source: International Energy Agency (World Energy Balances) and United Nations Statistics Division (Energy Balances).

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

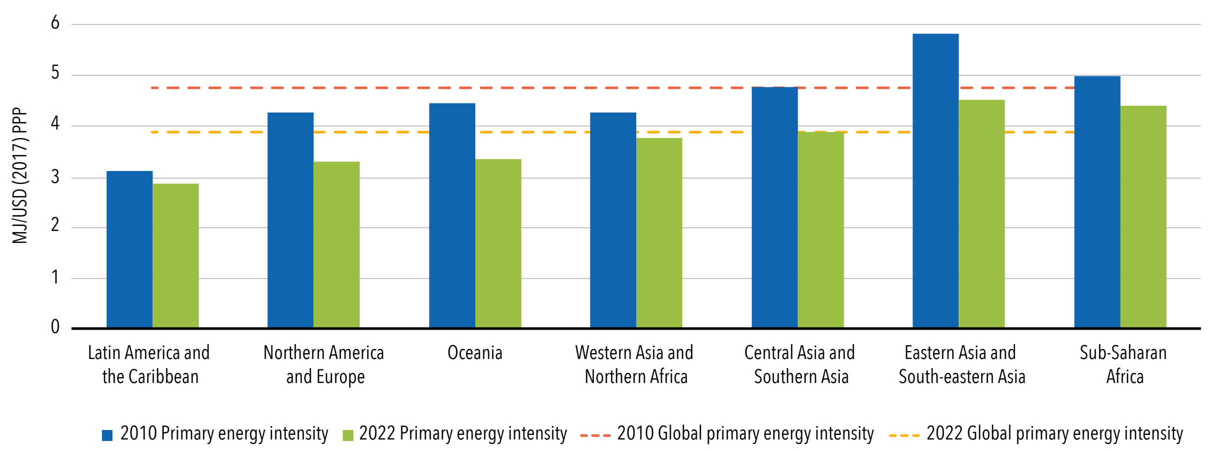
Change in primary energy intensity is an indicator for measuring an economy's energy efficiency improvement rate. It measures whether a country or region is becoming more efficient. Besides the change in intensity, measuring absolute levels of primary energy intensity helps evaluate how energy efficient (or inefficient) an economy is, keeping in mind that factors other than efficiency also affect intensity. World regions show notable differences in absolute levels of primary energy intensity.

Energy intensity was the lowest in Latin America and the Caribbean, which consumed around 3 MJ/USD of GDP (2021 PPP) in 2022. Intensity was highest in Eastern and South-eastern Asia, which consumed around 4.5 MJ/USD of GDP. However, between 2010 and 2022, energy intensity in Eastern and South-eastern Asia fell about 22 percent from almost 6 MJ/USD. This is the largest decline in any major region in this period. Given Asia's large population, this decline in energy intensity contributed toward global energy intensity falling from around 4.75 MJ/USD in 2010 to less than 3.9 MJ/USD in 2022, a nearly 20 percent decline.

Primary energy intensity in Northern America and Europe fell from around 4.3 MJ/USD to around 3.3 MJ/USD between 2010 and 2022, an improvement of 23 percent. This trend, however, is heavily influenced by the global energy crisis in 2022. Consumers in these regions reduced their energy consumption significantly to manage high energy prices and supply security risks. A similar decline was recorded in Oceania, of around 25 percent, from 4.4 MJ/USD to 3.3 MJ/USD, driven by similar forces. Energy intensity fell approximately 12 percent in Western Asia, Northern Africa, and Sub-Saharan Africa, where energy demand and GDP per remained significantly lower than in Northern America and Europe.

Meeting SDG target 7.3 requires doubling the global average annual rate of energy intensity improvement over 2010–30 relative to that in 1990–2010. When the target was set, doubling the rate meant annual energy intensity had to improve by around 2.6 percent per year between 2010 and 2030. Based on this target, the global primary energy intensity would be less than 2.8 MJ/USD in 2030. However, given the limited progress in recent years, meeting the original target requires an annual improvement rate of around 4.0 percent on average in the years remaining until 2030. Global primary energy intensity was slightly below 3.9 MJ/USD in 2022, indicating that a reduction of more than 27 percent is required until 2030 (figure 4.4).

FIGURE 4.4 • PRIMARY ENERGY INTENSITY, BY WORLD REGION, 2010 AND 2022



Source: International Energy Agency (World Energy Balances) and United Nations Statistics Division (Energy Balances).

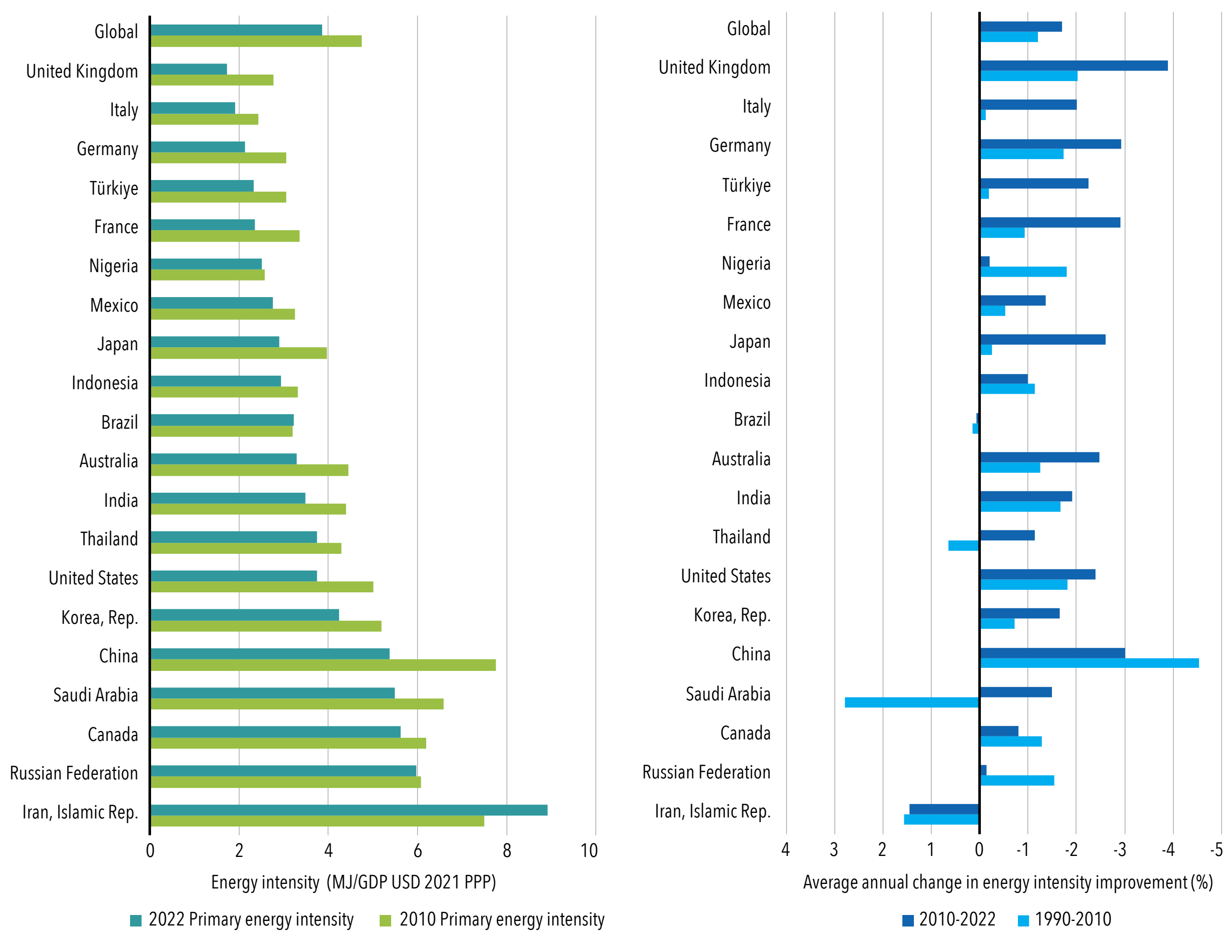
MJ = megajoule; PPP = purchasing power parity.

Trends in the 20 countries with the largest total energy supply

The 20 countries with the largest total energy supply are central to achieving SDG target 7.3, since they represent 75 percent of the world's energy use—and of its GDP. Between 2010 and 2022, energy intensity rates improved relative to the baseline period of 1990–2010 in 15 of these countries. The average improvement rate more than doubled in 2010–22 relative to that in 1990–2010 in nine countries (Australia, France, Italy, Japan, the Republic of Korea, Mexico, Saudi Arabia, Thailand, and Türkiye), but the 2.6 percent required for SDG target 7.3 was met by only China, France, Germany, and the United Kingdom.

Absolute levels of energy intensity differ widely across the selected countries. European countries such as the United Kingdom, Italy, and Germany saw the lowest levels in 2022, at around 2 MJ/USD (2021 PPP) or less. On the other side of the spectrum, Canada, Saudi Arabia, and China reported levels at least 2.5 times more intense, at over 5 MJ/USD. China's energy intensity improvements over 2010–22 were significant: it started in 2010 as the most-energy-intensive major economy, at almost 8 MJ/USD; this had dropped to around 5.5 MJ/USD by 2022 (figure 4.5).

FIGURE 4.5 • LEVELS OF AND CHANGES IN PRIMARY ENERGY INTENSITY IN THE 20 COUNTRIES WITH THE LARGEST TOTAL ENERGY SUPPLY



Source: International Energy Agency (World Energy Balances) and United Nations Statistics Division (Energy Balances)

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

When analyzing the drivers behind the change in primary energy intensity over 2010–22, several interesting trends emerge. Among emerging markets and developing economies (EMDEs), energy intensity improved in India, China, Indonesia, and Türkiye over 2010–22, and all but Indonesia saw improvement of more than 2 percent on average per year. This was mainly because a high GDP growth rate of at least 4 percent per year, on average, outpaced growth in total energy supply, which was more sluggish, at around 3 percent per year on average. These countries developed rapidly and expanded their economies, thanks in part to a growing (energy-intensive) industrial sector.

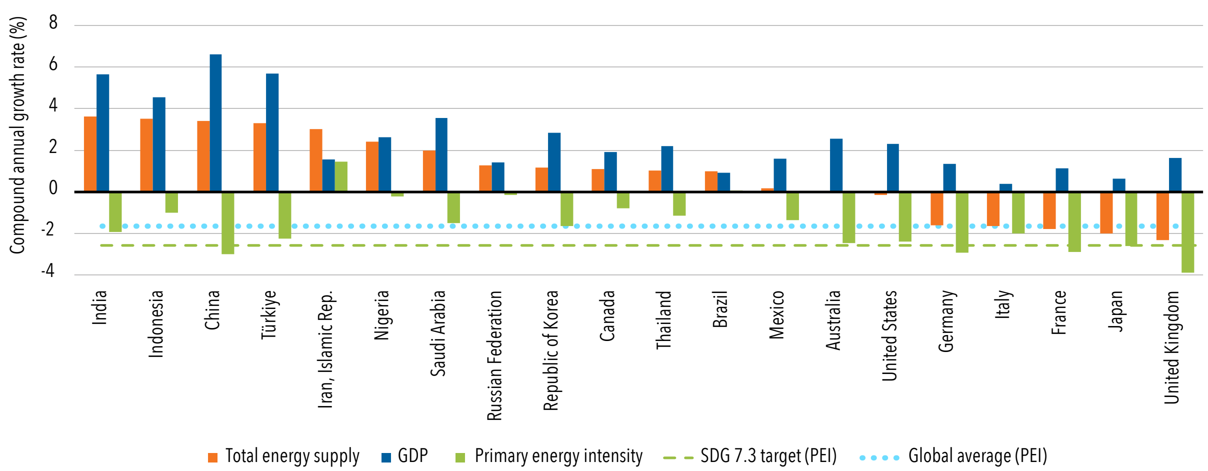
Several advanced economies, on the other hand, also saw their energy intensity improve at 2 percent or more over 2010–22, but due to different reasons. In Germany, Italy, France, Japan, and the United Kingdom, for example, primary energy intensity improved because total energy supply fell while GDP grew moderately, indicating decoupling and a move toward a more energy efficient economy.

In the United States and Australia, meanwhile, energy demand remained relatively stable while the economy grew over 2 percent per year on average, leading to energy intensity improvement of slightly over 2 percent per year. In the Republic of Korea, Thailand, and Mexico, both GDP and total energy supply grew, but the economy grew slightly faster than energy consumption, leading to moderate energy intensity improvement rates.

Economy and energy demand grew in parallel over 2010–22 in EMDEs such as Nigeria and Brazil—meaning energy intensity remained relatively flat. In these countries, just as in Canada, Saudi Arabia, the Islamic Republic of Iran, and the Russian Federation, fossil fuel extraction is an important driver of GDP. As a result, their energy intensity improvement rates have been slightly lower. Policy ambition to move away from fossil fuels to renewables while adopting more efficient electricity-powered technologies can help these countries accelerate progress on energy intensity (figure 4.6).

Energy intensity improved approximately 1.7 percent over 2010–22 globally. Meanwhile, achieving SDG target 7.3 by 2030 requires progress in energy efficiency in the 20 countries with the largest total energy supply. These countries can shift the needle, and will largely determine the global trend in the years to come.

FIGURE 4.6 • AVERAGE ANNUAL CHANGES IN TOTAL ENERGY SUPPLY, GDP, AND PRIMARY ENERGY INTENSITY IN THE 20 COUNTRIES WITH THE LARGEST TOTAL ENERGY SUPPLY, 2010–22



Source: International Energy Agency (World Energy Balances) and United Nations Statistics Division (Energy Balances)

GDP = gross domestic product; PEI = primary energy intensity; SDG = Sustainable Development Goal.

Efficiency trends in end-use sectors

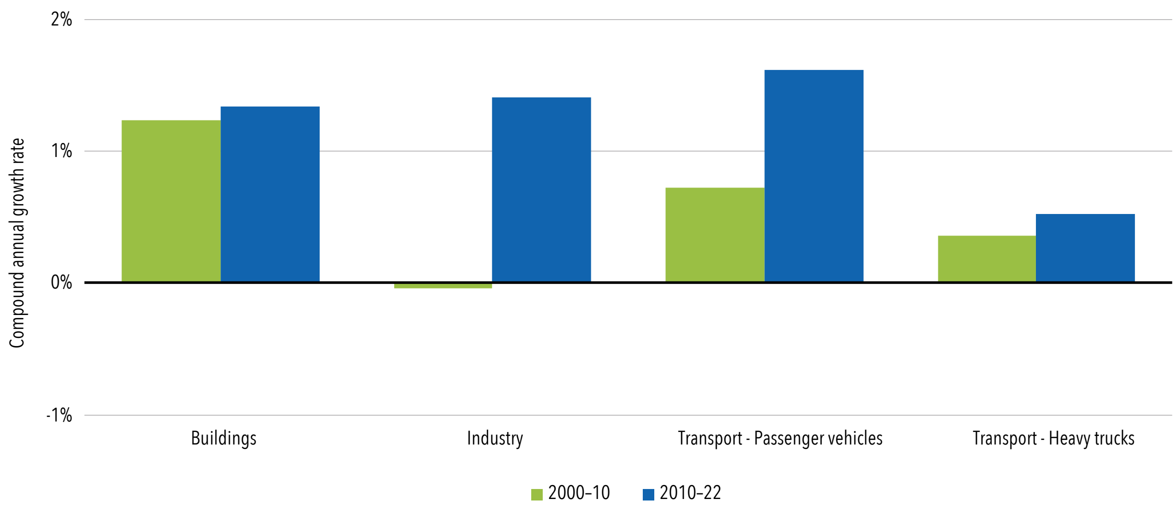
Next to overall energy intensity improvement, it is useful to analyze progress in different end-use sectors. Understanding which sectors are seeing rapid or slow improvement can help policy makers select national policy priorities. Between 2000 and 2010, progress in energy intensity was the fastest for buildings, followed by passenger transport and heavy trucks, whereas industry became slightly more energy intensive.

Between 2010 and 2022, progress in energy intensity across all end-use sectors improved compared with the previous decade. The average annual improvement rate for buildings increased slightly, from 1.2 percent to around 1.3 percent, as existing buildings became more energy efficient through retrofits, electrification of heating, and more efficient appliances, and new construction improved energy efficiency.

Progress compared with the previous decade was the largest for industry, from around 0 percent to 1.4 percent. Industrial processes have become more efficient and less fossil fuel is consumed for industrial heating, adding to efficiency gains.

Passenger vehicles registered a similar step up in energy efficiency, from around 0.7 percent per year on average over 2000–10 to 1.6 percent in 2010–22. This positive trend was driven by improved fuel economy standards and rapid adoption of electric vehicles (EVs), including two- and three-wheelers, and buses. EV sales, however, remain heavily concentrated in China, Europe, and the United States. Improvements compared with the previous decade were the slowest for heavy-duty trucks, from around 0.4 percent per year on average to 0.5 percent (figure 4.7).

FIGURE 4.7 • AVERAGE ANNUAL CHANGE IN ENERGY INTENSITY, BY SECTOR, 2000–10 AND 2010–22



Source: International Energy Agency (World Energy Balances) and United Nations Statistics Division (Energy Balances).

Note: Energy intensity is estimated as the ratio of total final energy consumption for each end-use sector to a sectoral activity indicator: floor space (buildings), value-added (industry), passenger-kilometers (passenger vehicles), or metric ton-kilometers (heavy trucks). These indicators are obtained from IEA's Global Energy and Climate Model. Their positive values denote an improvement (decrease) of energy intensity.

Trends in the efficiency of electricity generation

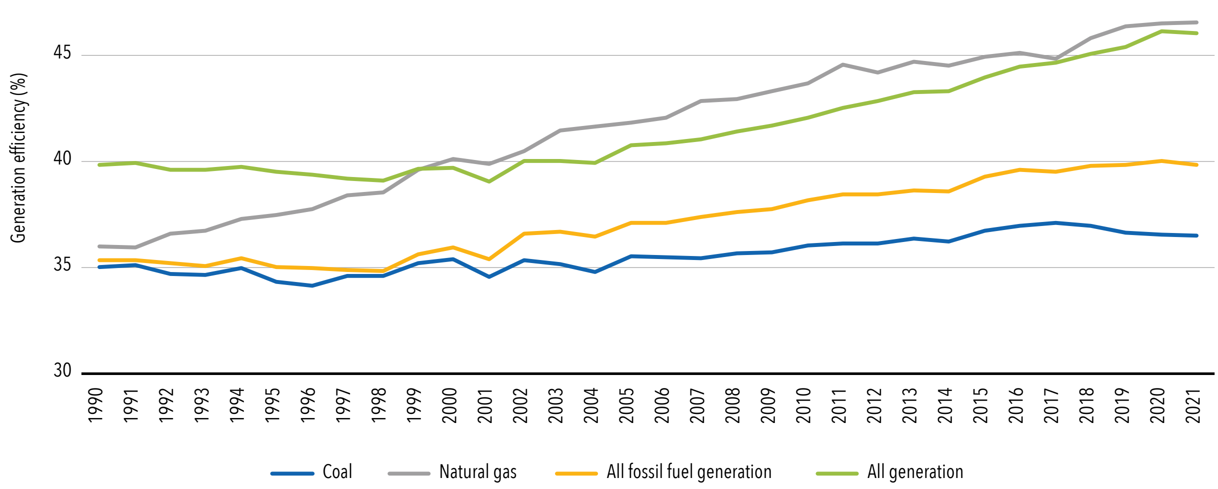
Primary energy intensity can also be lowered by boosting the efficiency of electricity generation, thus reducing primary energy use. Measures include modernizing infrastructure to reduce transmission and distribution losses, improving the efficiency of fossil fuel generation, phasing out inefficient power plants, and increasing renewables' share of the electricity generation mix.

Analysis of the two major fossil fuels used for electricity generation—coal and natural gas—shows that average efficiency increased between 2000 and 2022, after flat improvement rates in the 1990s. Efficiency improvements from natural gas offset slower improvements from coal generation (figure 4.8). An important factor influencing supply efficiency is renewables' share of the electricity generation mix. By convention, most renewable energy technologies are treated as 100 percent efficient, even though the conversion of resources such as sunlight and wind into electricity generates minor losses. Increasing renewables' share of the mix thus has a direct impact on the efficiency of electricity generation. The rapid deployment of renewable energies, especially in the past 15 years, has contributed to overall generation efficiency.

Between 1990 and 2010, overall generation efficiency increased from around 40 to 42 percent. Between 2010 and 2022, it increased further, to around 46 percent. Thus, in almost half the number of years, generation efficiency improved by twice as many percentage points. This growth was largely driven by the greater use of renewable energy to generate electricity. Between 2010 and 2022, the efficiency of coal-based generation remained flat, at around 36 percent, whereas that of gas-based generation improved moderately, from around 44 percent to nearly 47 percent.

Renewable energy is set to experience steady growth between 2022 and 2030, boosting overall generation efficiency further. Global natural-gas-fired generation is expected to see moderate but steady average annual growth, at about 1 percent, over 2025–27, and global coal-fired generation is expected to stagnate in the same period.

FIGURE 4.8 • GLOBAL ELECTRICITY GENERATION EFFICIENCY, BY FUEL TYPE AND OVERALL EFFICIENCY, 1990–2022



Source: International Energy Agency (World Energy Balances) and United Nations Statistics Division (Energy Balances).

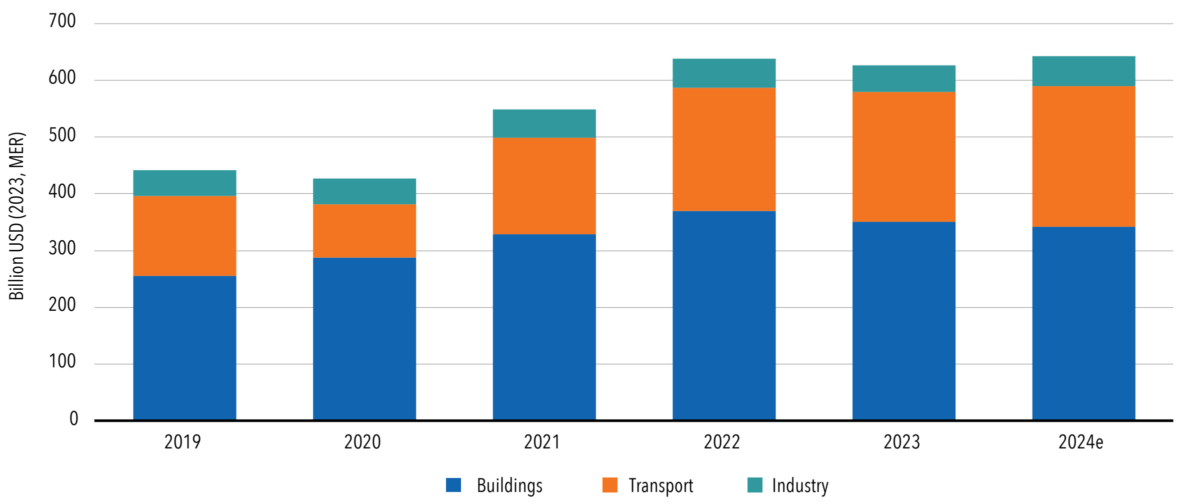
Investment in efficiency, electrification, and end-use renewables

Investment in energy efficiency, electrification, and end-use renewables has risen around 45 percent since 2019, reaching a total of about USD 640 billion. End-use investment in transport has grown the fastest, at around 77 percent, followed by 34 percent in buildings and 13 percent in industry. Total end-use-related investment grew around 16 percent relative to 2021, reaching new heights. The buildings sector represents the largest share of global end-use investment, at around USD 370 billion, followed by transport, at nearly USD 220 billion.

In 2023, efficiency investments in buildings are estimated to have fallen by around 5 percent and in industry by 8 percent. Strong EV sales supported the growth of end-use-related investments in transport by around 6 percent, although the total for 2023 is estimated to have remained relatively stable. The headwinds in the buildings and industrial sectors were partly caused by macroeconomic factors such as high inflation and high interest rates. This made efficient technologies more expensive to purchase and also meant that access to affordable finance to fund the investments was more limited.

Global end-use investment was still heavily centralized in the United States, Europe, and China, which together accounted for around three-quarters of the global total. EMDEs represented a smaller portion of efficiency-related investment, even though these countries represent over one-third of the global GDP. End-use investment is estimated to have grown strongly in EMDEs in 2023, however, including 10 percent growth in buildings. Europe, Asia Pacific, and Northern America registered combined end-use investment growth of 55 percent from 2019 to 2023. Europe represented the largest regional market, at USD 200 billion—a third of global investment—followed closely by China, also accounting for almost a third. Other Asia Pacific countries, such as India, Japan, and the Republic of Korea, together with Northern America, accounted for the other third of total investments (figure 4.9).

