Ewa Ryszarda Lazarczyk Carlson
Reykjavik University
ewalazarczyk@ru.is

SDG 7: Affordable and Clean Energy

Introduction

The adoption of the United Nations' Sustainable Development Goals (SDGs) in 2015 established a framework for addressing global challenges, from poverty eradication to climate action. Among these, Sustainable Development Goal 7 (SDG7) on "Affordable and Clean Energy" is particularly important, as access to reliable, sustainable, and modern energy is a prerequisite for social and economic development. Empirical evidence shows that access to electricity is closely linked to human well-being, as measured by the Human Development Index (Ouedraogo 2013); electricity is a cornerstone of modern societies.

Energy underpins critical services such as healthcare, education, water supply, and communication, while also serving as a key driver of industrial growth and innovation. Yet, despite some progress, in 2023 over 666 million people worldwide remained without access to electricity, and approximately 2.1 billion people still relied on unsafe and polluting fuels for cooking. Nevertheless, this represents progress compared to 958 million people without electricity and 2.7 billion without access to clean cooking in 2015 (IEA et al. 2025), the year that the Sustainable Development Goals, with targets and indicators, were defined.

SDG7, measured across six indicators, is characterised by large disparities between developed and developing countries, with only minor observed progress so far. SDG7 is closely related to the concept of energy poverty, which is often defined as the lack of modern energy services for heating, cooking, and lighting and/or spending more than 10 percent of the household income on energy services (Shyu 2021; Sovacool et al. 2017; Sovacool 2012). Both developed and developing countries face energy poverty, but the concept is understood differently.

In developed countries, where there is, in general, access to energy infrastructure and modern energy services, the concept of energy poverty relates to the affordability of energy and focuses on energy efficiency. In developing countries, access to energy infrastructure, energy markets, and therefore to modern energy services is often limited or absent which results in serious threats to public health, such as indoor air pollution from cooking, lack of refrigeration for food and medical purposes and lack of modern medical care in areas that do not have access to electricity (Sovacool 2012; Sy and Mokaddem 2022). The need to collect traditional biomass, mostly the labor of women and girls, diverts time from activities such as education or employment outside the household, thereby exacerbating gender inequalities.

However, SDG 7 is broader than the concept of energy poverty and encompasses not only expanding energy access and affordability but also transforming how energy is produced and consumed.

The remainder of this chapter examines the SDG7 targets and their indicators, discusses renewable energy expansion and system integration through sector coupling and low-emission hydrogen, and finally reviews the concept of energy efficiency.

Targets and indicators

Sustainable Development Goal 7 (SDG7) is structured around five specific targets:

1. Universal access to affordable, reliable and modern energy services (Target 7.1).
2. Substantially increased share of renewable energy in the global energy mix (Target 7.2).
3. Doubling of the global rate of improvement in energy efficiency (Target 7.3).
4. Enhancement of 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 (Target 7.a).
5. Expansion of infrastructure and upgrade of technology to supply modern and sustainable energy services to all in developing countries, particularly least developed countries, small island developing States, and landlocked developing countries, in accordance with their respective programmes of support (Target 7.b).

Achieving these targets requires reconciling competing demands: meeting rising energy needs, ensuring affordability, protecting the environment, and maintaining energy security. The global energy transition is further complicated by regional disparities, financial and technological barriers, and entrenched reliance on fossil fuels. At the same time, advances in renewable technologies, sector coupling, energy efficiency, together with storage solutions, and decentralised systems (microgrids) offer promising pathways forward.

To measure progress toward the targets, the international community tracks six indicators: energy access, clean cooking access, renewable energy share, energy efficiency, international financial flows, and infrastructure expansion.

Universal access to modern energy services is measured as **the proportion of the population with access to electricity**, which reached 92% in 2023, and **the use of clean cooking fuels**, which stood at 74% in the same year. While substantial improvements have been observed in regions such as Central and Southern Asia, Sub-Saharan Africa remains a significant outlier, accounting for 85% of the global electricity access deficit and facing severe disparities in clean cooking access, which disproportionately affect the health and educational opportunities of women and children (IEA et al. 2025).

Beyond basic access, SDG7 targets a substantial increase in renewable energy's share of the global energy mix and a doubling of the global rate of improvement in energy efficiency. The former target is reflected by **the share of renewable energy in the total final energy consumption**, and the latter as energy intensity measured in terms of primary energy and Gross Domestic Product (GDP).

Total final energy consumption refers to the energy consumed by end-users, including households, industry, and agriculture, excluding the energy used by the energy sector itself (Eurostat n.d.). In 2022, the share of renewables in total final energy consumption reached only 17.9%.

Energy efficiency is measured as **the amount of energy used per unit of GDP**, which in 2022 was at 3.87 MJ/USD. A lower ratio (fewer MJ per dollar) indicates that less energy is used to produce one unit of economic output, signalling an improvement in efficiency. As with previous indicators, large disparities are observed worldwide, with Canada, Czechia, Finland, and Iceland among the energy-intensive countries.