FIGURE 4.9 • GLOBAL INVESTMENT IN ENERGY EFFICIENCY, ELECTRIFICATION, AND RENEWABLES FOR END USES BY SECTOR, 2017–24E



Source: IEA 2024d.

Note: An energy efficiency investment is defined as the incremental spending on new energy-efficient equipment or the full cost of refurbishments that reduce energy consumption. The intention is to capture spending that leads to reduced energy consumption. 2024e = estimated values. MER = Market exchange rate.

Policy recommendations

Primary energy intensity improved by around 2.1 percent globally in 2022—more than four times the rate of 2021. This was driven by the 2022 global energy crisis, which triggered major shocks to energy demand in many regions. However, the energy intensity improvement of 2022 remains insufficient to achieve SDG target 7.3, which requires intensity to improve 2.6 percent per year between 2010 and 2030. The world is thus not yet on track to achieve the target for 2030. Given the slower than required progress in recent years, energy intensity must now decline by at least 4.0 percent on average per year through 2030 if target 7.3 is to be met.

Estimates for 2023 and 2024 indicate a slowdown in progress as energy intensity improvement drops to approximately 1 percent per year as some of the pressures of the 2022 global energy crisis ease off. While there are still significant regional differences in 2023, estimates for 2024 indicate smaller regional variations. Progress is set to slow slightly in advanced economies while remaining steady or increasing slightly in many EMDEs.

Energy efficiency policies and investments in cost-effective measures need to be scaled up significantly if the global target is to be met. Global investment in energy efficiency and electrification increased rapidly over 2019–22, but this growth is estimated to have stabilized in 2023 and 2024. Government support is crucial to enable consumers to invest in energy-efficient technologies, which can significantly lower energy bills. Universal access to electricity and clean cooking, increased electrification, and the incorporation of renewable energies improve energy intensity by making energy end uses significantly more energy efficient and reducing supply-side inefficiencies. More joint efforts are needed to leverage the synergies between the various SDG 7 targets.

Energy efficiency can deliver many shared benefits to people, such as lowering energy bills, improving health outcomes, and creating new jobs. A strong, early focus on energy efficiency is essential to achieve net zero emissions by 2050. But despite the many benefits of energy efficiency, there are still obstacles preventing people and businesses from investing in energy efficiency improvements. Faster progress in efficiency requires a people-centered approach to ensure fair outcomes, improve skills, create decent jobs, and bring about social and economic development, while engaging people as active participants.

In all sectors, the greatest efficiency gains are achieved by a package of policies that combine three main types of mechanisms: regulation, information, and incentives. Careful policy design and implementation will help leverage energy efficiency's full potential to bolster energy security, create jobs, increase living standards, cut energy bills, and reduce emissions. Successful examples of implementation have the potential to be replicated to boost energy efficiency globally. IEA has published an Energy Efficiency Policy Toolkit summarizing the main tools to be used across sectors (IEA 2024b). Both the technologies and the resources to double energy efficiency improvement by 2030 are available (UN 2021). While countries should work to develop a framework that includes different instruments and covers multiple sectors, in the short term, prioritization can be useful. Some policies can be implemented faster or can have larger effects. This depends on national circumstances, such as the existing policy mix, the structure and size of the economy, available fiscal space, and the country's institutions.

Buildings

Buildings account for about 30 percent of the world's final energy consumption and more than half its electricity consumption (IEA 2024a). To stay on the pathway toward net zero emissions by 2050 and accelerate the rate of energy intensity progress between now and 2030, buildings need to rapidly become more efficient.

Building energy codes set the minimum requirements for energy use in buildings. They may establish the requirements for the overall energy efficiency of an entire building (performance-based codes) or of individual building components, such as insulation, lighting systems, or heating and cooling systems (prescriptive codes). They may also include both types of requirements to provide flexibility to the market. Only energy-code-compliant buildings may be constructed. Building energy codes can also include requirements for on-site renewable energy production, embodied carbon, energy management, and the integration of smart appliances and equipment to enable a demand response. New buildings as well as existing buildings undergoing major renovations could be subject to building energy codes, which can make buildings more efficient and help the industry prepare for, and adapt to, market changes. As of 2024, approximately 85 building energy codes were implemented globally, with around half of the newly constructed buildings subject to energy efficiency requirements (IEA 2024a).

To complement building energy codes, countries can mandate **energy performance certificates** (EPCs), which offer information on a building's energy performance and energy demand, indicating how efficient—and often how environmentally friendly—the building is. EPCs can differ, but some of the key elements may include an energy efficiency rating, property details, energy efficiency recommendations, and the estimated energy use and carbon emissions.

For existing buildings, **retrofit grants** are an effective incentive tool to promote efficiency. Grants can reduce the up-front costs of energy-efficient technologies and make them more financially viable for consumers. This can help create a market pull, encouraging stakeholders to comply with energy efficiency regulations by implementing efficiency measures to improve the energy performance of buildings. Grants typically provide payment before the retrofit is done and cover part of the costs, for example, of adding insulation, upgrading heating or cooling systems, or installing solar photovoltaics.

Other supportive measures include mandatory energy and/or carbon disclosure programs at the point of a building's sale and/or lease; other financial and nonfinancial incentives linked to the building's energy performance; utility-based rewards and procurement regulations; periodic energy audits for large consumers; and training for architects, builders, building assessors, and inspectors.

Appliances

Appliances represent 45 percent of a typical building's electricity use and are responsible for almost 3 gigatons of carbon dioxide ($GtCO_2$) emissions a year (IEA 2024b). To stay on the pathway toward net zero emissions by 2050 and accelerate the global rate of energy intensity improvement between now and 2030 would require appliances to be 30–40 percent more efficient by 2030.

Minimum energy performance standards (MEPS) for appliances establish a minimum efficiency threshold to address efficiency improvement barriers, such as potentially higher purchase prices or product availability, and ensure fair competition in competitive markets. Equipment that does not comply with these minimum requirements may not be sold on the market. The MEPS-induced turnover of a product's stock occurs over a longer or shorter time period depending on the product's lifetime and possible policies to incentivize early replacement, such as financial rewards. Through MEPS, only more efficient products may be sold as new equipment. Less efficient equipment will leave the stock gradually as it is replaced. MEPS are among the longest standing energy efficiency policy instruments and are often quite cost-effective in improving the energy efficiency of products on the market. Comprehensive, harmonized, and regularly updated MEPS are crucial to accelerating efficiency improvement. As of 2023, more than 115 countries, representing 98 percent of global electricity consumption, have MEPS for at least some appliances (IEA 2024b).

Labeling programs can complement MEPS. They provide information to support decisions toward purchasing more energy-efficient products. Comparative labels, which are often mandatory, have a classification scale, which enables consumers to compare the energy performance of different products and is generally found on all products of the same type. Endorsement labels, which are voluntary, are found only on best-in-class models or those exceeding a certain efficiency level. These two types can also complement each other. Today, 107 countries have a labeling scheme for appliances.

Attractive **loans and rebates** can incentivize the adoption of more efficient appliances by helping to lower the up-front investment costs of appliances and offering financial support. They encourage consumers to buy more efficient products and motivate suppliers to produce them. Incentives also drive innovation and the adoption of new technology and practices. Rebates and loans are regularly combined in one policy instrument. Rebates can be expensive for governments, nevertheless, and require careful design. Low-cost loans provide funding up front and are available for highly efficient models. In many cases, the eligibility criteria include scrapping an old but functioning appliance.

Industry

Industry accounts for 37 percent of global final energy consumption (IEA 2024a) and around 20 percent of global greenhouse gas emissions (UNEP 2024). To stay on the pathway toward net zero emissions by 2050 and accelerate the rate of global industrial annual energy intensity improvement between now and 2030, industry needs to decouple the production of outputs from energy demand and increase the share of electricity in its energy consumption to 30 percent by 2030, from 23 percent in 2022 (IEA 2024b).

MEPS for industrial electric motors are a regulatory instrument in the industry policy package. They establish the requirements for a minimum level of energy efficiency that electric motors must meet in order to be sold in a particular jurisdiction. MEPS typically specify these minimum efficiency levels based on the motors' size, type, and application. Motors meeting or exceeding the specified efficiency levels are considered compliant, and noncompliant models are not allowed to be sold on the market. Efficiency is generally measured as the ratio of a motor's output power (mechanical power delivered to the load) to its input power (electrical power consumed).

MEPS for electric motors are often based on international standards for efficiency classes, and they can help countries meet their energy efficiency and carbon dioxide emission targets. These standards not only support motors in becoming more efficient overall, but they also help ensure efficiency levels across manufacturers are comparable for motor users. MEPS for industrial electric motors have been implemented in 62 countries, covering over half of the global industrial motor fleet as of 2022 (IEA 2024a).

Industrial energy efficiency networks (EENs) promote the exchange of energy-efficiency-related knowledge and information. They differ in structure but generally consist of a group of energy managers from different industrial sites that meets regularly to share knowledge and experience on improving industrial energy efficiency. They can operate solely for information exchange among peers, or they can include elements such as energy reporting and the setting of energy saving targets. These networks act to guide industries in becoming more efficient, in line with government policies, and to provide governments with improved industry-specific insight to develop more effective policy. There are over 1,000 industrial EENs worldwide (IEA 2024b), and this number is growing as governments seek to expand their policies and industries seek to reduce costs, energy consumption, and emissions.

Energy management systems (EnMSs) enable energy consumers to manage their energy consumption for energy efficiency as well as saving costs. A key framework for EnMSs is the international standard ISO 50001, which is based on a continuous cycle of monitoring, targeting, and implementing efficiency measures. In 2023, the International Organization for Standardization issued certificates in 105 countries; 58 percent of the 9,500 certificates awarded to industry were to those that were less energy intensive.

Transport

Private cars and vans were responsible for more than 25 percent of global oil use (IEA 2024c) and around 10 percent of energy-related CO2 emissions in 2022 (IEA 2024a). To stay on course toward net zero emissions by 2050 and accelerate the rate of global annual energy intensity improvement between now and 2030, cars need to become 5 percent more efficient every year (IEA 2024b).

Fuel economy standards regulate the efficiency of new vehicles by, in the simplest terms, defining annual corporate average standards, or targets, for fuel economy (miles per gallon or kilometer/liter) or greenhouse gas (GHG/CO2) emissions (in grams per mile/kilometer). There are different designs, but, in general, they define a standard for all auto manufacturers, for every year that the regulation applies. Some countries offer flexibility mechanisms, for example, credits for overcompliant manufacturers, which they can use in future years or trade with underachieving manufacturers. Fuel economy standards have increasingly included provisions to facilitate the adoption of EVs (including battery electric and plug-in hybrids) and fuel cell vehicles. These standards support the development of advanced technologies; can significantly reduce fuel use, boost energy security, and reduce emissions; help increase regulatory certainty for manufacturers; and may be most appropriate in countries with large markets and vehicle manufacturing facilities. Currently, fuel economy or emission standards for new cars exist in more than 40 countries (IEA 2024a), covering over 80 percent of new passenger vehicle sales globally.

Vehicle efficiency labels can complement fuel economy standards and provide consumers with information that helps them identify the most efficient vehicles. They can cover new and used vehicles, benefiting all vehicle purchasers. Labels can be in different formats, including displayed on vehicles in car showrooms and online. Increasingly, EVs feature labels with metrics that also include a vehicle's driving range. National comparison websites can also help potential buyers identify the most-fuel-efficient vehicles by category. Consumers can compare makes and models and identify the best-performing vehicles. In addition to information on fuel economy, labels can also include information on CO2 and air pollutant emissions, as well as information on fuel cost savings. Information on fuel cost savings will help buyers choose vehicles that cost less to run. Today, over 35 countries across the world have vehicle efficiency labels (IEA 2024b).

Subsidies for passenger EVs play a key role in accelerating electric car sales, especially to early adopters, and are in place in many markets. They can accelerate EV adoption by reducing the price gap between EVs and vehicles with internal combustion engines. Subsidies are typically in the form of discounts or rebates. They can also be implemented as tax reductions through income tax credits. Discounts and rebates are the most commonly used incentives to lower the purchase price of EVs. They can be fixed direct discounts deducted from a vehicle's cost at the point of sale, or rebates/refunds assigned once a vehicle has been purchased. Subsidies, which boost EV adoption, have been implemented in most major EV markets. The incentive levels and eligibility requirements differ, and consumers can, accordingly, choose more efficient or more affordable EV models.

Agriculture

Energy is needed at every stage of agrifood systems. The adoption of energy efficiency measures across agrifood value chains can help agrifood systems be more sustainable and resilient. Key steps include optimizing the efficiency of the use of agricultural inputs (e.g., mechanization, fertilizers, and irrigation systems); reinforcing insulation in biogas plants and integrating heat recovery systems while maintaining productivity levels; reducing the distance between points of agricultural goods' production and consumption; and enhancing cold chains to reduce energy use and minimize food loss and waste.

Cross-cutting

As electricity systems accommodate more renewables, there is a growing need for new sources of flexibility, driving greater interest in **demand-side management**. Today, almost all flexibility comes from traditional thermal-powered generation and hydropower. However, as variable renewables increase, demand response enabled by smart, connected appliances and efficient user behavior, as well as battery storage, are emerging as effective sources of flexibility. Future energy systems are expected to include several integrated and interconnected flexibility services. Digitalization can also play an important role in energy management, helping energy users manage their electricity load.

Energy efficiency obligation (EEO) schemes require the "obligated parties" to meet the energy or emission savings targets within their customer portfolios. Obligated parties may be energy utilities, retail energy sales companies, energy distributors, transport fuel distributors, and/or transport fuel retailers. EEO schemes are market-based instruments that do not prescribe measures to be deployed by obligated parties to meet their set targets (within certain limits). Some EEO schemes include "white certificates" (also called energy savings certificates), documents certifying that a certain reduction of energy or emission consumption has been achieved. White certificates are typically tradable between over- and under-performers and combined with an obligation to achieve a certain energy or emission savings target. EEO schemes are in use in 31 countries, and their number has grown steadily over the past 20 years (IEA 2024b).

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

Photo: © Dougberry / E+ / Getty Images

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 rose for the third year in a row, reaching USD 21.6 billion in 2023. Growth over three consecutive years has occurred only once before, in 2004–07, before being disrupted during the 2008 financial crisis. However, most of this growth is in major developing economies, as opposed to least-developed countries (LDCs), landlocked developing countries (LLDCs), and small island developing states (SIDS). Accelerating this growth trajectory while expanding finance to those furthest behind will be key to drive progress toward SDG 7.

Target for 2030. While there is no quantitative target for international public financial flows under indicator 7.a.1, developing countries received less in 2023 than in 2016, when international flows peaked at USD 28.4 billion. The tri-year growth (2021–23) is a positive sign, especially as it occurred amid economic, health, and geopolitical crises that prompted donors to redirect funds to other priorities, such as humanitarian aid and health. The international community must build on this momentum to consistently achieve greater annual flows supporting SDG 7, given its critical role in realizing other SDGs.

Technology highlights. Flows grew by 84 percent, with funding for solar energy projects accounting for most of the growth. Solar funding reached USD 9.44 billion and represented 44 percent of the total funding in 2023—the highest ever share of solar commitments in a single year. A substantial portion of commitments went to solar-based isolated grids and standalone systems to enhance energy access. Flows to wind and hydropower projects remained below their peaks but increased by 41 percent and 61 percent, respectively, reaching USD 2.4 and USD 2.3 billion. Wind and hydropower together constituted 22 percent of the total flows. More than a third (34 percent) went to projects supporting multiple/other renewables. Most of these projects combine renewable energy technologies; examples include efforts toward electrification and energy efficiency, grid transmission and distribution development, and manufacturing plants for electric vehicles. Such projects may also include technical assistance activities supporting a mix of renewable energy technologies.

Regional highlights. Only two regions, Central Asia and Southern Asia, have seen real progress in international public financial flows relative to their historic highs. Flows to these regions grew by a factor of 2.5 over 2022–23, reaching record highs of USD 5.6 billion, wing to greater commitments for solar energy projects in India and Uzbekistan. Record-high flows also went to developing countries in Northern America and Europe, where funding exceeded USD 1 billion for the first time since 2000, concentrated in Serbia and North Macedonia. While Sub-Saharan Africa, Western Asia and Northern Africa, and Eastern Asia and South-eastern Asia saw substantial increases in international public flows between 2022 and 2023, the flows remained well below their peak levels. Meanwhile, flows to Latin America and the Caribbean, and Oceania, dropped to USD 3.47 billion and USD 64 million, a downward correction after substantial growth in the year before (2022).

Commitment distribution highlights. The number of countries and territories accounting for 80 percent of flows grew from 19 in 2021 to 25 in 2022, and then increased by another four, to reach 29 in 2023. While this is the largest number of countries/territories to make up 80 percent of commitments in a single year, public financial flows remain concentrated in a relatively small number of countries/territories. Flows to LDCs remain well short of their historic highs, and LDCs' overall share of the total flows fell by 0.5 percent between 2022 and 2023, outpaced by non-LDC countries and territories. On a per capita basis, 51 countries/territories received more than USD 5 per person in 2023, but only 20 percent of LDCs, 44 percent of LLDCs, and 30 percent of SIDS are included in this bracket. Finally, a few countries received less than 10 US cents per capita: Iraq, Cabo Verde, the Syrian Arab Republic, Sudan, and Malaysia. Yemen received the least, at less than a 10^{th} of a cent per person.

Financing instruments. Despite interest rate hikes pushing the cost of debt to record-high levels in 2023, the share of debt-based instruments grew from 70 percent to 83 percent between 2022 and 2023. Standard loans remained the most-used financial instrument in 2023, at USD 13.6 billion (63 percent of the total), followed by concessional loans, at USD 4 billion (18.8 percent). Meanwhile, grants dropped to USD 2.1 billion (a 39 percent decline from 2022), making up just 9.8 percent of flows in 2023 compared with 20.5 percent in 2022. Equity financing fell to USD 807 million in 2023, representing just 3.7 percent of flows. Since donors typically prefer debt instruments, partly to manage their credit ratings, equity contributions remain limited: only 12 donors provided equity contributions of the 56 that provided any form of commitment in 2023. Finally, flows for dedicated risk-mitigation support (i.e., guarantees and credit lines) doubled in 2023, reaching USD 672 million, or 3 percent of total financial flows. These were provided across at least 10 countries (only one LDC), compared with six in 2022.

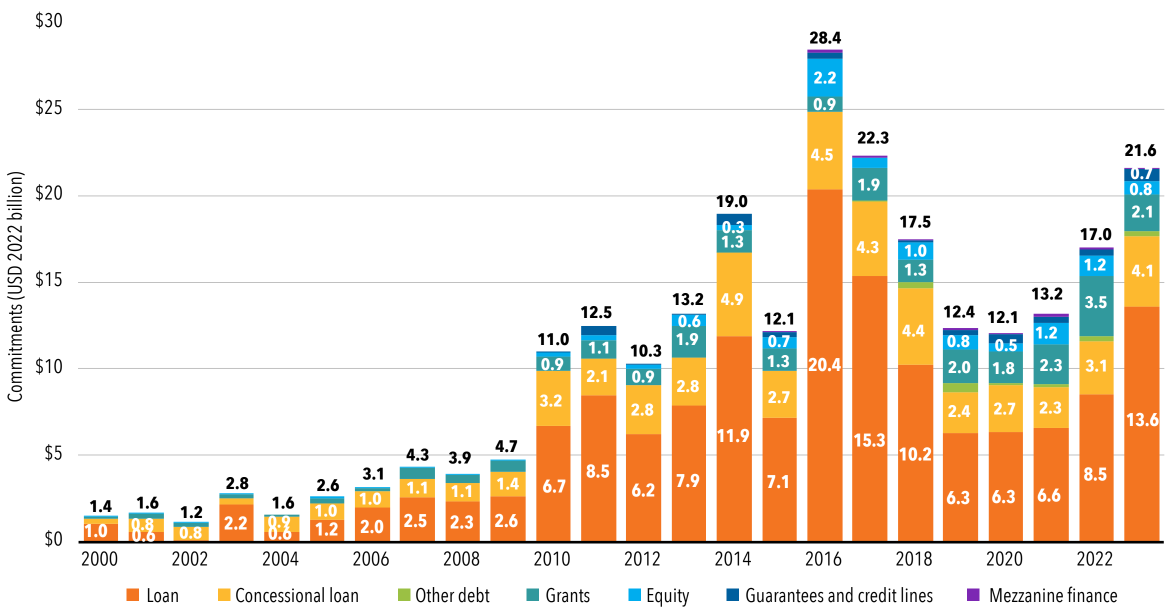
Are we on track?

International public financial flows[25] supporting clean energy research and development and renewable energy production in developing countries increased for the third year in a row, reaching USD 21.6 billion, in 2023. Such tri-year growth happened only once before, in 2004–07, before being disrupted during the 2008 financial crisis.

This tri-year growth occurred amid ongoing economic, health, and geopolitical crises that caused donors to shift priorities to domestic energy needs and other priorities, such as health, in-country refugees, humanitarian aid, and debt relief (OECD 2025). In 2023, bilateral and multilateral flows from European donors fell but were more than offset by other commitments from multilateral donors, such as the World Bank Group and the Asian Development Bank (ADB).

While there is no quantitative SDG 7.a.1 target for enhanced international cooperation, developing countries received fewer public flows in 2023 than they did in 2016, when the international flows from developed countries peaked at USD 28.4 billion (see figure 5.1).[26] Further, 63 percent of these flows were in the form of standard market-rate loans. Overall financial support falls well short of meeting the actual energy needs of developing countries, especially LDCs and SIDS (IRENA 2023). Given that a handful of funders are responsible for the majority of flows each year, these institutions' decisions going forward as well as the ability to attract broader funding will be critical to the achievement of SDG 7.

FIGURE 5.1 • ANNUAL INTERNATIONAL PUBLIC FINANCIAL FLOWS FOR RENEWABLES IN DEVELOPING COUNTRIES, BY INSTRUMENT, 2010–23



Source: IRENA and OECD 2024.

25 International public financial flows include official development assistance and other official flows that are transferred internationally to other countries. They are referred to as flows, commitments, and financing interchangeably in this chapter. These flows are reported at the time they were officially committed, not at the time they were disbursed.

26 Unless stated otherwise, all commitment amounts are expressed in US dollars at 2022 constant prices and exchange rates. Constant amounts are adjusted for inflation rates and changes in exchange rates. Annex 1 provides more information.

Multilateral banks increasingly channeled international public flows for renewables. For instance, the World Bank Group's International Bank for Reconstruction and Development (IBRD), International Development Association (IDA), and International Finance Corporation (IFC) were the top three providers of flows, accounting for USD 8.74 billion—a 2.5-fold increase from 2022. Although the World Bank Group accounted for over two-fifths of the year's total (its highest share ever in a single year), this USD 8.74 billion was still 16 percent less than the Bank's peak contribution in 2016. Moreover, concessional loans and grants made up just 25 percent and 3 percent of overall flows, respectively, while standard loans remained the most-used financial instrument. Finally, overall World Bank Group flows were distributed among fewer countries and territories in 2023 (54) than at the 2016 peak (68).

China remains the all-time-largest provider of international flows to date (19.5 percent of the total across 2000–23), but in 2023, its flows accounted for just 1.3 percent of the total (at USD 277 million). This decrease in share is likely because its overseas support for clean energy has shifted from development financing to a more market-driven approach, led by state-owned commercial banks and private investors—flows not captured in SDG 7.a.1 (IEA 2024a).[27] As a result, tracked flows have declined significantly: between 2014 and 2018, the China Development Bank and Export-Import Bank of China (the two Chinese donor agencies considered for this indicator) averaged USD 5.35 billion each year and constituted 27 percent of the total flows. Since then, their flows fell to less than USD 400 million in 2019–23, making up less than 3 percent of the total. While some of this decline may be due to limited data on these two institutions, as mentioned, considerable overseas investment continues to occur through other Chinese entities not considered here (American Enterprise Institute 2024; AIDDATA 2023; WRI 2023).

27 Last year's report stated that the two Chinese development banks considered for this indicator—the China Development Bank and the Export-Import Bank of China—had provided no international commitments in energy projects between 2021 and 2022. Retroactive changes show that, in fact, these institutions committed at least USD 1.01 billion in 2021–22.

Looking beyond the main indicators

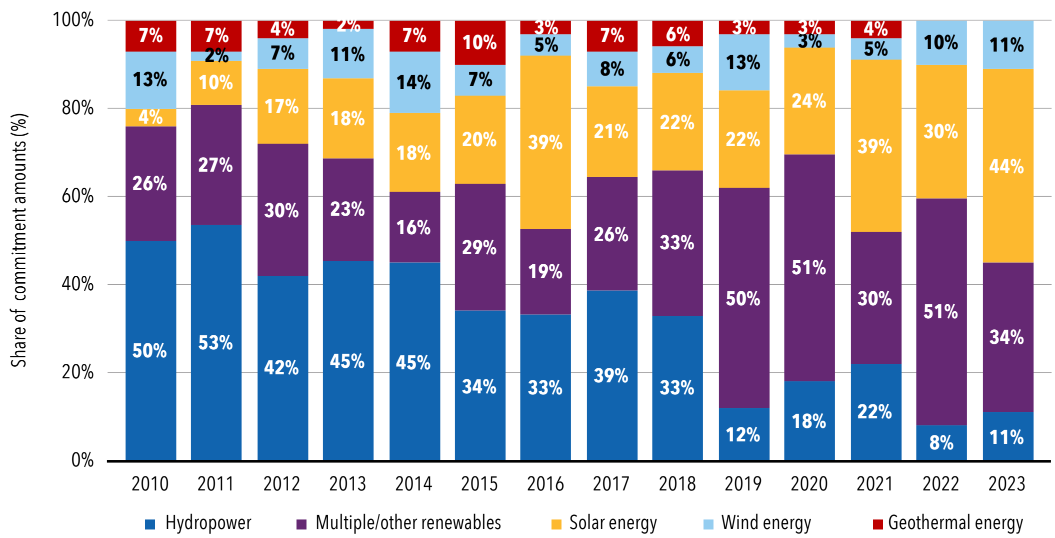
This section analyzes trends in international public flows from the perspective of technologies, geographic regions, countries, and financing mechanisms.[28]

Technology trends

International public investors categorize flows to clean energy by the type of renewable energy involved: hydropower, solar, wind, geothermal, and multiple/other[29] (figure 5.2).

Solar energy commitments accounted for 44 percent of flows in 2023—their highest ever share in a single year. A total of 542 commitments[30] were made in 2023, totaling USD 9.44 billion. These ranged from the largest commitment, with a ticket size of USD 410 million,[31] for a solar photovoltaic (PV) cell and module manufacturing facility in India (4 gigawatts [GW]) (US International Development Finance Corporation 2022), to more than 300 smaller commitments of USD 1 million or less, a significant portion of which focused on solar-based isolated grids and stand-alone systems. Almost 90 percent of these smaller solar projects (USD 1 million or less) received funds via grants, whereas projects with larger ticket sizes were predominantly debt based.

FIGURE 5.2 • SHARE OF INTERNATIONAL PUBLIC FINANCIAL FLOWS TO RENEWABLES, BY TYPE OF ENERGY, 2010–23



Source: IRENA and OECD 2025.

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

29 The multiple/other renewables category consists of unclear commitment descriptions in financial databases and details 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 broad range of technologies, such as renewable energy and electrification programs, technical assistance, energy efficiency programs, and other infrastructure supporting renewable energy.

30 A total of 542 commitments were made across 399 projects. Multiple commitments can be recorded for the same project.

31 In constant prices and exchange rates. In nominal terms, this is equivalent to USD 435 million.

An additional 11.3 percent of flows went to wind energy, equivalent to USD 2.4 billion for 37 projects. Although flows grew relative to 2022, they were still 11 percent short of the historic highs of 2014. Flows were primarily driven by large-scale USD 900+ million offshore wind projects funded by Japan in nonspecified areas in Eastern Asia, and another USD 349 million project funded by IBRD and IDA in India.

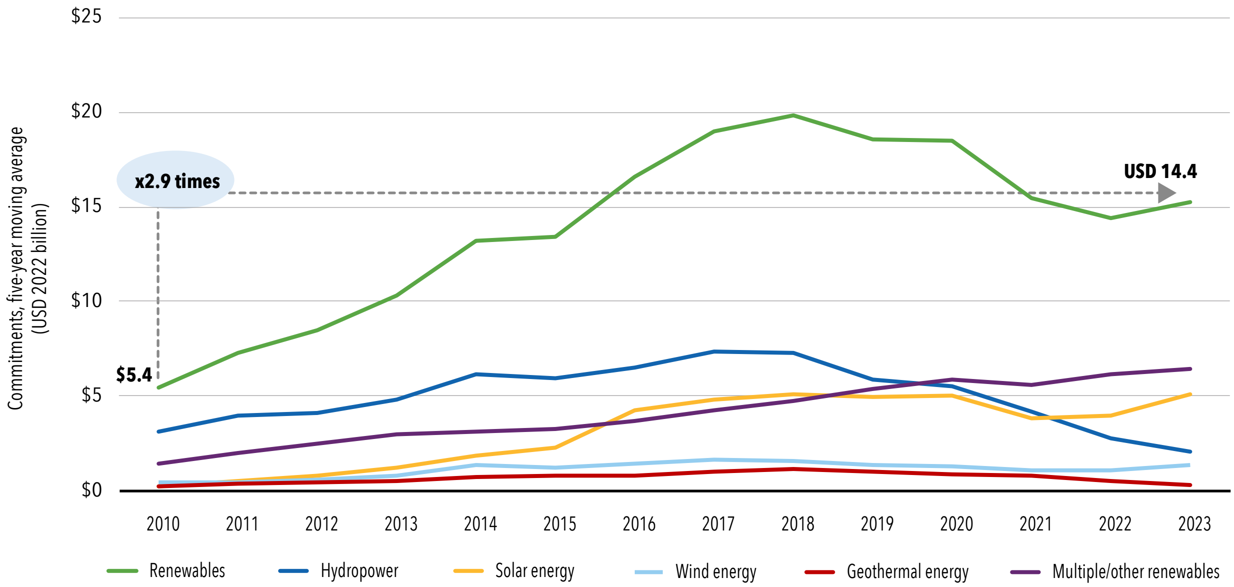
Hydropower projects received 10.7 percent of flows—equivalent to USD 2.3 billion—in 2023, less than a quarter of the peak hydropower financial flows in 2016. Although hydropower commanded larger shares of flows before 2019, this was driven by multi-billion-dollar commitments in single large-scale hydropower projects. Such large commitments were not recorded in the five years 2019–23. For instance, in 2013–18, 11 projects with a ticket size of USD 1 billion or more received funding. In the following five years, 2019–23, no projects of such large magnitude received international public funds.[32] Although hydropower generation is expected to continue growing across developing economies, its share of flows relative to other renewable energy sources is expected to decline (IEA 2024b).

More than a third (33 percent) of the flows went to projects supporting multiple/other renewables. This category's share of flows has grown, since it captures commitments for projects with an unspecified or unclear technology choice. Typically, such projects target a broad range of renewable energy technologies without providing a technology-specific financial breakdown. They can include larger projects linked to a combination of renewable energy technologies, such as electrification and/or energy efficiency programs, grid transmission and distribution development, and manufacturing plants for electric vehicles. Or they may be relatively small, such as multitechnology technical assistance programs and multipurpose financial instruments such as green bonds and capitalization of investment funds—the proceeds of which support multiple technologies. Bioenergy projects, whose commitments are almost negligible, are also included here. Bioenergy has the largest share of projects with ticket sizes of USD 1 million or less, due to the small-scale nature of these projects.

Given the substantial variation in annual commitments, a moving average smooths year-on-year fluctuations and provides a clear picture of the underlying trend (figure 5.3). After declining for four consecutive years, the moving average (MA5) for all renewables rose by 5.7 percent in 2023. The increase in flows in 2023 was enough to shift the general trend upwards, underpinned by consistent year-on-year growth during 2021–23. The technology-specific moving average for 2023 reveals that technologies other than hydropower and geothermal are mainly responsible for this growth.

32 A similar drop was seen for commitments of between USD 500 million and 1 billion. Meanwhile, commitments of USD 1 million or less increased, while those of USD 20–100 million, and USD 1–20 million, declined.

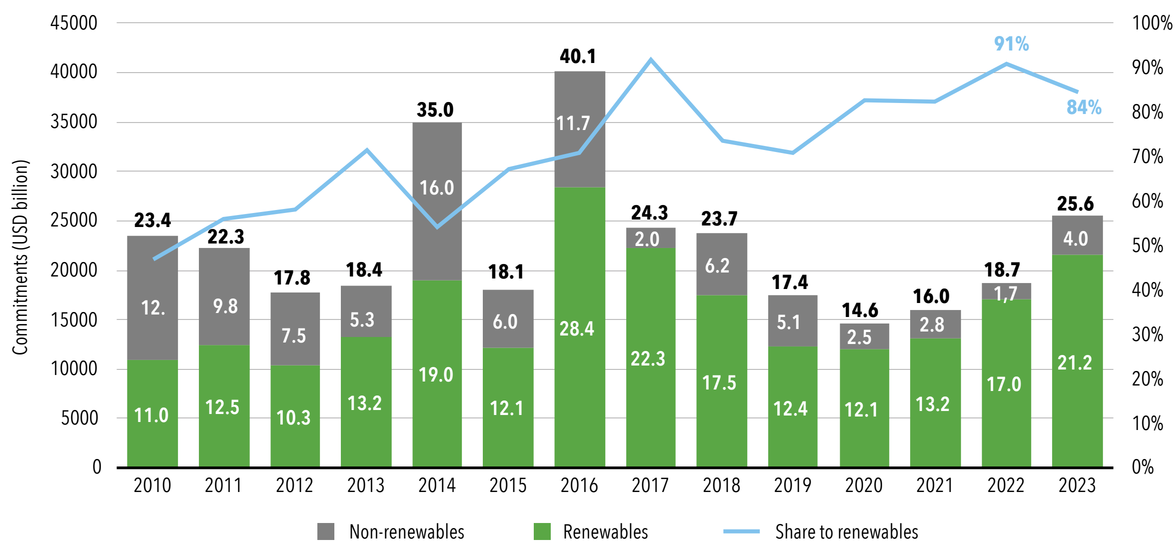
FIGURE 5.3 • FIVE-YEAR MOVING AVERAGE FOR INTERNATIONAL PUBLIC FINANCIAL FLOWS TO RENEWABLES, BY TECHNOLOGY, 2010–22



Source: IRENA and OECD 2024.

While renewables continued to dominate international public flows (increasing 84 percent in 2023, from 47 percent in 2010), flows toward non-renewables rebounded to USD 4 billion in 2023, up from their lowest level of USD 1.7 billion in 2022 (figure 5.4). The top three recipients were Bangladesh (43.3 percent), Peru (13 percent), and South Africa (12.9 percent). The flows included a USD 1.6 billion concessional loan for a coal power plant in Bangladesh, and two standard loans of approximately USD 500 million each for natural gas power plants in Peru and South Africa.

FIGURE 5.4 • ANNUAL COMMITMENT BY ENERGY TYPE: RENEWABLES AND NONRENEWABLES, 2010–23

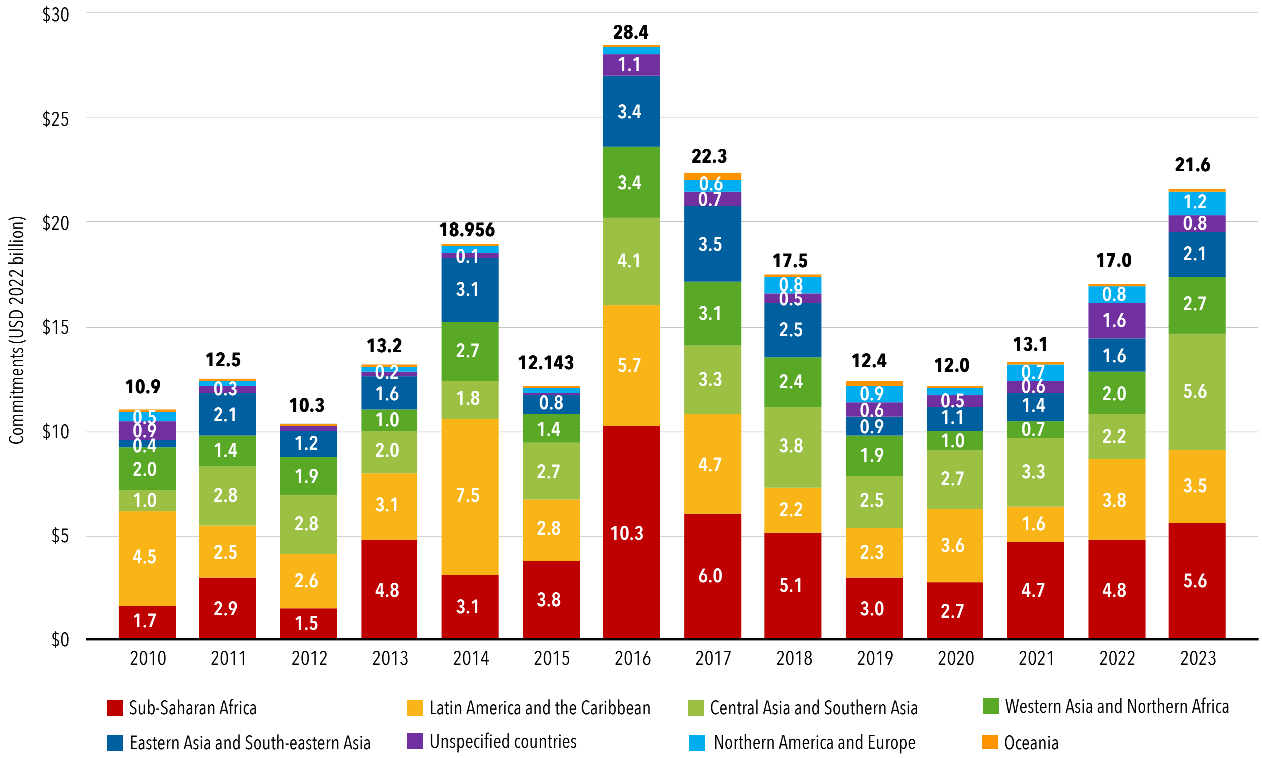


Source: IRENA and OECD 2024.

Regional trends

International public financial flows to all regions changed markedly between 2022 and 2023. The largest increase was for Central Asia and Southern Asia (figure 5.5), which, together with Sub-Saharan Africa, are the main destinations of all flows.

FIGURE 5.5 • ANNUAL INTERNATIONAL PUBLIC FINANCIAL FLOWS TO RENEWABLES, BY REGION, 2010–23



Source: IRENA and OECD 2024.

Note: See chapter 7 for the list of countries included in each region.

Only two regions have seen real progress in international public flows relative to their historic highs, setting a new record.

Central Asia and Southern Asia attracted record-high flows, of USD 5.6 billion, between 2022 and 2023—a more than 2.5-fold increase, mainly due to greater commitments for solar energy projects, which received a record high of USD 2.97 billion (a sixfold increase). About 89 percent of the flows went to just two countries: India (57.3 percent) and Uzbekistan (32 percent). Pakistan represented another 7 percent of the overall flows, as solar commitments to it grew sixfold. All three countries have seen their solar PV installed capacity grow significantly in recent years (IRENA 2024c).

ADB and IBRD were the top two providers of funds (47 percent of the region's total)—breaking past their historic regional highs to provide USD 1.35 billion and USD 1.28 billion, respectively. Saudi Arabia provided its first ever commitment to the region to fund two hydroelectric power plants in Pakistan and Tajikistan, both funded on a concessional loan basis. In general, however, the majority of the region's funding is earmarked as standard loans (77 percent).

Northern America and Europe also received record-high flows, surpassing USD 1 billion for the first time since 2000. Sixty-five percent of the flows went to projects for multiple/other renewable energy technologies (funded mainly by

European sources), while solar made up 20 percent. Flows for both technologies increased two- to threefold over 2022, with Serbia and North Macedonia attracting the majority. Together with Ukraine and Montenegro, they were among the top four recipients in 2023—making up 80 percent of the flows to the region. The European Bank for Reconstruction and Development (EBRD) was the top source, primarily providing standard loans to support state-owned utilities for new construction as well as liquidity support for existing renewable energy projects. Grants accounted for almost 23 percent of the funding to the region, three-fourths of which went to Ukraine, mainly for decentralized renewable energy solutions for social and public infrastructure.

Three regions saw a substantial increase in international public flows between 2022 and 2023, yet these levels remained well below their peak.

Sub-Saharan Africa saw an 18 percent increase in flows between 2022 and 2023, reaching USD 5.6 billion, after virtually no change between 2021 and 2022. Almost two-thirds of the flows went to solar, followed by hydropower, at 11 percent, while the rest went to multiple/other renewables, at 23 percent. The flows to the region were mainly provided by institutions such as the World Bank Group (59 percent), Germany (7 percent), and the European Union (5 percent). The region remains the largest beneficiary of grants in absolute terms—USD 822 million. Funding is distributed more equally in the region compared with others. For example, more than 80 percent of funds are distributed within 22 countries and territories, representing a near-equivalent portion of the region's population (World Bank Group 2024a).[33] On a cumulative basis, Sub-Saharan Africa received almost one-third of international public flows to renewables over 2010–23 (figure 5.6), mostly in the form of debt.

Western Asia and Northern Africa received 32 percent larger flows between 2022 and 2023, reaching USD 2.7 billion. Most of the commitments went to solar (40 percent), and wind (17 percent) projects, while 39 percent went to multiple/other renewable energy projects. Türkiye received over half the flows, joined by Tunisia, Morocco, and Egypt as the top four recipients, receiving 84 percent of the funding to the region. The top sources of the flows included IBRD and EBRD, which provided record-high commitments, of USD 967 million and USD 586 million, respectively, to the region.

Eastern Asia and South-eastern Asia saw flows increase by 29 percent in 2023, reaching USD 2.1 billion. Most of this growth was driven by a sixfold jump in flows to wind energy projects, which made up 50 percent of the overall flows to the region in 2023. Solar energy projects received 19 percent of the commitments, after the share of flows to the region grew by a factor of 2.5 over 2022–23. Commitments to multiple/other renewable energy projects made up 26 percent of the overall commitments, their value halving in 2022. About 42.5 percent of the flows went to unspecified areas. Otherwise, Indonesia, Viet Nam, and the Philippines were the top recipients. Cumulatively, Eastern Asia and South-eastern Asia received almost one-fifth of the international public financial flows to renewables in 2010–23 (figure 5.6), mostly in the form of debt.

Although commitments remain well below their historic highs, major economies (e.g., India, Türkiye, and Viet Nam) in the regions mentioned above have made considerable progress in increasing their installed renewable energy capacity and electrification rates since the 2010s. As policy and regulatory frameworks—and power markets—have evolved, fostering a more conducive investment environment, there has been a sizable increase in domestic public and private funding, as well as international private investment, especially among these countries. However, many countries, in particular LDCs, LLDCs, and SIDS, remain starkly underfunded; international public financing will be critical in these contexts, as discussed in the policy insights below.

Two regions saw a downward correction, after substantial growth the year before.

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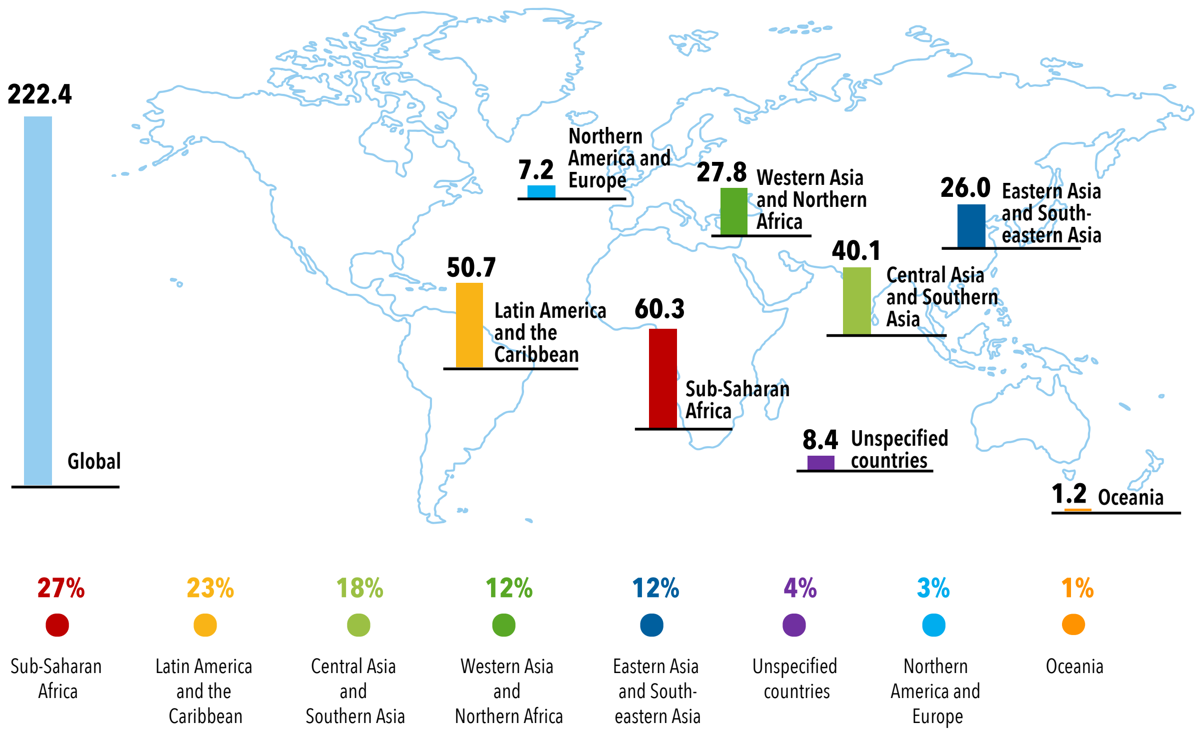
33 Sixteen percent of the funds could not be allocated to a single country.

Commitments to Oceania fell to USD 64 billion, a 27 percent decline, after growing sevenfold in 2022. All flows were provided as grants by Japan, the United States (United States Agency for International Development), Australia, and the Republic of Korea, among the major donors. About 77 percent of the flows went to multiple/other renewable energy projects, followed by solar energy (15.3 percent) and hydropower (7.7 percent). Papua New Guinea, Fiji, Vanuatu, and Palau were the top four recipients, taking in 55 percent of the flows.[34]

After flows to Latin America and the Caribbean doubled between 2021 and 2022, they saw a 9 percent correction, declining to USD 3.47 billion, in 2023. Consistent with 2022, about 31.5 percent of the flows went to solar energy, while 60 percent went to multiple/other renewables. Standard loans dominated all flows (85 percent), almost a third of which were provided by the Inter-American Development Bank. Cumulatively, Latin America and the Caribbean received almost one-fifth of the international public flows to renewables in 2010–23 (figure 5.6), mostly in the form of debt.

FIGURE 5.6 • CUMULATIVE INTERNATIONAL PUBLIC FINANCIAL FLOWS TO RENEWABLES, BY REGION, 2010–23



Source: IRENA and OECD 2024.

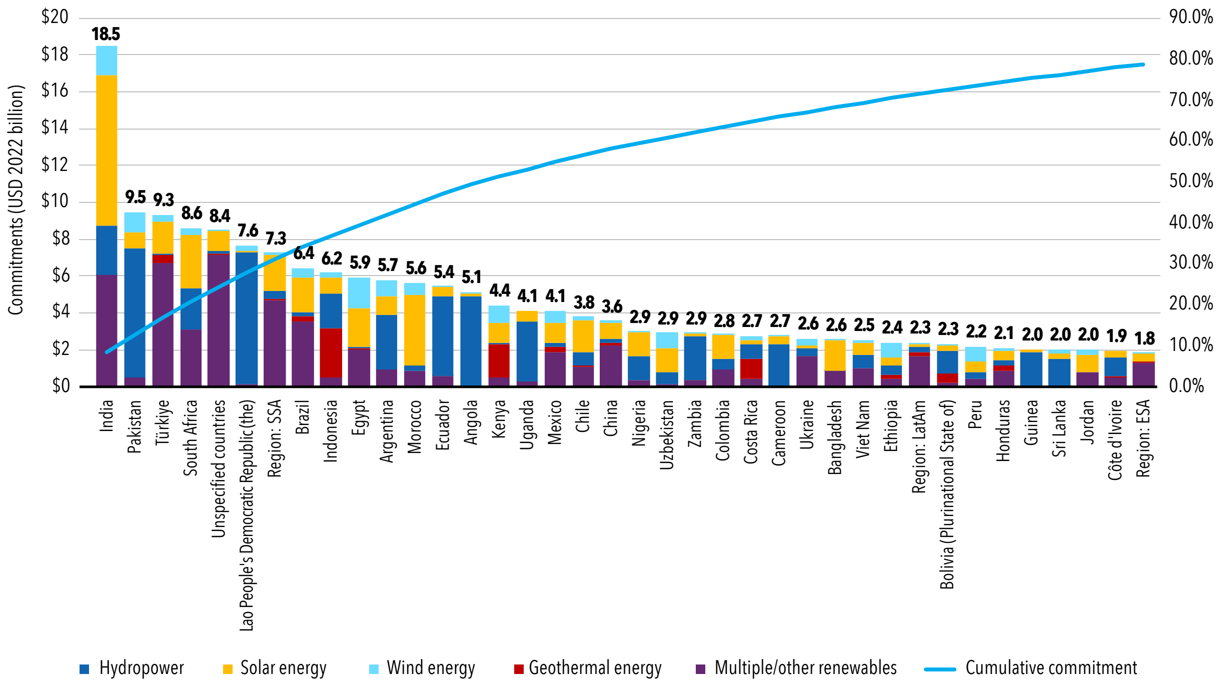
Disclaimer: This map is provided for illustration purposes only. Boundaries and names shown on the map do not imply an opinion on the part of IRENA concerning the status of any region, country, territory, city, or area, or its authorities, frontiers, or boundaries.

34 An additional 37 percent could not be attributed to a single country.

Country trends

In 2010–22, 80 percent of all commitments were concentrated among 38 countries and territories, compared with 40 countries and territories in 2023 (figure 5.7).

FIGURE 5.7 • TOP RECIPIENTS OF INTERNATIONAL PUBLIC FINANCIAL FLOWS TO RENEWABLES, BY TECHNOLOGY, 2010–23



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.

The number of countries and territories receiving 80 percent of flows rose from 19 in 2021 to 25 in 2022 and then 29 in 2023. Last year's report showed that the number of countries and territories receiving 80 percent of flows each year increased from 21 to 25 between 2021 and 2022. In 2023, financial flows were distributed to another four countries, increasing the count to 29. This is the highest number of countries and/or territories receiving 80 percent of commitments in a single year (the previous high was 28, in 2019). Together, these 29 countries represent 49.8 percent of the population and 37.8 percent of the GDP among the countries analyzed for SDG 7.a.1.

The top five recipients of international public flows in 2023 were India (almost USD 3 billion), Türkiye (USD 1.4 billion), Uzbekistan (USD 1.2 billion), South Africa (USD 935 million), and Nigeria (USD 829 million). Brazil, the top recipient in 2022, dropped to 11th place in 2023, while Egypt dropped from 3rd to 23rd place. Nigeria moved up to 5th place, and it was not even among the top 30 in 2022. Such movements are common given the high annual variance of international public financial flows.

India received almost USD 3 billion across 54 projects, mainly for solar and hydropower, in 2023. There are two key trends that stand out. In 2023, there was a sizable increase in large-scale projects with commitment sizes in the USD 1–100 million and USD 100–500 million ranges. In contrast, most commitments in 2022 were USD 1 million or less.

The larger commitments in 2023 included a USD 410 million standard loan[35] from the United States (International Development Finance Corporation) to develop a 4 GW solar module and cell manufacturing facility. Second, there was a consistent decline in the share of concessional loans, while that of standard loans grew. Between 2015 and 2023, the share of concessional loans fell, from 71 percent to less than 7 percent, while standard loans grew, from 11 percent to 85 percent. As India's renewable energy sector develops and offers private investors a more attractive risk-return profile, there is likely less need for concessional loans and risk mitigation.

Türkiye received USD 1.4 billion across 13 projects in 2023. Solar energy received about 38 percent, provided solely by IBRD as standard loans for two projects: one to boost renewable energy use among government-owned or -affiliated facilities and the other to boost it among small and medium industrial actors (World Bank Group 2023b, 2024b). Wind energy received 12 percent of the flows, including a USD 107 billion EBRD standard loan toward a locally operated independent power producer. Another 45 percent went to multiple/other renewable energy projects; the largest of these flows was a USD 240 million IFC loan to support the manufacture of electric vehicles in the country, followed by a USD 125 million loan to refinance the existing debt of a major renewable energy developer and operator (European Bank 2023a).

Uzbekistan received USD 1.2 million in 2023 across 31 solar and wind energy projects, 80 percent of them focused on solar. ADB was the primary financier in 2023; it provided 46 percent of overall flows, including USD 311 million to develop and upgrade the country's existing transmission and distribution infrastructure. With electricity demand projected to increase 6–7 percent (up to 2030), and most of the existing grid infrastructure dated at 30–50 years, an infrastructure upgrade is expected to enable further integration of renewable energy in the generation mix (ADB 2023, 2024). EBRD provided 18 percent of the flows in 2023. Most of these were committed to the development, construction and operation of Masdar's 897 megawatt (MW) portfolio in Samarkand, Jizzakh, and Sherabad and to support risk mitigation, including in the form of a revolving facility to provide liquidity (European Bank 2023b). The Asian Infrastructure Investment Bank also provided a USD 139 million loan for the same project, or 11.6 percent of the overall flows. The only concessional loan for new construction came from IFC, for a 250 MW solar PV plant with a 63 MW/126 megawatt hour (MWh) battery energy storage system (IFC 2023). The remaining flows were targeted toward a cross-sectoral government program focused on market creation and fiscal risk management to improve the business environment for various projects.

South Africa received USD 935 million across 28 projects in 2023. This is an 18 percent reduction from 2022, when flows increased more than threefold year on year. Forty-six percent of the flows went to solar energy projects, with the rest going to other renewables. The largest commitment was a USD 300 million standard IBRD loan made as part of the Just Energy Transition–Investment Plan (JET-IP). While the share of grants among the top three recipients was negligible, 4.6 percent of the flows to South Africa were earmarked as grants (the second largest share after Nigeria). The largest of these was a USD 22.8 million grant provided by Germany to fund industrial pilot projects as part of a green hydrogen program to help develop a sustainable hydrogen economy in South Africa (KfW 2023).

Nigeria received USD 829 million for 42 projects in 2023. Solar projects received 95 percent of the flows. Many projects in the country focus on electrification via decentralized renewable energy systems. The largest of these is the Nigeria Distributed Access Through Renewable Energy Scale-Up Project, which alone made up 84 percent of the flows, receiving a USD 698 million IDA concessional loan. The project will support the deployment of mini-grids and stand-alone systems (predominantly solar), while also promoting productive uses of energy among residential and commercial end users. Grants accounted for 5.9 percent of the total flows, with the largest contribution coming from the European Union (USD 35 million), for the EU-Nigeria Cooperation Programme for Sustainable Energy Sector

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35 This figure is adjusted for inflation and exchange-rate fluctuations. In nominal terms, the loan was valued at USD 425 million.

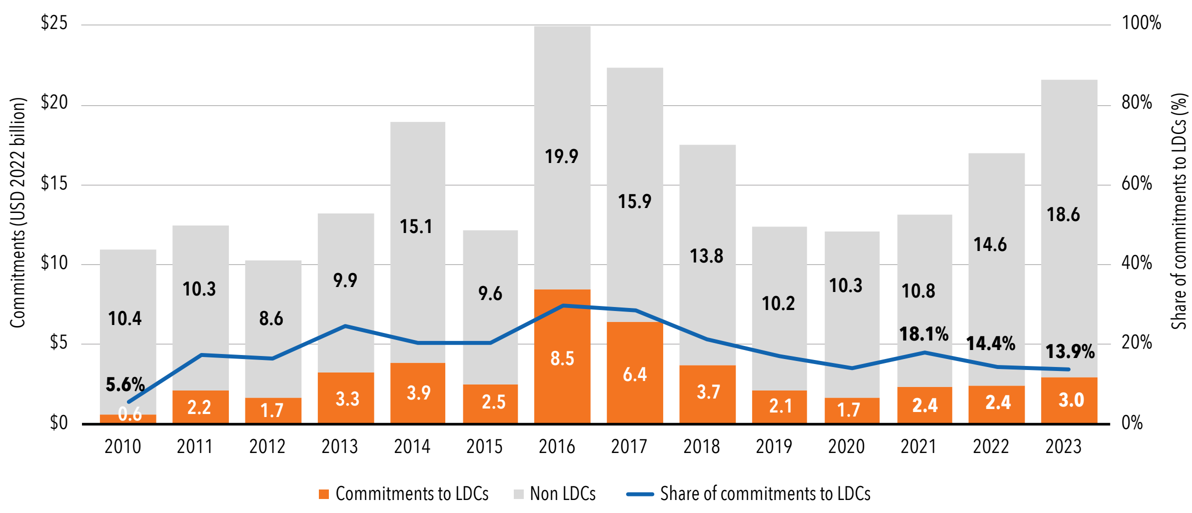
(Phase 1). The project, with a five-year implementation horizon (2023–28), aims to expand energy access by developing a large-scale solar PV plant and small-hydro solutions for agro-industry users, supported by technical assistance from various international organizations (European Union 2024).

Support to LDCs, LLDCs, and SIDS

Analysis of international public financial flows to renewables among the 44 LDCs, 32 LLDCs, and 40 SIDS[36] yields insights into flows to countries with high energy access deficits and often limited fiscal and monetary capacity to attract financing without significant international support.[37]

In 2020, flows to LDCs fell to an eight-year low of USD 1.7 billion amid the COVID-19 pandemic. Since then, flows have rebounded and risen above pre-pandemic levels to USD 3 billion (a 76 percent increase). However, flows to LDCs remain well short of the historic highs of 2016 by approximately two-thirds. The overall share of the flows to LDCs fell by 0.5 percentage points (figure 5.8) between 2022 and 2023—outpaced by growth among non-LDC countries and territories.

FIGURE 5.8 • INTERNATIONAL PUBLIC FINANCIAL FLOWS TO RENEWABLES AMONG LDCs AND NON-LDC COUNTRIES, 2010–23



Source: IRENA and OECD 2024.

LDC = least-developed country.

Forty-three LDCs received financial inflows in 2023, leaving only Guinea without. Nine LDCs received 81 percent of the inflows, led by the United Republic of Tanzania (USD 558 million), Bangladesh (USD 396 million), Madagascar (USD 315 million), and Rwanda (USD 315 million).

36 The United Nations' M49 regional classification includes 53 SIDS; this report excludes 13 of these 53 SIDS from the SDG 7.a.1 classification, as explained in Annex 1. 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).

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

LDCs face exorbitantly high financing costs and have some of the highest debt-to-GDP ratios in the world (UNCTAD 2023). This makes international public financial flows through grants, concessional debt, and risk mitigation support critical to unlocking financing for clean energy. In 2023, grants made up only 16 percent of the flows to LDCs, concessional loans made up 45 percent, while guarantees/other insurance products, just 1 percent.

Many LDCs (23) have also been affected by fragility, conflict, and violence (FCV),[38] experiencing significant energy access gaps that urgently need to be closed. These countries received just USD 656 million (3 percent of the flows) in 2023. FCV-affected non-LDCs received double that, at USD 1.3 billion, in 2023, mainly due to flows to Nigeria, Ukraine, and Cameroon.

Flows to LLDCs increased by almost 33 percent in 2023, reaching USD 3.62 billion. As in 2022, Uzbekistan drove the growth among LLDCs, receiving one-third of the total flows (USD 1.2 billion), followed by the Plurinational State of Bolivia (USD 317 million) and Rwanda (USD 314 million). Turkmenistan was the only LLDC to not receive any commitments in 2023.

Flows to SIDS increased by 31.5 percent in 2023, reaching USD 401 million. Although SIDS have historically received the smallest amounts of investment in absolute terms, they are among the highest recipients on a per capita basis, having received USD 737 per person in 2023. Tokelau, Tuvalu, and Montserrat are the highest recipients since 2010, attracting more than a cumulative average of USD 300 per person. At the other end of the spectrum, Cabo Verde, Grenada, Cuba, and Guyana received less than 1 US cent per capita. Many of the SIDS have committed to 100 percent renewables in their electricity mix by or before 2030. This ambition is driven by a focus on energy security and other socioeconomic benefits that are constrained by dependence on fossil fuel imports. However, the majority of these targets remain conditional on international support in the form of financing, technology transfer, and technical assistance (Rana and Abou Ali 2022). Providing this financing is critical, given that 40 percent of SIDS' inhabitants lack access to clean cooking and almost 22 percent lack basic access to electricity.

Distribution of financial flows among countries

The number of countries receiving no commitments fell from 28 to 27 in 2022 (figure 5.9), and remained at 27 in 2023.

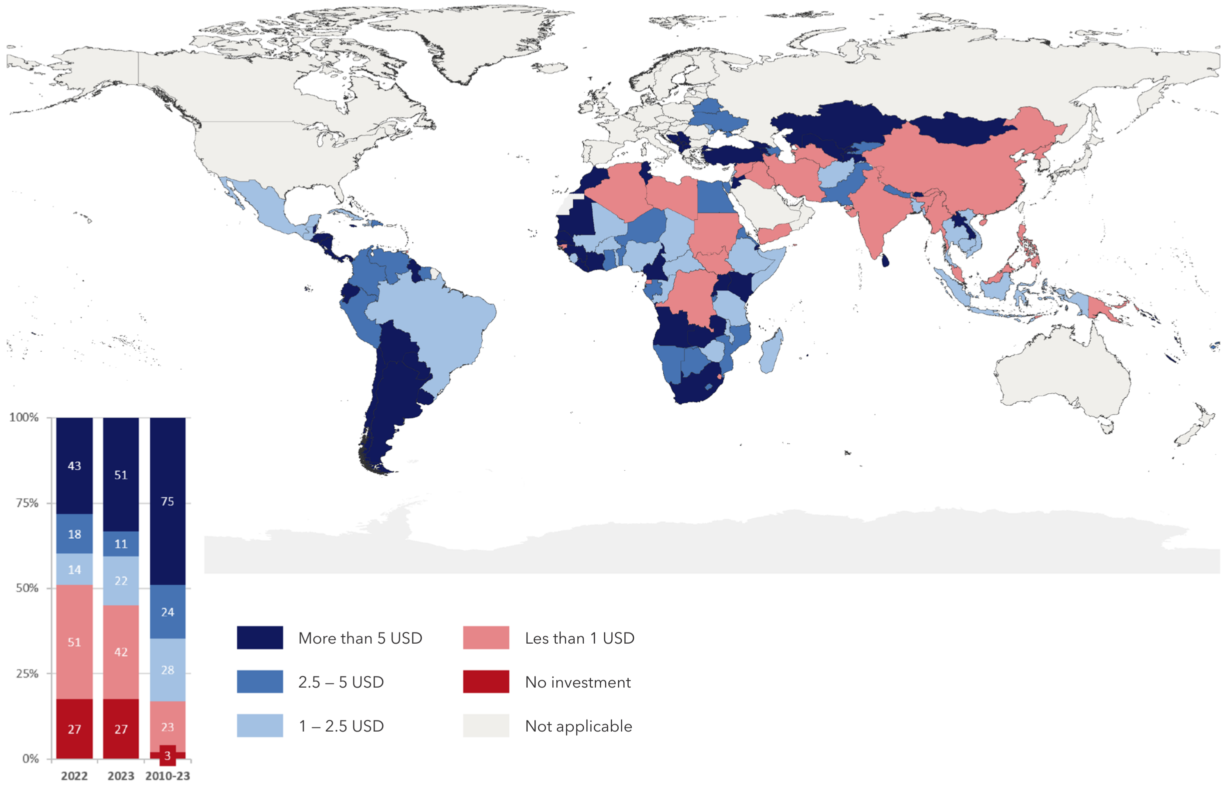
On a per capita basis, countries receiving more than USD 5 per person increased from 43 in 2022 to 51 in 2023. Only 44 percent of LLDCs are in this bracket, chief among them being North Macedonia (USD 133), Uzbekistan (USD 34), and Botswana (USD 30). In addition, only 20 percent of LDCs and 30 percent of SIDS are among the countries that received more than USD 5 per person.

Meanwhile, the majority of countries and territories (33) received USD 1–5 per person.

Finally, there are a few countries that receive less than 10 US cents per capita: Iraq, Cabo Verde, the Syrian Arab Republic, Sudan, and Malaysia. Yemen received the least amount of flows, at less than a 10th of a cent per person.

38 For the official 2024 list, see https://thedocs.worldbank.org/en/doc/608a53dd83f21ef6712b5dfef050b00b-0090082023/original/FCSListFY24-final.pdf.

FIGURE 5.9 • AVERAGE PER CAPITA INTERNATIONAL PUBLIC FINANCIAL FLOWS TO RENEWABLES, BY COUNTRY, 2010–23



Source: Data from IRENA and OECD 2024.

Disclaimer: This map was produced by the World Bank's Geospatial Operations Support Team, in the Cartography Unit. 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.

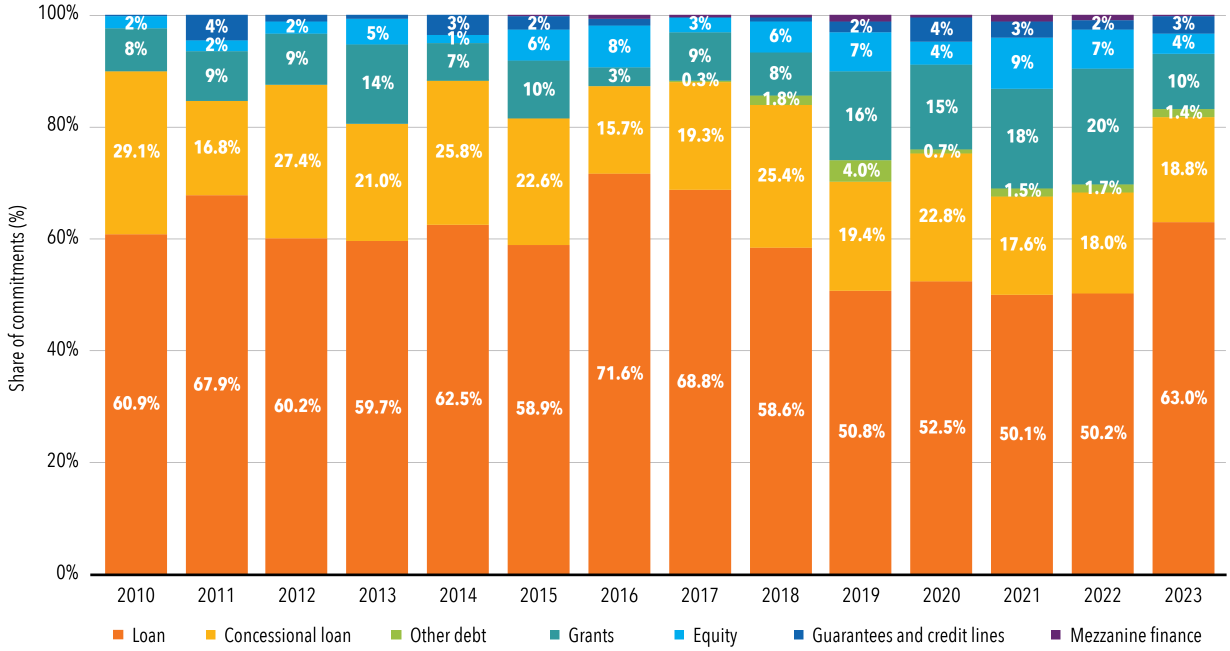
Globally, inclusive of all regions and categories within the scope of the indicator, Palau (USD 233), Montenegro (USD 181), and Belize (USD 179) received the largest flows per capita in 2023, indicating that countries with small populations receive more international public flows per capita, despite not receiving large absolute amounts. Palau averaged USD 196 per capita in 2010–23, Montenegro averaged USD 43 per capita, and Belize averaged USD 19 per capita. However, these large per capita values do not necessarily mean that these countries are better off than more highly populated countries. Smaller economies could face higher costs for deploying renewable solutions at the same relative scale than larger countries, due to potential operational, logistical, and strategic complications.

Investments by financing instrument

Since 2010, debt, mainly at market rates, has continued to fund international public financial flows to clean energy. Grants rank third, followed by equity financing. Support in the form of risk mitigation, such as guarantees and insurance products, vary year to year, and these instruments can make a considerable actual contribution, despite their small share in the overall total, given their potential to attract private capital. Although this capital structure will likely remain unchanged, there have been multiple calls over the past few years to move away from profit-driven debt-based financing to more grants and concessional debt (UN 2023; IISD 2023). This is especially relevant as major central banks raised interest rates to their peak levels by 2023 (BIS 2025), pushing the cost of new and existing debt to record highs (UNCTAD 2024a).

Despite this chain of events, debt-based instruments drove most of the increase in international public flows in 2023 (a 55 percent increase), and their share expanded from 70 percent to 83 percent over 2022–23, the majority of which are at market rates. Grants' share fell 39 percent, to make up just 9.8 percent of the flows in 2023—compared with 20.5 percent in 2022 (figure 5.10).

FIGURE 5.10 • INTERNATIONAL PUBLIC FINANCIAL FLOWS TO RENEWABLES, BY INSTRUMENT, 2010–23



Source: IRENA and OECD 2024.

Among debt-based instruments, standard loans remained the most-used financial instrument in 2023. They composed almost two-thirds of international public financial flows to renewables in 2023, at USD 13.6 billion, up 59 percent from 2022. The largest grant was a USD 1.18 billion standard loan from IBRD and IDA to India for hydropower, solar, and wind energy development. Concessional loans increased to USD 4 billion in 2023, up 32 percent from 2022. While Germany had historically been the largest provider of concessional loans, it was overtaken by IDA in 2020. In 2023, IDA provided a concessional loan of nearly USD 700 million to support energy access in Nigeria (see the section on country trends). Other debt-based instruments included asset-backed securities, green bonds and sustainability-linked bonds, and other debt securities (see Annex 1 for more details), which constituted less than 1.5 percent of the overall financing.

Grants dropped to a 39 percent share of international public financial flows, falling to USD 2.1 billion, after reaching an all-time high of USD 3.5 billion the year before. Overall, the largest beneficiaries of grants were Ukraine, where energy infrastructure has suffered extensive damage in the ongoing conflict (Human Rights Monitoring Mission in Ukraine 2024), and several Sub-Saharan African countries, primarily Somalia, Nigeria, Eritrea, and Senegal, where electrification rates were 48–68 percent in 2022 (World Bank 2023a). Germany provided the most flows in the form of grants in 2023, equivalent to USD 1.16 billion across 44 countries and territories, and has remained the highest grant provider since 2010, contributing 17 percent of the total grant financing since 2010.

Equity financing dropped to USD 807 million (a 32 percent decrease) in 2023, when it accounted for just 3.7 percent of flows. Equity contributions are limited as financiers typically prefer to participate as debt providers. This is because equity exposes institutions to more risk than debt, which can adversely impact their credit ratings and hamper their ability to raise funds at low interest rates in capital markets (Strohecker 2024). Since 2000, only 30 of 76 financiers recorded in the database have made an equity contribution. In 2023, this was limited to just 12 out of 56 financiers, the largest of which were the IFC, the Green Climate Fund, the Asian Infrastructure Investment Bank, FMO (Dutch Development Bank), and the EBRD. For instance, IFC took an equity stake in several companies (electric mobility, mini-grids, steel) and funds (targeted at companies as well as infrastructure development) across India, Brazil, and Sub-Saharan Africa. That said, a lack of equity financing in renewable energy projects has been touted as a significant barrier to bringing projects to reach financial close (Haliru Audu and Adeline Duclos 2024).

Guarantees and credit lines more than doubled to USD 672 million in 2023 —their highest ever total—constituting 3 percent of the overall flows. Such commitments were provided to at least 10 countries, compared with 6 in 2022, and only 3 in 2021. The largest of these was a USD 170 million credit line to a Vietnamese state-owned commercial bank, for financing renewable energy projects in Viet Nam as part of the Japan Bank for International Cooperation's broader activity in the region (JBIC 2018).

Policy insights

Lack of sufficient and affordable financing remains among the key reasons for the slow progress and regressions in achieving the Sustainable Development Agenda, including SDG 7 (UN Inter-Agency Task Force on Financing for Development 2024). As discussed in more detail in chapter 6, realizing SDG 7 requires scaling up financing across energy access, clean cooking, renewable energy, and energy efficiency. Although energy-transition-related investments exceeded USD 2 trillion for the first time in 2023, the vast majority went to advanced markets in China, Europe, and Northern America as these markets offer supportive policy frameworks, low financing costs, and large domestic demand—all of which boost the risk-adjusted returns that profit-seeking investors require. Emerging markets and developing economies (excluding China) received less than 14 percent, and most of this was concentrated in a handful of economies with relatively low investment risks (real or perceived). Sub-Saharan Africa, home to 565 million people without electricity access and more than 955 million people without access to clean cooking, received just USD 12 per capita in transition-related investments in 2023—more than 40 times less than the world average and 115 times less than the flows per capita to advanced economies (IRENA 2024a). The knock-on effects of economic and geopolitical conditions, including reduced fiscal space, high debt burdens, and both real and perceived risks, have further driven up the already high cost of capital in developing economies (IRENA 2024b). The investment shortfall has deepened in turn, with developing economies receiving less overall foreign direct investment (both public and private) in renewable energy projects in 2023 (UNCTAD 2024b).

In this regard, international public finance, which is tracked in this chapter, plays a critical role, both as a provider of capital and as a risk absorber and mitigator. The tri-year rebound of international financial flows offers a positive sign, even though the USD 21.6 billion committed in 2023 falls short of the peak in 2016 as well as the overall investment needs to accomplish SDG 7 (as discussed in more detail in chapter 6).

Previous editions of this report have discussed a range of policy priorities, including a need to reform multilateral and bilateral lending, the importance of effective national policy frameworks and regulations to catalyze (private) capital, and a need for more impact-driven public financing to close the energy access gap. Since then, developed countries agreed during intergovernmental climate negotiations to triple climate finance to at least USD 300 billion a year by 2035, while working toward an aspirational target of at least USD 1.3 trillion per year by 2035 from both public and private sources, including philanthropies and carbon markets (UNFCCC 2024). These funds will be a critical source of financing for accomplishing SDG 7, supporting both climate action and socioeconomic development. But there has been significant criticism on the scale of this commitment, and lack of clarity on the mix of grants and loans (Carbon Brief 2024b, 2024a; SciencesPo 2025; ODI Global 2024a). Against this background, this section discusses the scale of international public financing needed and the mix of financial instruments that will best mitigate risks in diverse developing country contexts, from emerging economies like India and Brazil, to LDCs with limited access to affordable financing.

The scale of financing needs to be expanded significantly to achieve SDG 7, with a greater focus on impact rather than profit. Thus, scaling up grants and concessional finance are priorities. In 2023, multilateral development banks (MDBs) drove the majority of the growth in international public flows. Meanwhile, debt-based instruments continue to dominate, making up 83 percent of overall flows, while grants' share fell to less than 10 percent (from 20 percent in 2022). The continued reliance on debt-based financing risks further exacerbates fiscal pressure in developing economies, many of which are in or at risk of debt distress. Several reform efforts are underway to enhance the financial capacity and development impact of MDBs (Nancy Lee and Samuel Mattews 2024; ODI Global 2024b). For instance, the World Bank announced that an additional USD 150 billion could be made available as a result of recent and ongoing reforms (World Bank Group 2024c). However, there have been no specific commitments regarding the financing instruments utilized. Ensuring that such funds are delivered at terms that make fiscal sense for countries will require a step change in how MDBs evaluate and embed risks in decision-making. Meanwhile, such institutions also need to preserve their credit ratings, to raise funds at low cost for additional country support. Similarly, bilateral donors and development finance institutions need to boost current financing efforts to support SDG 7, backed by greater ambition and clarity on the mix of grants versus debt.

Where renewable energy markets are relatively established and a pipeline of bankable projects is available, international public funds can continue to focus on mitigating risks to make projects bankable. Public financing is typically undertaken with a view to ensuring project bankability and to crowd in private capital, involving debt financing; technical assistance; and a wide range of risk mitigation products such as guarantees, insurance products, liquidity facilities, and currency hedging mechanisms. In developing economies, with sound macroeconomic conditions and relatively established renewable energy markets, such instruments can be deployed at reasonable costs and can be an effective way to mobilize private resources (e.g., in India, South Africa, and Viet Nam). In such contexts, international public funds should scale up tried and tested models with historically delivered results, while fine-tuning them to ensure an optimal risk and benefit allocation between public and private actors, particularly given the rising debt stress in many developing countries. In 2023, guarantees/credit lines amounted to USD 672 million—mostly provided to countries that fit such contexts. Going forward, such products could be expanded to more countries that would benefit from such support. However, this would require strong buy-in and coordination from government counterparts.

In certain high-risk contexts, international public financing needs to move beyond narrow bankability considerations to increasingly value the impact potential of projects for achieving the SDGs. An overly narrow focus on bankability and profitability in renewable energy deployment risks leaving many marginalized communities behind. In some contexts, bankability may be difficult to achieve even when risk-mitigation instruments are available. This is often the case in the many LDCs that struggle with high electricity and clean cooking access deficits and would benefit particularly from the accelerated deployment of sustainable energy solutions. For example, of the 10 countries that received guarantees in 2023, only one was an LDC. In these cases, funding for projects should not hinge on their business case and profitability; instead, projects should benefit from greater support in the form of grants, highly concessional loans, technology and knowledge transfer, and technical assistance. Such interventions need to be carefully planned with a view to addressing systemic risks and eventually creating an enabling environment for the deployment of a regular pipeline of projects. This means international donors need to prioritize their development mandates and develop a higher tolerance for risk, while treating capital preservation and return objectives as a critical but secondary objective.

Given that public resources are scarce, integrated financial planning and policy making, as well as country platforms, can help fulfill the broader SDG agenda and ensure country ownership. Significant investment is needed not just for a climate-aligned energy transition but also to fulfill the overall SDG agenda, with estimated annual funding gaps of USD 2.5 trillion to USD 4 trillion in developing countries alone (UN Inter-Agency Task Force on Financing for Development 2024). Given the role of SDG 7 as an enabler for virtually all SDGs, ensuring complementary targets, comprehensive policy planning, and associated international financing that considers relevant interlinkages between energy and other sectors, such as food and water—as well as social and development, environmental impacts, decarbonization, adaptation, and governance—is key (IRENA 2024d). Equitable outcomes for vulnerable populations such as women, children, and internally displaced people need to be carefully considered from the outset. For instance, energy interventions fall short of supporting greater gender equality because aid to the sector still does not sufficiently incorporate gender-focused approaches (OECD 2024). The socioeconomic benefits of the energy transition can be maximized and the overall financing costs can be lowered by greater effort toward integrating national financing frameworks and strengthening comprehensive policy making.

In conclusion, a suite of actions is needed to scale up investments while ensuring their equitable distribution. This includes reforming multilateral and bilateral lending to expand the availability of public capital; mobilizing more concessional finance, grants, and risk-mitigation instruments; improving risk tolerance among donors; and enacting appropriate national policy frameworks, regulations, and reforms through integrated and rigorous planning. The exact mix of these actions will vary across contexts. Efforts to reform the international financial and economic system and enhance international (financial) collaboration, ranging from the Bridgetown Initiative to the 4th Financing for Development Summit, will be important. Scarce administrative resources can be used more effectively and more financing can be channeled directly to sustainable energy programs if donor support is optimized by consolidating and expanding support across common platforms, as well as improving established mechanisms. Meaningful progress toward SDG 7 can be possible with continued commitment backed by tangible support from the most economically powerful countries, including those represented in the Group of Twenty (G20) and Group of Seven (G7). The 2025 United Nations Climate Change Conference (COP30) in Brazil also offers an opportunity to improve on the climate finance outcome at the 2024 United Nations Climate Change Conference (COP29) by providing more clarity on the instrument mix and expanding on the aspirational target to provide USD 1.3 trillion in climate finance for developing countries.

CHAPTER 6

THE OUTLOOK FOR SDG 7

Main messages

- **Outlook for progress toward 2030 goals.** Sustainable Development Goal (SDG) 7 is off track. Even so, progress in policy and technology has shown promising results, especially in additions to renewable generation capacity. The years marked by the COVID-19 pandemic and 2022 energy crisis slowed progress, notably in Africa, where advances in energy access were stymied or reversed. However, a preliminary analysis of 2023 and 2024 trends justifies optimism. In addition, several high-profile international agreements are raising attention to all aspects of SDG 7. Among these are the COP28 consensus on tripling renewable power capacity and doubling the rate of energy efficiency, as well as the Clean Cooking Declaration, the Dar es Salaam Declaration, and several energy compacts, all of which are setting new targets and objectives to bolster access to electricity and clean cooking access in Africa, where the access gap is largest today. In aggregate, these efforts could foretell an improving outlook, as the ambitions spelled out in the declarations are backed by concrete measures and investments.
- **Outlook for access to electricity.** Progress on electricity access has been remarkable in recent decades. Since 2000, the world has reduced the number of people without access by 925 million, and 45 countries have reached near universal access to electricity. However, the International Energy Agency (IEA) projects that around 645 million will still lack access in 2030, 85 percent of them in Sub-Saharan Africa. Based on today's policies, around a fifth of the countries presently lacking universal access will close the gap by 2030. Achieving universal electricity access by 2030 requires significant investment and policy support and will rely increasingly on distributed solutions, which have scaled up rapidly in recent years thanks to low-cost solar power and batteries.
- **Outlook for access to clean cooking.** Since 2010 the number of people having no access to clean cooking has dropped by 900 million, predominantly through the use of liquified petroleum gas (LPG). Still, universal access by 2030 remains out of reach under current policies and investments: Some 1.8 billion people will still lack access to clean cooking by the end of the decade. Around 58 percent of those lacking access will be living in Sub-Saharan Africa, 36 percent in Asia, and the 4 percent in Latin America and the Caribbean. Improvements through 2030 will continue to be marked by strong regional disparities, as in past years. The number of people without access to clean cooking in Sub-Saharan Africa is growing and expected to reach 1 billion by 2030, largely because population growth is outstripping gains in access. On the positive side, estimates project a continued decline in the use of polluting fuels and an increase in the use of gaseous fuels and electricity for cooking, but reaching full access to clean cooking will require an annual investment of USD 10 billion through 2030, half for Sub-Saharan Africa alone.
- **Outlook for renewable energy.** Renewable energy is the fastest-growing energy source today. Projections under today's policies show that renewables are set to surpass coal as the predominant electricity source globally in 2025. To meet the call to triple renewables made at COP28, the world would need to reach at least 11,000 gigawatts (GW) of global renewable power capacity by 2030; corresponds to renewables (modern uses) attaining a 32–35 percent share in total final energy consumption (TFEC) by 2030 in IEA and International

Renewable Energy Agency (IRENA) scenarios. Under current plans and policies, the world is expected to make significant progress in renewable power capacity, but an ambition gap of between 3.8 and 4.2 TW remains through 2030.

- **Outlook for energy efficiency.** Energy efficiency has gained important political momentum, driven by rising security concerns, recent energy price spikes, and the target of doubling the improvement rate agreed upon at COP28. Early estimates for 2024 show a modest 1 percent annual improvement in the rate of energy intensity, around half the pace of progress achieved during the 2010–19 period. Achieving the doubling target rate by 2030 would require robust policy action and a significant increase in investment. The rate of improvement would need to be just over 4 percent to achieve the COP28 target toward 2050, according to IEA and IRENA net-zero scenarios, which are roughly aligned with the SDG 7 target.
- **Investment needs.** Achieving the SDG 7 target demands a substantial increase in clean energy investments. IEA and IRENA estimate average annual energy-transition-related investments in the range of USD 4.2–4.5 trillion by 2030.[39] It will be essential to address this investment gap, particularly in developing economies grappling with the high cost of capital.

39 IEA's investment estimate accounts for capital spending on energy supply, infrastructure, end-use, and efficiency required for alignment with a 1.5°C Scenario. IRENA's estimates cover investments in renewable power generation, energy efficiency, and grid and flexibility improvements needed for an energy transition aligned with the 1.5°C Scenario.

Presentation of scenarios

This chapter describes the results of global modeling exercises undertaken to determine whether current policy settings and investments are sufficient to meet the SDG 7 targets and to identify what additional actions might be needed. Scenarios for the targets are taken from IEA's *World Energy Outlook* (IEA 2024a), IRENA's *World Energy Transitions Outlook: 1.5°C Pathway* (IRENA 2024a), and WHO's Business-as-Usual Scenario (see annex 1). The modeling also draws on insights from the IEA's COP28 Tripling Renewable Capacity Pledge (IEA 2024) and IRENA's Delivering on the UAE Consensus (IRENA et al. 2024). The chapter explores scenarios in which energy trends evolve under today's policies as well as more ambitious pathways that deliver on all energy-related SDGs, including substantial reductions in air pollution (SDG target 3.9) and 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 modeling is conducted that provides a sense of the prevailing direction for the energy sector based on a detailed reading of the latest policy settings in countries around the world. It accounts for energy, climate, and related industrial policies that are in place or that have been announced. The aims of these policies are not automatically assumed to be met; they are incorporated in the scenario only to the extent that they are underpinned by adequate provisions for their implementation. The Net Zero Emissions by 2050 Scenario considers the SDG 7 goals for 2030 and net-zero energy sector emissions for 2050 as targets to determine what would be needed to achieve desired outcomes. Under the Net Zero Emissions by 2050 Scenario, by 2030, modern renewables reach a 30 percent share of total final energy consumption (TFEC), and average annual energy efficiency improvements in global energy intensity attain a level in the neighborhood of 4 percent over 2024–30. In this scenario, energy sector emissions reach net zero by 2050, aligned with broader scenarios consistent with limiting the end-of-century global temperature increase to 1.5°C over preindustrial levels.

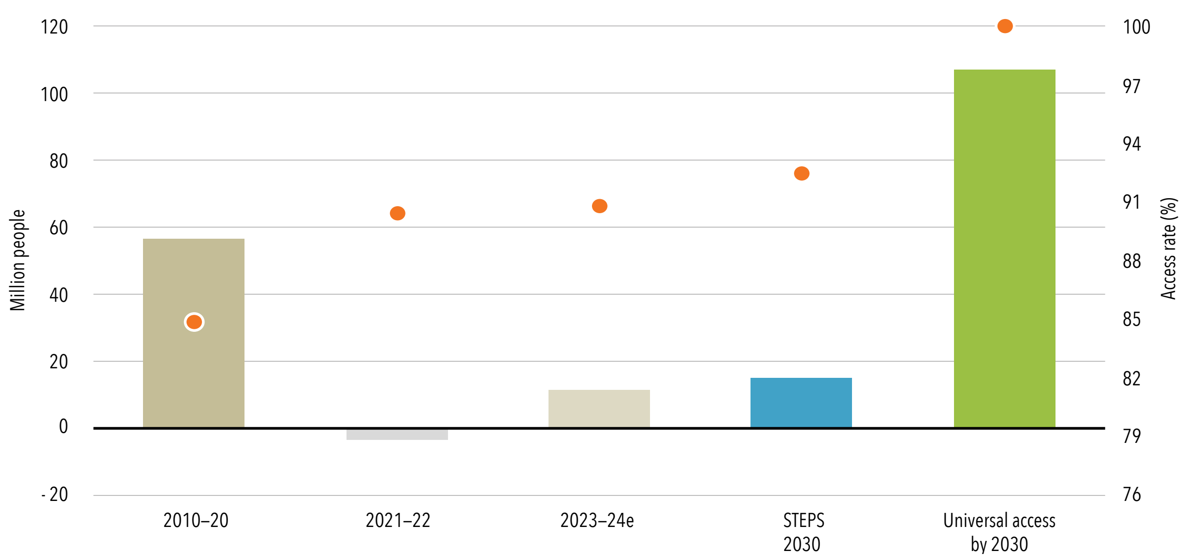
IRENA's Planned Energy Scenario offers a perspective on future energy system developments based on government energy plans, targets, and policies. The 1.5°C Scenario outlines a pathway that aligns the global energy transition with the goal of limiting the global temperature rise to 1.5°C above preindustrial levels by the end of the 21st century. This scenario is driven by key technological and policy measures, including the rapid expansion of renewables-based power, direct renewable energy use, improvements in energy efficiency, widespread electrification of end-use sectors, deployment of clean hydrogen and its derivatives, and the integration of carbon removal solutions such as carbon capture and storage (CCS) and bioenergy with CCS. These measures would result in a net-zero carbon energy system by midcentury.

Under WHO's Business-as-Usual Scenario, no new policies or interventions are implemented or take place. Current trends are extrapolated into the future until countries approach 100 percent access to clean fuels and technologies. As such, the scenario provides a neutral baseline for assessing the effects of various interventions.

The outlook for access to electricity

The latest data indicate that the number of people without access to electricity declined by more than 18 million from 2022 to 2023. This follows a period of stagnation and setbacks in expanding electricity access, a period in which population growth exceeded new connections in many countries. Preliminary data collected by the IEA for 2024 suggest that improvements are set to continue this year, as the number of people without access to electricity is expected to decline by a similar amount as in 2023. Today, around 85 countries lack universal access: Under today's policy trajectory, 20 of these countries will achieve the target by 2030, only nine in Sub-Saharan Africa. Under IEA's Stated Policies Scenario, 645 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 around 40 countries without universal access to electricity have official targets, yet only about half of those targets are as ambitious as SDG target 7.1. Achieving targets requires adequate policies, holistic electrification plans (including centralized and decentralized solutions), and resourced implementing institutions. Targets and electrification plans alone though, often do not directly translate into actual progress on the ground when not accompanied by comprehensive enabling frameworks (figure 6.1).

FIGURE 6.1 • REDUCTION IN POPULATION WITHOUT ACCESS TO ELECTRICITY ANNUALLY AND ACCESS RATES, HISTORICALLY AND IN 2030 UNDER IEA SCENARIOS



Source: IEA 2024a.

e = estimate; STEPS = Stated Policies Scenario.

Most developing countries in Asia remain on track to reach near-universal access by 2030; less than 2 percent of the region's population remains without electricity access in 2030. Reaching the target of universal access would require substantially faster progress in Afghanistan, Mongolia, and Pakistan, however. In Central and South America, only the most remote populations will remain without electricity access by 2030. 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.

Sub-Saharan Africa is home to 80 percent of all people lacking electricity access today, a figure that remains unchanged by 2030 under today's trends, with the region still accounting for 546 million people without access by the end of the decade.

Robust electrification plans supported by sufficient financing 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 Niger) have been witnessing a rise in the number of people without access. Several new policies were implemented in 2024 in countries with electricity gaps, notably in Africa within the context of Mission 300 (see also chapter 1). These new policies are adding positive momentum to the latest projections, although many countries that endorsed the Dar es Salaam Energy Declaration have not yet announced new policies to reinforce their latest targets (Africa Energy Summit 2025).

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 lack access in 2030. Of the 20 countries with the largest access gap, 18 are in Sub-Saharan Africa, 13 of which are facing situations of fragility, conflict, and violence. These countries host significant numbers of displaced people, adding an extra layer of complexity in providing appropriate electrification options to temporary settlements.

Achieving universal electricity access by 2030 would require some 120 million people to gain access each year, requiring annual investments of USD 45 billion through 2030, based on the IEA's least-cost assessment. These investments include electricity generation, electricity networks, and decentralized solutions. International support, including in the form of concessional finance, plays a major role, especially as public finance remains strained after a series of global crises. This is particularly true in the least-developed countries. Opening the electricity sector to private sector participation and using concessional support to de-risk their investments can help accelerate progress, especially in contexts where energy markets are relatively well established and a pipeline of bankable projects exists (see also chapter 5). Changes in policy will also play a central role. Many successful electrification campaigns have a strong focus on electrifying health facilities, schools, and productive uses (including agricultural enterprises) alongside households' needs.

Success will depend on the right regulatory provisions for decentralized solutions, improved tracking and monitoring, improved geospatial data to help private sector players better target communities, development of a pipeline of bankable projects, and adequate public finance, including grants from international donors and philanthropies.

Decentralized systems are also set to play a growing role in closing the access gap, especially in Africa. Lower costs, higher quality, and more adequate business models have helped these technologies reach more remote communities that lay beyond the near-term plans for grid expansion. While in developing Asia, grid connections play the largest role in extending new access, in Sub-Saharan Africa they provide only 43 percent of new connections by 2030, according to IEA's latest country-by-country geospatial analysis to identify the least-cost feasible pathway toward providing connections to unelectrified populations. Conversely, 30 percent of new connections are to be provided through mini-grids. The remainder would be stand-alone systems, mostly solar home systems.

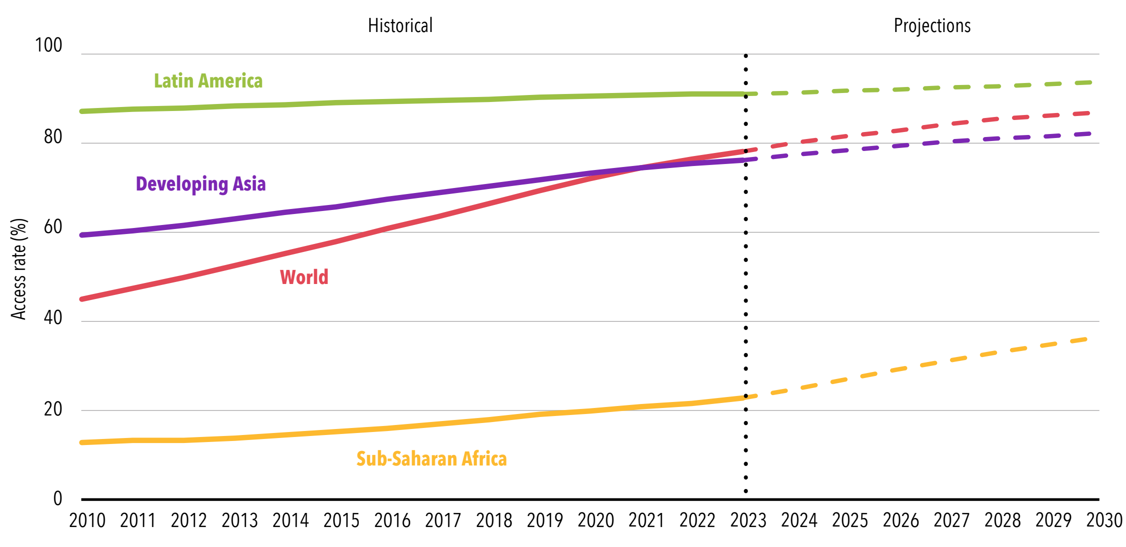
Affordability remains a key issue. About a third of the Sub-Saharan African population presently lacking access to electricity cannot afford basic energy services without additional financial incentives. Accordingly, small solar home systems are a rapidly growing market and could quickly provide basic electricity services to households before full access solutions reach these households. Based on IEA estimates, if the one-third of households where other options are unaffordable were to gain access first via small solar lighting systems the cost would be USD 5 billion annually by 2030. This spending would defer total investment costs of roughly USD 12–13 billion annually between now and 2030, which would need to be allocated to upgrading electricity connections beyond 2030 to bring these households to basic levels of access.

The outlook for access to clean cooking fuels and technologies

The policies in place today are insufficient to achieve universal access to clean cooking. If current trends continue, both IEA and WHO estimate that 22 percent of the world's population—or around 1.8 billion people—will still lack access to clean cooking by 2030 (figures 6.2 and 6.3). Significant progress has been made in Asia, where more than a billion people have gained access since 2010. In Sub-Saharan Africa, on the other hand, almost the same number of people as today are expected to be without access to clean cooking fuels and technologies at the end of the decade (IEA 2024a). WHO estimates that more than three-quarters of them—or close to a billion people—are expected to be relying on polluting fuels and technologies in 2030 in Sub-Saharan Africa (WHO 2025) (figure 6.3). Many African countries are not expected to achieve universal access even into the 2050s. Countries facing fragility, conflict, and violence have demonstrated particularly slow rates of progress. Achieving universal access will require delivering access to more 300 million people each year through 2030—half of them in Sub-Saharan Africa. Some African countries are implementing clean cooking plans, yet more often than not they lack the resources to support them. Today, less than 20 percent of clean cooking plans are backed by clear financing schemes (IEA 2024a).

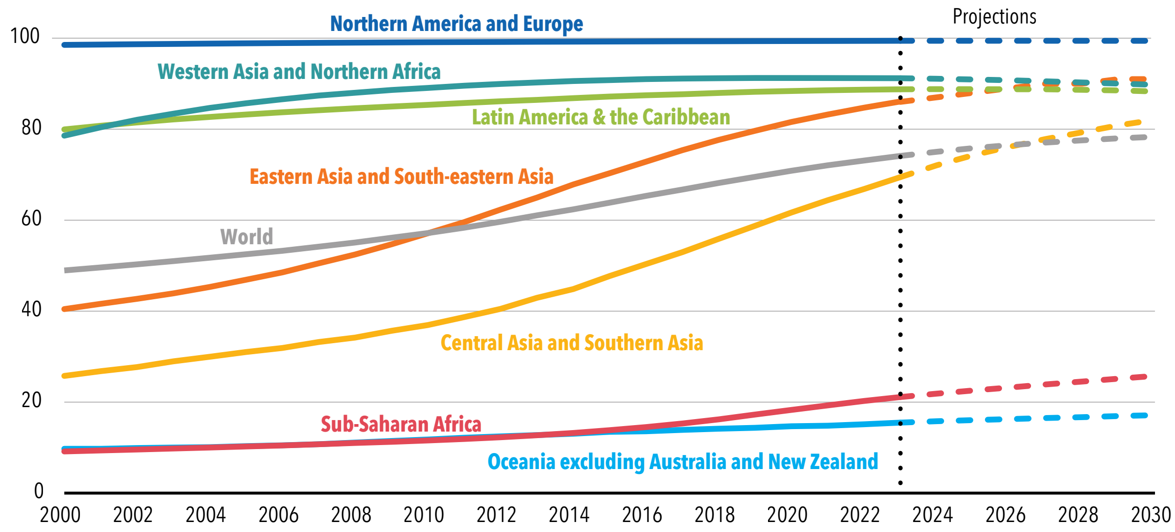
Other regions also display disturbing access trends. Under WHO's Business-as-Usual Scenario, an estimated 88 percent of those living in Oceania outside Australia and New Zealand (or 12 million people) will not have access to clean cooking fuels and technologies in 2030 (figure 6.3). For Central Asia and Southern Asia the corresponding figures are 18 percent (more than 400 million people).

FIGURE 6.2 • HISTORICAL AND PROJECTED CLEAN COOKING ACCESS RATE BY REGION, AND IN IEA'S STATED POLICIES SCENARIO, 2010–30



Source: IEA 2024a.

FIGURE 6.3 • HISTORICAL AND PROJECTED CLEAN COOKING ACCESS RATE BY REGION UNDER WHO'S BUSINESS-AS-USUAL SCENARIO, 2000–30



Source: WHO 2025.

Note: Australia and New Zealand are excluded as both the historical and projected access rates are 100 percent.

If current trends continue through 2030, WHO projects that 60 percent and 8 percent of the population in low- and middle-income countries will primarily use gas and electricity, respectively, for cooking. At the same time, 19 percent are expected to still be relying on unprocessed biomass, 5 percent on charcoal, and close to 2 percent on kerosene and coal. The overall growth in clean cooking will be largely driven by the increased adoption of gaseous fuels.

A scenario in line with universal access would cut the use of solid biomass by 50 percent. The resulting mix of cooking solutions in emerging markets and developing economies by 2030 would have more than half of the population cooking predominantly with natural gas or LPG, 25 percent with electricity, and the remainder with modern bioenergy. In such a scenario, LPG plays a leading role in providing new access, followed by improved cookstoves, and then electricity. In some regions, new infrastructure would be needed, particularly in Sub-Saharan Africa. Achieving universal access by 2030 would imply demand for LPG grows threefold by 2030 according to IEA assessments (IEA 2023a), requiring an expansion of distribution services and an increase in cylinders and refilling stations. In the same scenario, electric cooking would increase demand for electricity by 16 percent by 2030 in Sub-Saharan Africa. While most improved cookstoves alone do not provide the full benefits of cooking with electricity, gas, LPG, or bioethanol, they do represent an important transition for households without the economic means to afford stoves using purchased fuels—and where modest affordability support from governments is unlikely to be enough. Evidence shows that cooking on an efficient improved cookstoves (ISO tier 3 and above) reduces biomass use compared with a traditional stove by 20–75 percent, with most commercial improved cookstoves yielding efficiencies at the higher end.

Achieving universal clean cooking access could cut greenhouse gas emissions by 1.5 gigatons of CO_2 equivalent ($GtCO_2eq$) owing to reduced biomass combustion and less deforestation, a figure comparable to the current annual emissions from aviation and shipping combined (IEA 2024a). This reduction stands alongside major health and social benefits. Reducing household air pollution improves health outcomes and lessens the need for daily fuelwood collection—typically a substantial burden on women and children—freeing up time for education, work, or leisure.

Required capital investments in clean cooking technologies and infrastructure through 2030 total USD 10 billion annually (IEA 2024a)—a substantial increase from current investment levels (USD 2.5 billion). For these investments to materialize, policy guidelines and institutional frameworks must be put in place to incorporate clean cooking into energy planning strategies, thereby attracting private funding and making optimal use of public funding.

Last year, the Summit for Clean Cooking in Africa mobilized a record USD 2.2 billion in additional commitments and precipitated a number of new targets and policies on clean cooking (IEA 2024b). The results of the summit have created positive momentum. Bridging the access gap in clean cooking will depend on a coordinated combination of national action, international collaboration, and private investment to lower the cost of clean cooking through innovation in clean fuels and technologies. Climate finance, particularly carbon finance, if properly managed, can be pivotal in making clean cooking more accessible and affordable, especially for the most underserved communities.

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 system by 2050 require a tripling of the installed capacity of renewables-based power by 2030. The tripling is reflected in the historic COP28 agreement, which calls for at least 11,000 GW of renewable power by 2030 (UNFCCC 2023a), in line with IEA's Net Zero Emissions by 2050 Scenario and IRENA's 1.5°C Scenario. Under current plans and policies, the world is likely to make significant progress—but a shortfall of 3.8–4.2 TW from the 11,000 GW target would remain.

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 17 percent in 2023 to 23 percent in 2030, and the share of modern renewables, which excludes traditional use of biomass, is projected to increase from 13 percent in 2023 to 19 percent in 2030. Under IRENA's Planned Energy Scenario, the overall share of modern uses of renewables in TFEC would grow to 23 percent in 2030. Achieving the 11,000 GW level of renewable energy capacity would mean bringing the share of renewables in TFEC to around 32–35 percent.

Greater ambition—and matching policy action—remain key. These will include strategic long-term planning, modernization and expansion of transition infrastructure, development of enabling regulatory frameworks, market design reforms optimized for high penetration of renewable energy sources, and the strengthening of the institutional capacities and human resource capabilities essential for accelerating deployment.

Bridging the gap: Insights from IEA's Stated Policies Scenario and Net Zero Emissions by 2050 Scenario

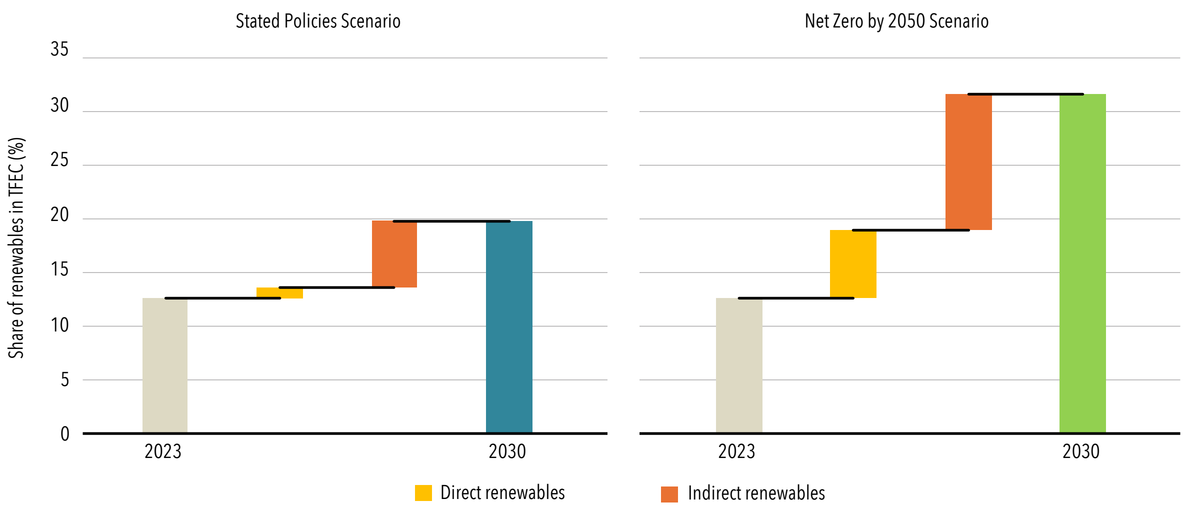
Renewables in the power sector continue to be the fastest-growing energy source worldwide. Annual capacity additions for renewables in 2023–30 are projected to triple over the trends seen in 2015–22, with solar photovoltaic (PV) and wind spearheading the expansion. The projected rate falls short of the COP28 goal to triple existing capacity by 2030, but not by much: Renewable capacity is expected to account for 80 percent of the progress needed by the end of the decade under today's policies—that is, under the Stated Policies Scenario (IEA 2024a).

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 of the growth in electricity demand from 2023 to 2030 under today's policy trends, followed by wind, at around 35 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 the electrification of end uses, should enable the share of renewables-based electricity in TFEC to rise above 10 percent by 2030, up from 6 percent in 2023. This figure includes increased use of electricity in transport owing to greater penetration of electric vehicles.

The pace of renewables' growth in transport, industry, and buildings is projected to double between 2024 and 2030 in the Net Zero by 2050 Scenario compared with the previous seven-year period. Combined with growing electrification, renewables' share in transport rises to nearly 17 percent (IEA 2024c). For transport, renewable electricity will account for half of this growth, led by adoption of electric vehicles followed by biofuels, with small contributions from biogases, hydrogen, and e-fuels. Direct use of renewables, principally biofuels, constitutes 11 percent of fuel for road transport, on average. Nevertheless, renewables' share in transport increases by only two percentage points, to 6 percent in 2030. For heat, consumption of renewables expands more than 50 percent, driven by renewable electricity use for heating in non-energy-intensive industries and buildings, followed by bioenergy (IEA 2024c).

The use of renewables increases twice as rapidly under the Net Zero Emissions by 2050 Scenario as under the Stated Policies Scenario (IEA 2023b). Under the more ambitious Net Zero Emissions by 2050 Scenario, modern uses of renewables would represent around a third of TFEC in 2030 (figure 6.4).

FIGURE 6.4 • RENEWABLES' SHARE IN TOTAL FINAL ENERGY CONSUMPTION IN 2023 AND UNDER IEA SCENARIOS BY 2030



Source: IEA 2024c.

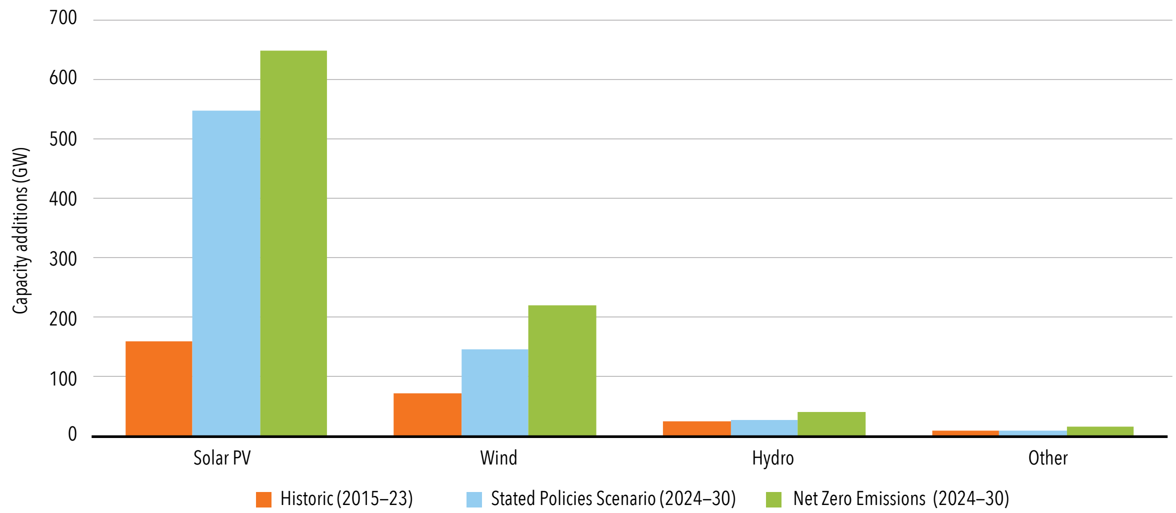
Under IEA's Net Zero Emissions by 2050 Scenario, increased electrification of end uses is a primary means to boost renewables' share in TFEC. Under this scenario, electricity's share in the final energy demand rises to over 30 percent by 2030, compared with about 12 today. This growth is driven primarily by the electrification of transport and heat.

Renewable energy is used for heating in various applications, including space and water heating, cooking, and industrial processes. This heat can come directly from sources like bioenergy, solar thermal, or geothermal energy, or indirectly through electricity and district heating generated from renewables. Transitioning to direct renewable heat—such as solar thermal water heating, biomass, and low-carbon gases—can help decrease reliance on fossil fuels. In 2023, renewables represented 12 percent of the total energy consumed for heating worldwide. By 2030, this share would increase to around 30 percent under the Net Zero Emissions by 2050 Scenario.

The share of traditional uses of biomass falls to 3 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, being replaced with more modern and efficient fuels and technologies.

The fastest increase in the share of renewables under the Net Zero Emissions by 2050 Scenario occurs in electricity generation—reaching 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 under the Net Zero Emissions by 2050 Scenario, to approximately 22,520 terawatt-hours by 2030. This is supported by unprecedented solar PV and wind capacity additions, reaching, respectively, 640 GW and 220 GW a year on average over 2024–30 (figure 6.5). Annual investment in renewables-based power triples over the decade, topping 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 6.5 • AVERAGE ANNUAL CAPACITY ADDITIONS OF RENEWABLE POWER GENERATION, BY TECHNOLOGY, UNDER IEA SCENARIOS



Source: IEA 2024a.
GW = gigawatt; PV = photovoltaics.

Energy policy, socioeconomic factors, and natural resource availability shape the growth of renewables differently across regions. In developing economies, renewable electricity generation is projected to account for more than 80 percent of growth by 2030 under the Stated Policies Scenario. Under the same scenario, the share of renewables in electricity generation by 2030 varies widely, from 15 percent in the Middle East and 17 percent in Northern Africa to around 80 percent in Central and South America, where hydropower dominates. In the Net Zero Emissions by 2050 Scenario, renewables play an expanding role in all regions, reaching or surpassing 50 percent of total electricity generation in many areas by 2030.

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 million in 2030. 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 GtCO2 is captured via carbon capture, utilization, and storage and by CO2 removal technologies that do not include nature-based measures.

Accelerating the energy transition: Insights from IRENA's 1.5°C Scenario and Delivering on the UAE Consensus

The target to triple renewable power capacity is an essential element for achieving SDG 7 and climate action under SDG 13. Advancing the energy transition at the required pace and scale would require that the electricity sector be decarbonized completely by midcentury, making the years to 2030 crucial. While a diverse selection of technologies is essential to fully decarbonize the energy system by 2050, the urgency of the 2030 goal narrows 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 faster deployment across a much broader suite of technologies.

IRENA's 1.5°C Scenario details six key categories of performance indicators, including scaling up renewable energy's share in TFEC and electricity generation to 35 and 68 percent by 2030, with a corresponding increase in the share of energy consumed in the form of electricity to 30 percent.[40]

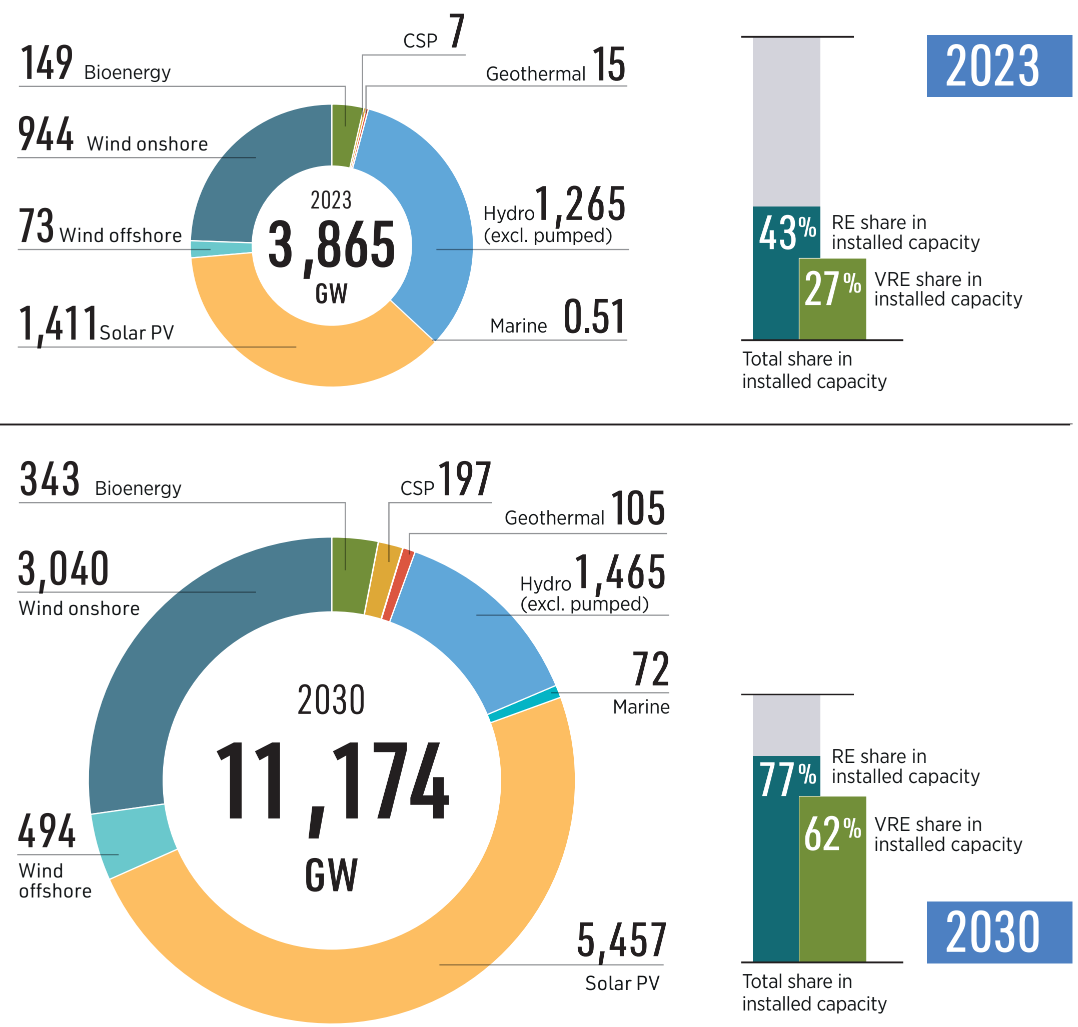
Tripling global renewables-based power capacity by 2030 is technically feasible and economically viable, but doing so will require commitment, policy support, and investment at scale. Since 2015, newly installed renewables-based power capacity has consistently outpaced new fossil fuel and nuclear power installations combined, reaching an estimated 473 GW in 2023 and 585 GW in 2024 (IRENA 2024b, 2025). By contrast, new capacity additions of onshore and offshore wind, hydropower, geothermal, bioenergy, concentrated solar power, and marine energy in 2023 lagged behind the requirements of IRENA's 1.5°C pathway. The significant acceleration in solar PV deployment—with 346.9 GW added in 2023 (73 percent higher than in 2022)—indicates that solar PV is the only renewable technology that is on track to grow annual additions each year to reach its target of 5.5 TW of capacity required by 2030 (figure 6.6). Notably, rapid electrification of heating and transport applications, alongside increased green hydrogen production, would significantly boost the demand for electricity under IRENA's 1.5°C Scenario.

To reach the goal of tripling renewable energy capacity, the world needs to add an average of 1,044 GW annually, which corresponds to a compound annual growth rate of 16.4 percent through 2030 (figure 6.7). This would require installed capacity to rise from 3.9 TW to 11.2 TW from 2024 to 2030, an increase of 7.3 TW in fewer than seven years.

Existing national plans and targets would amount to only half of the annual growth in renewable power capacity needed. Plans would deliver 3.5 TW (48 percent) of the required capacity expansion. This would bring global installed capacity to 7.4 TW by 2030, 3.8 TW (34 percent), well short of the tripling target.

40 The average annual primary energy intensity improvement rate would need to increase to 4 percent between 2023 and 2030, doubling the rate observed in 2022. The production of clean hydrogen would need to increase to 125 Mt by 2030. Finally, some investment in CO_2 removal technologies would also be required, namely, in the hard-to-abate sectors, such as heavy industry.

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

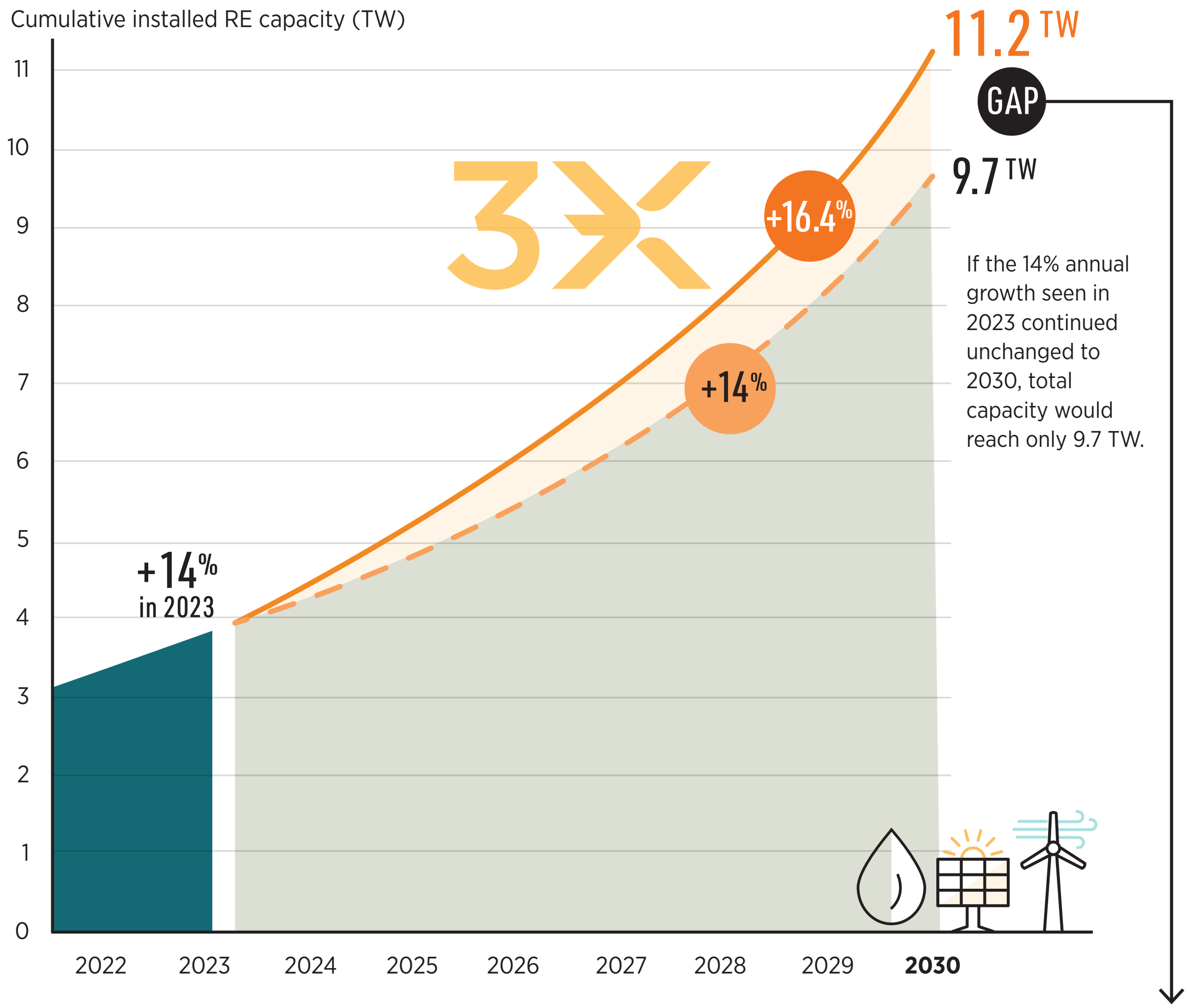


Source: IRENA et al. 2024.

Note: Bioenergy includes biogas, biomass waste, and solid biomass.

CSP = concentrated solar power; GW = gigawatt; PV = photovoltaic; VRE = variable renewable energy; RE = renewable energy; hydropower data excludes pumped hydro.

FIGURE 6.7 • CLOSING THE GAP TO REACH TRIPLING RENEWABLE POWER CAPACITY BY 2030 UNDER IRENA'S 1.5°C SCENARIO



Renewable power targets in NDCs =

5.4 TW

total global installed renewable power capacity in 2030

Renewable power targets in national plans and policies =

7.4 TW

total global installed renewable power capacity in 2030

1.5°C Scenario =

11.2 TW

total global installed renewable power capacity in 2030

Source: IRENA et al. 2024.

The levels of ambition stated in the Nationally Determined Contributions set by nations in connection with their participation in the SDGs are even lower, according to IRENA's quantification of renewable power targets found in the NDCs. Stated targets for new renewable capacity additions translate to 1.5 TW in new capacity, bringing the total global installed renewable power capacity to just 5.4 TW. These findings underscore both the need for aligning national policies with NDCs, as well as the broader imperative of enhancing global ambition.

The achievement of the Paris Agreement's 1.5°C climate target is at significant risk owing to insufficient progress in the energy sector. While some advancements have been made, the deployment of renewables, energy efficiency improvements, and electrification efforts remain far below the levels required to align with the Paris Agreement. Urgent, accelerated action is needed, particularly leading up to 2030, to scale up renewable energy deployment, phase out fossil fuels, and enhance energy system resilience.

The outlook for energy efficiency

At COP28 in late 2023, nearly 200 countries reached an agreement to collectively double the global average annual rate of energy efficiency improvements by 2030. This marked the strongest governmental acknowledgment of energy efficiency's crucial role in the clean energy transition. One year later, however, progress in efficiency had yet to accelerate, highlighting the need for stronger policy implementation.

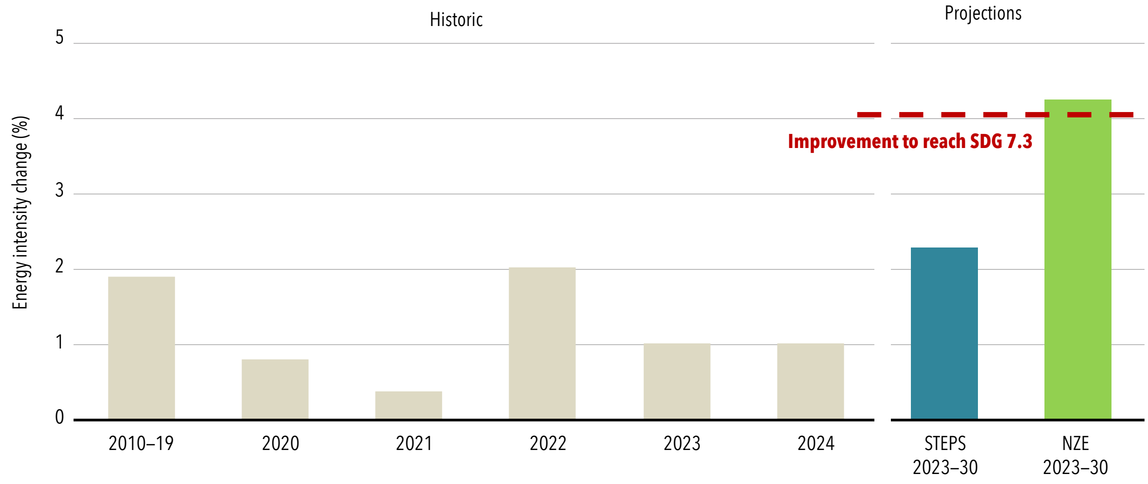
Initially, SDG target 7.3 called for doubling the global rate of improvement in energy efficiency to 2.6 percent between 2010 and 2030 over the 1990–2010 baseline. Given that the improvement was less than 2 percent in the following decade (2010–22), an annual rate of at least 4 percent from 2023 until 2030 became necessary to achieve the same target. That target was expressed in the COP28 Global Renewable and Energy Efficiency Pledge.

Energy efficiency improvements can be achieved through structural shifts and technological advancements, particularly electrification and the deployment of renewable energy. Key measures include increasing the adoption of electric heat pumps and electric vehicles, scaling up building retrofits, optimizing industrial energy consumption through efficient electric motors, and advancing circular economy practices. These measures would not only reduce overall energy demand while enhancing system flexibility, but also facilitate decarbonization by shifting consumption toward clean electricity sources.

In 2024, governments representing more than 70 percent of global energy demand introduced new or updated efficiency policies, which is one of the main reasons for positive progress in the Stated Policies Scenario. The European Union strengthened regulations to achieve a zero-emission building stock by 2050, including measures to encourage retrofitting. China enhanced appliance standards and set more ambitious national efficiency targets, while the United States tightened fuel economy standards for heavy-duty vehicles, although these are now being re-evaluated. Kenya revised its building energy code to mandate efficiency requirements for new construction. Over the past year, governments allocated approximately USD 60 billion for building efficiency and USD 45 billion for low-emission vehicles, bringing total efficiency-related funding over the last five years to more than USD 1 trillion (IEA 2024d).

Regrettably, global progress on energy efficiency—measured by the rate of change in primary energy intensity—will likely show only minimal improvement (1 percent) in 2024, well below the average rate over the 2010–23 period. While progress accelerated in some countries in response to the global energy crisis following the war in Ukraine, overall improvements have slowed. While recent years produced large regional differences, the disparities shrank in 2024: Intensity improvements in advanced economies have slowed, while progress in many emerging and developing economies held steady or increased slightly (figure 6.8). China led global improvement over the previous decade (2010–19) with an annual average improvement in energy intensity of 3.8 percent, but the pace since then has slowed, with a 1 percent deterioration in 2023 and a modest improvement of 1.5 percent in 2024. The European Union saw historic improvements in 2022 and 2023 in the wake of Russia's reduced gas flows to the European Union, but progress is likely to slow to 0.5 percent in 2024, while the United States is estimated to see progress fall from 3.5 percent in 2023 to 2.5 percent in 2024 (IEA 2024d)

FIGURE 6.8 • HISTORICAL AND PROJECTED IMPROVEMENT IN GLOBAL ENERGY INTENSITY BY SCENARIO, 2010–30



Source: IEA 2024d.

NZE = Net Zero Emissions by 2050 Scenario; SDG = Sustainable Development Goal; STEPS = Stated Policies Scenario.

Renovating existing building stock is another critical component of global energy efficiency efforts, given that buildings account for a substantial share of energy consumption. However, current renovation rates remain at approximately 1 percent per year—far below the level required to meet climate targets. While there is growing momentum in retrofitting buildings with energy-efficient technologies, a significant acceleration is necessary to achieve the required reductions in energy consumption by 2030 (IRENA et al. 2024). The same is true of other end-use sectors (figure 6.9).

Accelerated electrification is a key efficiency improvement strategy, involving the adoption of more energy efficient technologies such as electric heat pumps and electric vehicles. These technologies consume less energy than fossil fuel-based sources while also contributing to emissions reductions. As electricity grids increasingly integrate renewable energy sources, the efficiency and decarbonization benefits of electrification will become even more pronounced. Progress in transport electrification during 2023 marked significant strides but remains insufficient to meet the targets set in IRENA’s 1.5°C Scenario. By 2030, the global electrification rate in total final energy consumption for transport would need to reach nearly 7 percent, with road transport offering the greatest potential for growth. The current stock of battery electric vehicles and plug-in hybrid electric vehicles would need to grow ninefold to reach 360 million by 2030, a trajectory far above current growth rates (IRENA 2024c). In the heating sector, the continued adoption of heat pumps will be essential for energy-efficient decarbonization (IRENA et al. 2024). While progress has been made across end-use sectors it remains insufficient, as discussed in chapter 4.

FIGURE 6.9 • PROGRESS TOWARD AND GAPS IN GLOBAL ENERGY EFFICIENCY AND ELECTRIFICATION OF END USES BY 2030

ENERGY EFFICIENCY	RECENT YEARS	2030
Energy intensity improvement rate (%)	2%[a]	4%[b]
Building renovation rate (% stock/year)	1%[c]	2%

ELECTRIFICATION OF END-USE CONSUMPTION	RECENT YEARS	2030
Electrification rate in TFEC (%)	23%[d]	30%
Electric and plug-in hybrid light passenger vehicles stock (million)	40M[e]	360M
Heat pumps in buildings (GW)	1 280GW[f]	8 937GW
Heat pumps in industry and in DH systems (GW)	no data/ negligible[g]	434GW

Source: IRENA and others 2024, plus other works cited in notes below.

Notes DH = district heating; GW = gigawatt; M = million; TFEC = total final energy consumption

a. Energy intensity improvement achieved in 2022

b. Average annual improvement rate required between 2023 and 2030

c. Estimated percentage of renovated buildings in the global stock in 2021

d. 2022 value, IEA World Energy Statistics and Balances (IEA 2024g)

e. 2023 value (IEA 2024h)

f. 2023 value estimated from (IEA 2021, https://www.iea.org/reports/clean-energy-market-monitor-march-2024)

g. No database of industrial heat pumps is available today (Schlosser and others 2020). Industrial heat pumps are assumed to represent a negligible share of the total final energy consumption in industrial process heat supply (Agora Energiewende 2023).

If energy efficiency improvements are to double, there is a need for robust government policy packages incorporating information, regulations, and incentives—and a tripling of global investments. For example, almost half of newly built floor area around the world is not yet covered by efficiency requirements, and the regulations in place vary significantly by country in scope and stringency. Similarly, just three out of five industrial electric motors in use globally are covered by minimum energy performance standards (IEA 2024d).

In a pathway aligned with the doubling of efficiency agreed at COP28, between now and 2030, cars would become 5 percent more efficient each year, largely through electrification and a switch to smaller vehicles. In industry, annual energy productivity would increase by 2.3 percent per year, and electricity would account for 30 percent of energy use by 2030. The retrofit rates for buildings would more than double to 2.5 percent per year, generating energy savings large enough to power all buildings in China and India. Appliances including air conditioners and refrigerators would require 30–40 percent less energy, and consumers would make active behavioral changes, for example, limiting home heating to 19–20°C (IEA 2024d).

While achieving this rate of improvement will be challenging, it is not unprecedented. Of the vast majority of the 150 countries for which data are available since 2012, energy intensity improved by 4 percent or more at least once and by more than half at least three times (IEA 2024ed). 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 technologies already available. The minimum energy performance standards of many governments are already at or very close to the levels set forth under the Net Zero Emissions by 2050 Scenario. Implementing and enforcing these standards across sectors would aid in the collective effort of doubling progress in energy efficiency.

Investments needed to achieve SDG 7

Between 2015 and 2021, annual clean energy investments averaged over USD 1 trillion (in 2022 dollars) (IEA 2024f). Global clean energy investments, encompassing renewables-based power, renewables-based fuel, energy efficiency, end-use electrification, and resilient grids, rose by more than 5 percent in 2023. Yet, investments in renewables also remain unevenly distributed, with 84 percent of investments flowing to China, the European Union, and the United States. Sub-Saharan Africa, where 565 million people still lack access to electricity, received 40 times less than the per capita world average for transition-related investment (IRENA and OECD 2024). While international public flows to developing countries in support of clean energy rebounded to USD 21.6 billion in 2023, they remain below the 2016 peak of USD 28.4 billion and fall far short of the energy needs of developing countries, especially least developed countries. (For more, see chapter 5.)

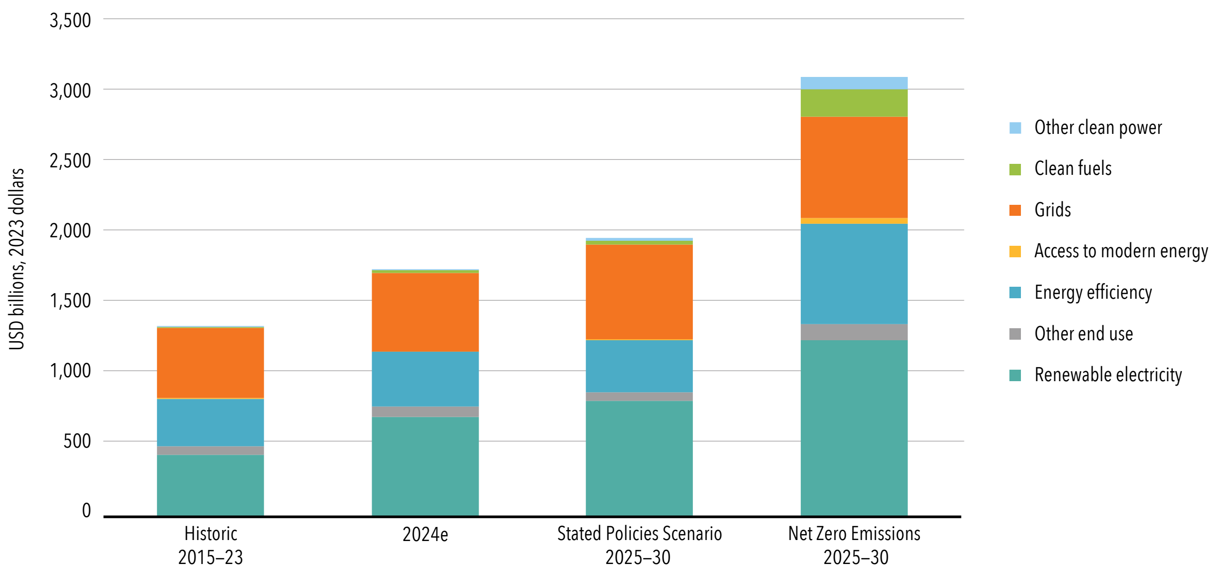
Both IEA and IRENA emphasize the pressing need to escalate investments in the energy transition across the globe. According to IEA's Net Zero Emissions by 2050 Scenario, an average annual investment of USD 4 trillion in the energy sector is required over 2023–30, whereas energy investments under the Stated Policies Scenario average more than USD 3 trillion in the same period (figure 6.8).

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.

Under IEA's Net Zero Emissions by 2050 Scenario, achieving universal energy access in developing economies necessitates average annual investments of USD 55 billion by 2030. Two-thirds 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 spending levels for access remains challenging owing to the small-scale nature of projects and the affordability challenges faced by end users. International support through development aid and from multilateral development banks will be crucial in mobilizing investment and mitigating the risks associated with access and other energy investments in emerging markets and developing economies.

FIGURE 6.10 • AVERAGE ANNUAL INVESTMENT IN SELECTED TECHNOLOGIES UNDER IEA SCENARIOS, 2015–30



Source: IEA 2024a.

Under IRENA's 1.5°C Scenario, USD 31.5 trillion in cumulative investment in renewables, grids, flexibility measures, energy efficiency, and conservation would be required by 2030 to meet the renewable power capacity and energy efficiency targets of the UAE Consensus (UNFCCC 2023b). While annual investments in renewable power capacity reached a record high of USD 570 billion in 2023, they fall far short of the average USD 1.5 trillion needed each year between 2024 and 2030.

Given current progress, IRENA estimates that annual investments for solar PV are on track to meet the goal to triple global renewable power capacity. In contrast, annual investments in other technologies such as wind, hydropower, bioenergy, CSP, and geothermal are still falling short. And investments in power grid networks and other flexibility measures (especially energy storage) are urgently needed in parallel with the expansion of renewable power capacity.

An estimated average of USD 717 billion per year is needed in grids and flexibility between 2024 and 2030, nearly double the investment made in 2023 (figure 6.11).

To double energy efficiency, IRENA's 1.5°C Scenario estimates that current investments (USD 323 billion in 2023) will need to increase almost sevenfold. This would translate into USD 2.2 trillion across buildings, transport, and industry each year between 2024 and 2030.

FIGURE 6.11 • INVESTMENTS REQUIRED TO TRIPLE RENEWABLE POWER CAPACITY AND DOUBLE ENERGY EFFICIENCY BY 2030 COMPARED WITH 2023 PROGRESS

All numbers in 2023 USD billion	Investment in 2023	Average annual investments required 2024-2030
RENEWABLE POWER GENERATION CAPACITY [3]		
Marine	0	63
Geothermal	1	64
CSP	2	102
Bioenergy	13	115
Hydro (excl. pumped)	21	149
Wind offshore	30	209
Wind onshore	116	433
Solar PV	387	397
Total	570	1,532 USD billion/yr
ENERGY EFFICIENCY		
Buildings	255	1,047
Industry	25	1,020
Transport	43	152
ENERGY CONSERVATION	4.7	31
Total	328	2,250 USD billion/yr
GRIDS AND FLEXIBILITY	391	717
TOTAL	1,289	4,499 USD billion/yr
		2024-2030 USD 31.5 trillion

Source: IRENA et al. 2024. PV = photovoltaic; CSP = concentrated solar power; yr = year.

Conclusion

While progress has been made toward the achievement of SDG 7—which aims for universal access to affordable, reliable, sustainable, and modern energy by 2030—significant challenges remain across all targets. Innovations in technology and policy have expanded access to electricity and clean cooking, especially in Asia. However, regional disparities persist, with slow progress and insufficient support for Sub-Saharan Africa being of particular concern. Existing solutions, including mini-grids and solar home systems, can help support electricity access in hard-to-reach areas. But enhanced international cooperation, a broad range of financing mechanisms tailored to country circumstances, and adaptable and inclusive policy frameworks designed to optimize public spending and attract private investment are needed to power sustainable development. Comprehensive electrification strategies that also consider productive uses are essential to tackle the full spectrum of challenges and to ensure no one is left behind.

Scaling up renewable energy and improving energy efficiency are essential not only to meet SDG 7 but also to address the broader environmental and socioeconomic challenges reflected in the broader SDG agenda. Achieving these goals demands a fundamental shift in energy production, distribution, and consumption, supported by increased investments and enabling policies. Policy makers can play a crucial role in fostering sustainable energy transitions by creating favorable conditions for the adoption of renewable energy and improvements in energy efficiency, all toward the end of facilitating investment and ensuring that marginalized communities are able to benefit from the energy transition. Empowering people, including youth, with the skills and knowledge to engage in the energy sector fosters a forward-looking mindset that is crucial for achieving long-term progress.

Advancing a sustainable energy future requires collaboration among governments, the private sector, international organizations, and civil society. This collective effort should focus on mobilizing and channeling financing, making clean energy technologies more affordable, and ensuring equitable distribution of benefits and burdens associated with the energy transition. The energy and development needs of people must be at the center of efforts to build a sustainable energy future. Scaling up efforts with a holistic approach can bridge energy access gaps and move the globe toward a sustainable future and inclusive energy future for all.

Photo: © Kali9 / IStock/Getty Images Plus

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). The 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 (ESMAP) produces and publishes the report.

This chapter provides a descriptive summary of the data for each indicator and the methodological challenges. Further details can be found in the United Nations' metadata repository for SDG indicators (https://unstats.un.org/sdgs/metadata/).

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 [renewables-based] 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 (MTF), to better capture the spectrum of energy services sought and used by households: capacity, availability, reliability, affordability, quality, formality, healthiness, and safety.[41] 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.

Advancing capacity-building activities, such as the training of energy statisticians through bilateral and regional programs, will improve the tracking of electricity access by building the skills needed for effective data collection and analysis. More user-friendly and more comparable data sets will, in turn, help governments and energy practitioners apply new technologies and leverage data analytics to inform policy and implementation. Resources like the World Bank's online Atlas of Sustainable Development Goals,[42] which features interactive storytelling and graphical representations of electricity access trends, demonstrate how accessible data can enhance insights relevant to key SDG indicators. Also, the use of large-scale, open databases that provide real-time information based on satellite data will clarify where and how electricity is being used, while also revealing socioeconomic trends related to energy consumption. Ongoing efforts to improve data quality and granularity are critical, as is sustained investment in both data collection and capacity building. In 2021, ESMAP, the Living Standard Measurement Study (LSMS), and WHO collaborated to publish the "Core Questions on Household Energy Use," providing detailed guidelines for fieldwork and data tabulation, including on electricity quality. These standardized modules are being integrated into national surveys so that they provide more timely and actionable insights in support of universal access, rather than merely serving as retrospective assessments. The World Bank has also partnered with national statistical offices to deepen their understanding of energy indicators and improve survey methodologies. ESMAP's MTF survey has been implemented in 25 countries, with the aim of establishing a baseline for energy access in over 35 countries by 2025, while a recent ESMAP-LSMS initiative plans to conduct household surveys in 15 countries aligned with the Mission 300 goals. Strengthening these initiatives will ensure a more precise and detailed understanding of electricity access, ultimately supporting more effective policy making and accelerating progress toward the SDGs.

41 Information on the MTF can be found at https://mtfenergyaccess.esmap.org/.

42 https://datatopics.worldbank.org/sdgatlas?lang=en.

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 guidelines for indoor air quality and household fuel combustion (2014). 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 picture 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). 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 by 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.[43]

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 make clean cooking estimates more granular and aid in the formulation of better national and global policies (World Bank and WHO 2021).

43 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) among 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 make renewable energy statistics more reliable. For example, a broader range of questions on biomass use in households and organizations could help determine to what extent it can be considered a sustainable energy source. Traditional fuelwood harvesting is associated with deforestation and habitat loss, 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. Remote sensing might help measure it, but still a long time will be needed to calibrate it against well-run household surveys.

Energy efficiency

Energy intensity, defined as the ratio of total energy supply and 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. Supply-related information is collected from administrative sources or via surveys of higher-level players, such as energy suppliers.[44] 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, because end users are diverse. 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 energy 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 registration, 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.[45]

44 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.

45 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 consistent way.

Tracking public financial flows requires an understanding of how recipients intend to spend aid and other 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. Most data on public investments in clean energy and renewables continue to be collected in a decentralized manner, adversely affecting consistency. For comparability across public donors, data collection must be centralized, using 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 (2022) and by converting local currency values to US dollars using exchange rates from the baseline year (2022).

Installed renewable electricity: Generating capacity in developing and developed countries

Indicator 7.b.1 tracks the installed capacity of power plants generating electricity from renewable energy sources (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 year-end net maximum installed electrical capacity. 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.

Data on renewable energy capacity 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 relevant national agencies, 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 (the most recent edition is that of 2024). Population data are extracted from the "World Population Prospects" (the most recent edition is UN Population Division 2023) and represent a country's population at midyear (July 1).

A measure of indicator 7.b.1 in watts per capita is computed by dividing a country's year-end renewable-electricity-generating capacity 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 the demand for modern and sustainable energy services in a country.

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 to track SDG 7 at a global level, 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, the 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, these 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, in turn improving the SDG 7 indicators. Recently, thanks to the IEA's Sub-Saharan Africa program funded by the European Union, Nigeria implemented a new household survey in 2024 and a survey for industry in March 2025.

The custodian agencies for SDG 7 highlight 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.

ANNEX 1. Methodological Notes

Chapter 1. Access to electricity

The World Bank's Global Electrification Database

The World Bank's Global Electrification Database compiles data from nationally representative household surveys and from censuses for the period 1990–2023. 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 (MTF), which classifies access from Tier 0 (no access) to Tier 5 (the highest level of access). At the time of this analysis, the database had 1,438 surveys from 149 countries over 1990–2023.

A multilevel, nonparametric model is applied to extrapolate data for missing years (described below). The modeling 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.[46] Where data were available, access estimates were weighted by population. Multilevel, nonparametric modeling considers the hierarchical structure of data (at country and regional levels), using the regional classification of the United Nations.

The model was applied in all countries for which at least one data point was available. To use as much real data as possible, results based on survey data were reported in their original form for all the years for which they were available. The statistical model was used to fill in data for years in which data were otherwise missing and to conduct global and regional analyses. When survey data were not present 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. High-income countries are assumed to have 100 percent electrification rates (for the years the countries belong to that income category).

For 1990–2010, the statistical model was based on insufficient data points or outdated household surveys. To avoid electrification trends in this period overshadowing efforts made since 2010, the model was run twice: once with survey data and assumptions for 1990–2023 (for model estimates for 1990–2023) and once with survey data and assumptions for 2010–23 (for model estimates for 2010–23). The first run extrapolated electrification trends for 1990–2023, given the available data points. The second run considered only real data collected since 2010 and estimated the historical evolution over 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.

46 The model draws on the modeling of solid fuel use for household cooking presented in Bonjour et al. (2013).

Under the adapted WHO methodology, regional trends affect the estimation of yearly values for countries missing data points for certain years. Depending on the regional trend and the years elapsed since the last year in which data were available for a given 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 for Brazil, Bolivia, Jamaica, and Lao People's Democratic Republic.

The Multi-Tier Framework (MTF)[47] of the Energy Sector Management Assistance Program (ESMAP) further complements the Global Electrification Database's information through household surveys, primarily consumer questionnaires, which provide insights into the quality and reliability of the energy services received by people and also delve into affordability issues. To date, the MTF has conducted such surveys in over 25 countries, assessing electricity access across five tiers of service. ESMAP is looking to focus and expedite the use of such multisectoral surveys in countries where the access gaps are widest.

Night-Time Light (NTL) Satellite Imagery for Electrification Estimation is used to further validate and correct survey data. Gaps are filled where surveys were conducted several years ago or were disrupted—such as during the COVID-19 pandemic, or due to situations involving fragility, conflict, and violence (FCV). NTL satellite imagery works by measuring artificial light emissions from the Earth's surface. It helps track human activities such as urbanization, economic growth, and electrification. Satellites have been recording NTL emissions since 1992, with increasing spatial resolution and precision. Since 2012, the Visible Infrared Imaging Radiometer Suite (VIIRS) has provided global nightly NTL data. NTL imagery complements survey-based approaches with a remote sensing solution, especially for regions for which field data are limited. It provides high-resolution estimates of electrification at the village level, helping to track progress over time and identify access gaps. Repeated rounds of cross-checks and validation further enhance estimates and make data more reliable for policy makers, researchers, and stakeholders through the report series.

Comparison between demand- and supply-side data

While the Global Electrification Database collects data mainly from household surveys and censuses, the International Energy Agency's (IEA's) Energy Access Database draws from government reports on 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 at times 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.

A comparison of the two datasets in the previous edition of this report (updated in this edition) highlights their respective strengths. Household surveys, 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, survey data convey user-centric perspectives on electrification. They capture all forms of access, painting a more complete picture than may be possible using data supplied by service providers. But a comprehensive and accurate survey-based understanding of electricity access requires greater investment in data collection and capacity building.

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

Government-reported electrification data, as provided by the 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, about 34 percent of countries have published or updated their electricity data at intervals of two to three years, the recommended time frame 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, which may result in the access deficit being underestimated.

Measuring access to off-grid solar-based electricity

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

Off-grid solar lighting products eligible for inclusion 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 they submit, an independent consultancy (Berenschot), as well as GOGLA, Lighting Global, and the Energy Savings Trust, check the data for quality.

Both off-grid solar product manufacturers and distributors report sales, but public reports cover only manufacturers' sales—which include business-to-business transactions (e.g., sales to distributors, governments, and nongovernmental organizations) as well as direct sales to customers—so that sales reported by both manufacturers and distributors are not double counted. The most recent *Market Trends Report* (Lighting Global/ESMAP et al. 2022) estimates that the 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[48] created by the GOGLA Impact Working Group, additional steps are taken to calculate energy access tiers:

Tier 1. A "SEforALL factor" is applied to sales numbers.[49] This 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 unlock either partial or full Tier 1 access. It then calculates the number of people who have achieved either partial or full Tier 1 access.

Tier 2. Products that have capacity of more than 50 watts peak, or 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 the energy service with the requirements for Tier 2 access. Products that have enabled a household to achieve Tier 2 access are not included in the final Tier 1 estimates.

48 The Global Impact Metrics are available at https://gogla.org/reports/standardised-impact-metrics-for-the-off-grid-solar-energy-sector-v4/.

49 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 to thus prevent Tier 1 access from being underrepresented in calculations.

Measuring access to mini-grid–based electricity

The International Renewable Energy Agency (IRENA) collects off-grid capacity and generation data from a variety of sources, including from its own 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 photovoltaic capacity, based on solar panel import statistics obtained from the United Nations' COMTRADE Database.

IRENA's 2024 decentralized energy database contains global data on off-grid renewable energy for Africa, Asia, South America, Central America and the Caribbean, and Oceania, covering 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).

Data from censuses for more than 200 countries, conducted at varying frequencies and over different periods, are used to track electricity access. Where anomalies are identified through internal validation, analysts use internal reviews, household survey–based validation, and satellite imagery. Where this occurs, corrections are made to access levels, using methodologies duly approved by technical experts, who are a key part of the guidance for the Tracking Report. While this is a robust approach, it has its challenges and limitations.

Challenges in measuring and reporting global electricity access fall under three broad topics: (1) data consistency, (2) frequency of data collection, and (3) challenges in data collection. Data inconsistencies in reported figures and difficulties in cross-country comparisons arise from diverse definitions of electricity access across countries, variations in survey questions, and different data collection approaches. Data collection frequency is a challenge: only about 34 percent of countries have been updating their electricity survey data within two to three years, the required time frame, since 2010. This implies that extrapolations are required to update overall estimates. Data collection challenges include sampling errors, especially for household surveys in remote or rural areas, hampered by logistical challenges and capacity constraints. This means that regional disparities cannot be fully captured and estimates rather than actual survey data are used for areas with weak statistical systems. As private sector investments are leveraged, particularly in off-grid and mini-grid areas, there is a need for the type of information that helps private investors and consumers decide on investments and installations. The binary categorization of "access" or "no access" is increasingly seen to be insufficient. Multisectoral approaches are needed to assess affordability based on income levels, while more information on the geography and composition of underserved areas with a high density of unelectrified households would help decide where and how to focus investments to narrow the access gap. Frequency and accuracy of data collection are other limitations. More work is needed to make household surveys nimbler, faster, and backed by greater analytical strength. There is also a need for harmonized standards, greater collaboration, and the adoption of new technologies like satellite imagery and artificial intelligence to make data more accurate and more comparable in measuring global electricity access. However, even state-of-the-art technologies have limitations that need to be carefully considered. Two examples are given below:

Country-specific variations. Light emissions do not translate directly into access rates; for the same electrified population, different countries emit different light levels. Factors such as outdoor activity, energy-saving practices, and infrastructure differences influence results.

Limited multidimensional insight. Electrification is more than just light emissions. Quality household surveys with a multisectoral approach are a must for assessing consumer requirements, affordability thresholds, and the reliability and quality of options available.

Chapter 2. Access to clean fuels and technologies for cooking

Data sources

The WHO Household Energy Database contains data from nationally representative household surveys (WHO 2024). It is regularly updated, relies on multiple sources (table A1.1), and serves as the basis for all modeling efforts in this report. The database contains more than 1,650 surveys conducted in 171 countries (including high-income countries) between 1960 and 2023. A quarter of the surveys cover the years 2013–18; 330 new surveys cover 2016–23. Modeled estimates are provided only if there are underlying survey data on cooking fuels. Thus, there are no estimates for Lebanon, Libya, and Bulgaria.

Population data are from the latest revisions of the United Nations World Population Prospects (2024) and Urbanization Prospects (2018).

TABLE A1.1 • OVERVIEW OF DATA SOURCES FOR CLEAN FUELS AND TECHNOLOGY

NAME	ENTITY	NUMBER OF COUNTRIES	QUESTION
Census	National statistical agencies	109	What is the main source of cooking fuel in your household?
Demographic and Health Survey (DHS)	Funded by the United States Agency for International Development (USAID); implemented by ICF International	82	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	Which is the main source of energy for cooking?
Multiple Indicator Cluster Surveys (MICS)	United Nations Children's Fund (UNICEF)	90	What type of fuel does your household mainly use for cooking?
Study on Global AGEing and Adult Health (SAGE)	World Health Organization (WHO)	6	NA
World Health Survey	WHO	50	NA
National surveys		117	NA
Other		84	NA

Model

Given household surveys are conducted irregularly and reported heterogeneously, the WHO Global Household Energy Model (GHEM), 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., liquefied petroleum gas)
- Electricity

Trends in the proportion of the population using each fuel type are estimated using a Bayesian hierarchical model—based on country survey data and with urban and rural disaggregation. 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 for relevant fuel types. Estimates produced by the model automatically presume that total fuel use equals 100 percent.

The GHEM is implemented using the R programming language and the NIMBLE software package for Bayesian modeling 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 country estimates for the use of four polluting cooking fuels and two cooking clean fuels for each year from 1990 to 2023, together with associated measures of uncertainty. Further details on the modeling 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).

The analysis included only surveys where less than 15 percent of the population reported "missing," "no cooking," and "other fuels." 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 in the 2023 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 for which there were no data suitable for modeling (Bulgaria, Lebanon, and Libya). Modeled fuel-specific estimates were reported for 128 low- and middle-income countries, plus three countries with no World Bank income classification (República Bolivariana de Venezuela, Niue, and Cook Islands). Estimates of overall clean fuel use were reported for 195 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 estimates may be statistical noise arising from either the modeling process or survey variability, and may, therefore, not reflect a real variation in the numbers, which vary based on the fuels between years. The uncertainty intervals should, therefore, be considered when assessing changes in the rate of access to orthe use of specific fuels between years.

Moreover, for some countries, unavailability of recent survey data (e.g., for the past 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 Prospects (2024) and Urbanization Prospects (2018) (for disaggregation by residence) were used to derive the population-weighted regional and global aggregates (UN 2024, 2018). Low- and middle-income countries for which data were not available 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 the 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 accounts for population growth by making use of the final national access rate.

Projections

Projected access rates, access deficits, and fuel use can be estimated using the GHEM, whereby 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 estimated consumption of renewables-based electricity and renewables-based heat. 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 transport, industry, and other sectors (equivalent to the difference between total final consumption and nonenergy use). Total final energy consumption excludes energy transformed into other forms (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 solid biomass is consumed for energy purposes in the residential sector in countries outside the Organisation for Economic Co-operation and Development (OECD). IEA's statistics classify solid 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 of products. Traditional consumption/use of biomass is a "conventional proxy" because it is estimated rather than measured directly, due to limited data on the use of solid biomass in traditional and inefficient cookstoves.

Modern uses of renewable energy consumption. This is the difference between the total renewable energy consumption and the traditional consumption/use of biomass.

Methodology for the indicator

The indicator used in this report to track Sustainable Development Goal (SDG) 7.2 is the share of renewable energy in total final energy consumption. Data from the International Energy Agency's World Energy Balances (IEA 2024a) and the United Nations Statistics Division's Energy Balances 2022 (UNSD 2024) are used to calculate the indicator according to this 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, and HEAT = gross heat production; the subscript RES corresponds to the portion coming from renewable energy sources.

The denominator is the total final energy consumption across all energy products (as defined above). The numerator—final renewable 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. For the calculation at the final energy level, the amount of electricity and heat consumption deemed to come from renewable sources is allocated based on the renewables' share 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 for transport is excluded from this aggregation. Electricity used to produce district heat is also not included, because it is not part of final consumption. Electricity used to produce heat in electric boilers and heaters (except where this heat is distributed as district heat) is included, however, since official data at the final energy service level are unavailable to determine what electricity is used for heat.

Heat refers to the amount of energy consumed for heating 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, electricity-based heat in electric boilers and heaters—the final consumers—is not included in this aggregation.

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 for transport. The majority is consumed in rail and road transport, followed by pipeline transport. The amount of renewables-based electricity consumed in the transport sector is estimated as the product of the annual shares of renewable sources in the 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 renewable electricity–generating capacity of power plants by the country's midyear population. Data from IRENA are used to calculate this indicator.

IRENA's electricity capacity database contains information on installed electricity-generating capacity, measured in megawatts. The dataset covers all countries and areas from the year 2000, records whether capacity is on- or off-grid, and is divided into 36 renewable energy types, which together constitute the six main sources of renewables-based electricity. For the population part of this indicator, IRENA uses the latest population data from the United Nations World Population Prospects (UN 2024).

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. This definition is consistent with International Recommendations for Energy Statistics (IEA 2024a; UNSD 2024).

Gross domestic product (GDP) in 2021 US dollars (USD) at purchasing power parity (PPP)

This is the sum of the gross value-added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the products' value. It is calculated without making deductions for the depreciation of fabricated assets or for the depletion and degradation of natural resources. GDP is measured in constant 2021 USD PPP. The data source is IMF's World Economic Outlook (https://www.imf.org/en/Publications/SPROLLs/world-economic-outlook-databases/), complemented by World Bank's World Development Indicators (https://databank.worldbank.org/source/world-development-indicators) and CEPII's CHELEM database (http://www.cepii.fr/CEPII/en/bdd_modele/bdd_modele_item.asp?id=17).

Primary energy intensity in MJ/2021 USD PPP

$$Primary\ energy\ intensity = \frac{TES\ (MJ)}{GDP\ (USD\ 2021\ PPP)}$$

The TES–GDP ratio is measured in MJ per 2021 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 indicator of an economy's energy efficiency, since an economy can only be meaningfully aggregated in monetary terms, and changes over time can provide insights into progress in efficiency. However, it is an imperfect indicator, since changes are affected by other factors in addition to energy efficiency, especially changes in the structure of economic activity.

Average annual rate of improvement in energy intensity (%)

This is calculated using the 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 t2

EI_{t1} is energy intensity in year t1

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), whereas 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

The sum of the energy consumption of the different end-use sectors, excluding nonenergy uses of fuels, TFEC is broken down into final energy demand in industry, transport, residential, services, agriculture, and other sectors. It excludes international marine and aviation bunkers, except at the global level, where it is included in the transport sector (IEA 2024a; UNSD 2024).

Value-added in 2023 USD PPP

Value-added is the net output of a sector after adding all outputs and subtracting intermediate inputs. It is calculated without making deductions for the depreciation of fabricated assets or the depletion and degradation of natural resources. The industrial origin of value-added is determined by the International Standard Industrial Classification, revision 3 (IEA 2024b).

Industrial energy intensity in MJ/2023 USD PPP

$$Industrial\ energy\ intensity = \frac{Industrial\ TFEC\ (MJ)}{Industrial\ value\ added\ (USD\ 2023\ PPP)}$$

Ratio of industry TFEC and industry value-added, measured in MJ per 2023 USD PPP (IEA 2024a, 2024b.

Road passenger transport energy intensity in MJ/passenger-kilometer (km)

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

Ratio of final energy consumption for road passenger transport and road passenger transport activity measured in MJ per passenger-km (IEA 2024c).

Freight transport (heavy trucks) energy intensity in MJ/tonne-km

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

Ratio of freight transport (heavy trucks) final energy consumption and activity measured in MJ per tonne-km (IEA 2024c).

Buildings energy intensity in MJ/unit of floor area

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

Ratio of buildings TFEC and square meters of building floor area (IEA 2024c).

Fossil fuel electricity generation efficiency (%)

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

Ratio of electricity output from fossil fuel–fired (coal, oil, and natural gas) electricity generation and the fossil fuel–based energy input to electricity generation

Fuel inputs to and electricity output from combined heat and power plants (CHPs) are excluded from this figure (IEA 2024a).

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

Data sources

For SDG indicator 7.a.1, a combined subset from two databases is used. The databases, the Creditor Reporting System (CRS) of the OECD's Development Assistance Committee (DAC) and IRENA's Renewable Energy Public Finance Database, are used to track international public financial flows. The CRS is a quarterly updated database containing various financial flows provided by investors to countries for multiple purposes (OECD 2025). Progress in this indicator is tracked based on only a subset of the commitments in this database. To obtain that subset, we downloaded bulk data from the CRS from 2000 onward; consolidated the files; removed unused columns, noncommitments, and flows from private sector donors (flow code 30); and filtered the data to include clean energy investments (purpose codes 23210–23290, 23410, 23631).

IRENA's Renewable Energy Public Finance Database covers commitments beyond those included in the CRS, especially by non-DAC donors that do not report their commitments through the CRS. These flows represent approximately 40 percent of the financial value of the commitments in both databases combined. We categorized each commitment by type of energy, financial instrument, and other metadata that matches the CRS. Reporting precedes data compilation in the CRS by a few months. After the CRS data were released, we reviewed individual commitments 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 generally reflects a three-year lag in the publication cycle and a one-year lag in the latest reporting data (that is, the 2025 cycle will report commitments up to 2023 at 2022 constant prices).

International financial 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 US dollar in a recent year (2022 in this report). For 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.[50] The following formula converts the nominal investment amounts in current US dollars to US dollars at constant prices and constant exchange rates:

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

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

50 The OECD publishes DAC deflators for each donor. For more information, see https://www.oecd.org/dac/financing-sustainable-development/development-finance-standards/informationnoteonthedacdeflators.html. 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.

Regional aggregations and classifications

Regional aggregations start with the microdata of commitments. Each commitment is assigned to either a specific country or to an unspecified country, or to a 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 region name. 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 on the region or country is available, are classified as multilateral and excluded from the indicator, since 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 types 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 disbursements, which may occur over weeks, months, or years.

Tracking of financial commitments can yield quite different results than tracking disbursements. Disbursement information would portray the actual yearly renewable energy financial flows more accurately but disbursement data are often limited or not available. On the other hand, a more comprehensive and granular analysis of financial flows is possible through tracking commitments, which also 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, canceled, or altered. Any changes must be reflected in the annual values.

Financial instruments

The financial instruments used by public financial institutions were categorized based on OECD's list of financial types and IRENA's 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 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 the 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 the 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, nor 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, and 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.

FINANCIAL INSTRUMENT	DESCRIPTION
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.
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.
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 to only foreign direct investment (FDI). Reinvested earnings on FDI consist of the retained earnings of an FDI enterprise, treated as if they were distributed and remitted to foreign direct investors (in proportion to their ownership of the enterprise's equity) and then reinvested 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 2024.

Changes to data

Several revisions were made to the combined public investments database (OECD and IRENA). Some commitments were canceled, some were reclassified to different years, and some recipient countries were removed from the dataset. In addition, all figures were subsequently updated to reflect 2022 prices and exchange rates (table A1.3). As a result, the difference in the reported dollar amounts reflects a compounded effect of both these data revisions and the shift from 2021 to 2022 constant USD values.

TABLE A1.3 • REVISIONS TO PUBLIC FLOWS, 2000–22

YEAR	BEFORE REVISION (2021 USD MILLIONS)	AFTER REVISION (2022 USD MILLIONS)	DIFFERENCE (2022 USD MILLIONS)
2000	1,535	1,447	-88
2001	1,739	1,610	-129
2002	1,283	1,169	-114
2003	2,878	2,787	-91
2004	1,723	1,573	-149
2005	2,772	2,629	-143
2006	3,231	3,122	-109
2007	4,391	4,336	-55
2008	4,066	3,886	-181
2009	4,896	4,739	-157
2010	11,334	10,964	-370
2011	12,826	12,489	-337
2012	10,085	10,316	230
2013	13,322	13,190	-132
2014	18,076	18,956	879
2015	12,329	12,143	-186
2016	28,454	28,427	-27
2017	22,840	22,320	-520
2018	17,680	17,483	-197
2019	12,758	12,353	-405
2020	12,151	12,053	-98
2021	12,385	13,159	774
2022	15,433	17,014	1,581
Total	228,186	228,163	-23

Source: IRENA and OECD 2024.

The difference over the past two decades reflects a minor downward revision of the total USD 23 million in commitments. This minor difference is mainly due to upward revisions for 2022 (USD 1,581 million), 2021 (USD 774 million), and 2014 (USD 879 million), along with downward revisions for 2017 (USD 520 million) and 2019 (USD 405 million). In addition, part of the difference is due to the shift from using 2021 to 2022 as the constant USD base year.

Chapter 6. Outlook for SDG 7

Investment figures from IEA scenarios are in constant 2021 USD at the market exchange rate. Investment figures from IRENA scenarios are in constant 2015 USD at the market exchange rate.

IEA methodology

The analysis in this chapter is based on results from the Global Energy and Climate Model (GEC Model) and IEA's analysis in the World Energy Outlook (WEO). Detailed documentation of the WEM methodology is available at: https://www.iea.org/reports/global-energy-and-climate-model

IEA presents in this report two of its models. The Stated Policies Scenario (STEPS) is designed to provide a sense of the prevailing direction of energy system progression, based on a detailed review of the current policy landscape. It provides a more granular, sector-by-sector evaluation of the policies that have been put in place to reach stated goals and other energy-related objectives, taking account not only of existing policies and measures but also those that are under development. They are implemented under this scenario to the extent that they are supported by specific policies, funding, and measures. The scenario also reflects progress with the implementation of corporate sustainability commitments.

The Net Zero Emissions by 2050 Scenario (NZE Scenario) is a normative scenario that shows a 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 key energy-related Sustainable Development Goals (SDGs), in particular universal energy access by 2030 and major improvements in air quality. It is consistent with limiting the global temperature rise to 1.5 °C (with at least a 50% probability), in line with emissions reductions assessed in the Intergovernmental Panel on Climate Change (IPCC)'s Sixth Assessment Report. This scenario is based on the following assumptions:

- Adoption 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.
- The entire energy sector sees an orderly transition that ensures the security of fuel and electricity supplies at all times, minimizes stranded assets where possible, and avoids volatility in energy markets.

Methodology for tracking access to electricity and 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 access to clean cooking, the main sources are the WHO's Household Energy Database and IEA's Energy Balances. Both databases are regularly updated and form the baseline for the WEO energy access scenarios to 2040.

The projections under 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 for universal access to electricity as well as clean cooking. For electricity access, the analysis incorporates a geographic information systems (GIS) model based on open-access geospatial data; technology, energy prices, electricity access rates, and demand projections are obtained from the GEC Model. This analysis was developed in collaboration with the KTH Royal Institute of Technology, Division of Energy Systems Analysis (KTH-dESA), in Stockholm, Sweden. on the IEA methodology for energy access projections can be found in the Global Energy and Climate Model documentation (https://www.iea.org/reports/global-energy-and-climate-model)

Methodology for renewable energy projections

The annual updates to the WEO projections reflect the broadening and strengthening of policies over time, including for renewables. Projections for renewables-based electricity generation are derived in the renewables submodule of the GEC Model, which projects the future deployment of renewables for electricity generation and the required investment. This future deployment relies on an assessment of the potential of and costs for each renewable energy source (bioenergy, hydropower, photovoltaics, concentrated solar power, geothermal electricity, wind, and marine energy) in each of the 27 GEC Model regions. Under all scenarios, IEA modeling incorporates a process of learning by doing that affects costs. The model calculates deployment as well as the resulting annual investment needs for each renewable source in each region by including the financial incentives for the renewables' use and the nonfinancial barriers in each market; technical and social constraints; and the value added by each technology to the system in terms of energy, capacity, and flexibility.

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 GEC Model 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 for each end use, at least six types of energy are shown: coal, oil, gas, electricity, heat, and renewables. The main oil products—liquefied petroleum gas, 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 the 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 the 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 27 GEC Model 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).
- Buildings' 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 a series of roadmaps outlining renewables-dominated pathways for deploying low-carbon technologies for a clean and sustainable energy future globally, regionally, and nationally.

The findings in this report are based on IRENA's World Energy Transitions Outlook: 1.5°C Pathway workstream. The Planned Energy Scenario (PES) reflects energy system developments based on governments' existing energy plans, targets, and policies as of early 2023. Meanwhile, the 1.5°C Scenario (1.5-S) presents an energy transition pathway supporting the Paris Agreement's goal of limiting global temperature rise to 1.5°C above preindustrial levels.

IRENA's energy scenarios are developed using its Renewable energy roadmap (REmap) energy modeling tool. The first step is an extensive process of collecting data on energy balances, energy statistics and policy and regulatory frameworks (by sector), and key activity indicators relevant to the energy system under analysis.

These data serve as input variables for its REmap tool, which translates them into detailed energy and emission flows, generating full energy and emission balances. These outputs undergo consistency checks against national references, thematic studies, and IRENA's internal work. The results are iteratively refined until they align with a scenario's normative objectives and pass quality control. The REmap tool covers the entire energy system—from final energy consumption (fuels, electricity, and heat) to transformation centers (power and heat plants, hydrogen production, and biofuels) and primary energy supply (raw energy sources). Final energy consumption is further divided into buildings, transport, and industry, with each sector further subdivided into subsectors, technologies, and energy carriers. The model estimates consumption based on activity levels, efficiency rates, and technology shares, enabling scenario adjustments through:

- Activity reduction, including energy conservation and circular economy measures;
- Efficiency improvements, reducing energy consumption per unit of activity; and
- Technology shifts, increasing renewables and electrification.

Once final energy consumption is determined, the analysis examines transformation centers, which convert primary energy (e.g., solar, wind, crude oil, and biomass) into final energy (e.g., electricity, gasoline, and biodiesel). The transformation centers are modeled based on energy transformation efficiency, linking energy demand to primary supply.

Scenario development

Each analysis begins with deriving the Planned Energy Scenario, which reflects current national policies and plans. This scenario serves as the foundation for the 1.5°C Scenario, which targets net-zero emissions by midcentury. While the 1.5°C Scenario considers existing policies, it prioritizes ambitious mitigation measures, including:

- Demand reduction through conservation and efficiency measures;
- Lower energy and emission intensity through technological improvements; and
- Rapid deployment of clean energy through renewables and electrification.

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

IRENA socioeconomic modeling

Since 2016, IRENA has been analyzing the socioeconomic implications of transition roadmaps. Socioeconomic analysis is conducted using a macroeconometric model (E3ME)[51] that integrates the energy system and global economies into a single quantitative framework. IRENA's analysis of key drivers and impacts has yielded insights supporting energy transition planning at different geographical scopes.

The socioeconomic analysis sheds light on the trade-offs between economic prosperity and employment; it also examines welfare aspects, including the distributional implications of policy choices. It discusses the socioeconomic differences between transition pathways at different levels of ambition. Policy makers need to be aware of how policy choices will affect people's well-being and overall welfare, and of the potential gaps and hurdles that could affect progress. The results from the analysis of the socioeconomic footprint include GDP (aggregated economic activity), employment (economywide and with a deep-dive into the energy sector), and the IRENA Welfare Index (which has five dimensions relating to the energy transition—economic, social, environmental, distributional, and access—and two indicators per dimension).

WHO projections

The projected access rates, access deficits, and fuel usage presented in chapter 6 are estimated using the WHO GHEM (detailed further 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 in this chapter are based on a hypothetical business-as-usual scenario derived from 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.

Chapter 7. 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 A1.4). 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).

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51 The E3ME global macroeconometric model (www.e3me.com) is used for the assessment of socioeconomic impacts. Results for REmap roadmaps (e.g., energy mixes and the related investments) are used as exogenous inputs for each scenario, as well as climate- and transition-related policies.

TABLE A1.4 • 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
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)

CATEGORY	COUNTRIES/TERRITORIES WITHIN THE CATEGORY
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, 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, Armenia, Azerbaijan, Bhutan, Bolivia (Plurinational State of), Botswana, Burkina Faso, Burundi, Central African Republic (the), Chad, Eswatini, Ethiopia, Kazakhstan, Kyrgyzstan, Lao People's Democratic Republic (the), Lesotho, Malawi, Mali, Mongolia, Nepal, Niger (the), North Macedonia, Paraguay, Republic of Moldova, Rwanda, South Sudan, Tajikistan, Turkmenistan, Uganda, Uzbekistan, Zambia, Zimbabwe
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.

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