Supporting the transitions towards SDG7 targets requires international cooperation and robust **international financial flows**, which peaked in 2016 at $28.4 billion, primarily for solar and microgrid projects. However, while progress is notable, current efforts are considered too slow to meet the 2030 targets, necessitating significant investment increases in emerging economies to ensure a sustainable global transition (IEA et al. 2025).

The last target aims to expand the infrastructure for modern energy services in developing countries and is measured by **renewable energy capacity per capita**. Developed nations average 1,162 watts, compared to a mere 40 watts reached in Sub-Saharan Africa (IEA et al. 2025).

Renewable energy

Historically, renewable energy was the only available energy source until the discovery of fossil fuels (Deshmukh et al. 2023). In the 19th and 20th centuries, fossil fuels revolutionised the economies of industrialised countries through heating, transportation, and electricity production. However, as fossil fuels are depleting and contributing to the climate crisis, the importance of renewable energy sources has been increasingly acknowledged in the 21st century.

Renewable energy lies at the heart of SDG7, particularly the target which calls for a substantial increase in the share of renewable energy in the global energy mix. Unlike fossil fuels, renewable energy sources, such as solar, wind, hydropower, and geothermal, can deliver energy services while substantially reducing greenhouse gas emissions and local air pollution. Despite rapid growth in renewable electricity generation over the past two decades, the global energy system remains dominated by fossil fuels, which, as of 2019, still accounted for approximately 81% of total energy production (IEA n.d.).

One reason for the low share of renewable energy in the energy mix is that large shares of fossil-fuel-based energy are still used for transport, heating, and industry. Electricity, with the increasing participation of renewables, accounts for only a portion of total final energy consumption. Consequently, although renewables account for a growing share of electricity production in many regions, their contribution to total final energy consumption remains comparatively low globally. In the EU, renewable energy accounted for 25.2% of energy consumption in 2024, up from 24.6% in 2023. The share of renewables used in transport in the EU also increased from 10.9% in 2023 to 11.2% the following year (Eurostat, 2025). Globally, the results are much lower: a 4% share of renewables in transport (IEA 2025b, p. 10) and a share of renewable energy in total final energy consumption reaching only 17.9% in 2022.

Renewable energy also plays a critical role in expanding energy access, particularly in developing countries where access to the public electrical grid is limited. Off-grid and mini-grid systems based on solar and wind technologies provide a cost-effective way to supply electricity to remote and rural communities where extending national grids would be prohibitively expensive (Bhattacharyya and Palit 2016). These decentralised systems can support lighting, mobile communication, refrigeration, irrigation, and small-scale productive activities, thereby directly contributing to poverty reduction, education, and health outcomes. In this way, renewables support both universal energy access (target 7.1) and an increased share of renewables in the total energy mix (target 7.2).

The large-scale integration of renewables into energy systems poses technical and economic challenges. Solar and wind power are variable and weather-dependent, therefore called intermittent, meaning that electricity generation does not always coincide with demand and requires balancing by power plants that can start on demand (dispatchable) (Fogelberg and Lazarczyk 2017). As the share of variable renewables increases, power systems require additional flexibility, which can be provided through grid expansion, digitalisation, storage technologies, and demand-side management (Le Coq et al. 2025). Hydropower, geothermal energy, and sustainable biomass can provide more stable generation, but their availability is geographically constrained. As a result, renewable-based power systems require careful system planning and substantial investment in flexibility and infrastructure.

Beyond these technical system challenges, the pace of renewable energy deployment is also shaped by financial and institutional conditions. Especially in many low- and middle-income countries, the deployment of renewable energy is constrained by financial and institutional barriers, which may hinder the policy support required for the successful expansion and integration of renewables into the energy system (Carley et al. 2017). High upfront investment costs, limited access to capital, weak regulatory frameworks, and political risk can deter private investors. The initial successful uptake of renewables in Europe was due to policy instruments such as Feed-in Tariffs (FiT) or Feed-in Premiums (FiP) (Barnea et al. 2022). FiT, used to promote renewable energy, were popular in Germany, Spain, and Denmark; under this scheme, electricity producers were guaranteed a fixed price for each unit of electricity delivered to the grid. FiT and FiP offer revenue support to renewable energy providers; however, in the latter scheme, electricity producers retain some exposure to market signals, as the premium is offered on top of the wholesale market electricity price. In the USA, the Renewable Portfolio Standards (RPS), a market-oriented support scheme, played an important role in expanding renewables by requiring electricity suppliers to provide a specified share of their output from renewable sources (Barnea et al. 2022). The full spectrum of policies promoting sustainable energy is much broader and includes areas such as legal framework, policies targeting renewables expansion, incentives and regulatory support, grid connection and use, counterparty risk and carbon pricing and monitoring. Apart from various policies the international climate finance and investments in institutional capacity are necessary to strengthen renewables expansion in the developing countries in the short and medium term (Galeazzi et al. 2024).

Renewable energy also contributes to energy security and economic resilience. Unlike fossil fuels, which are concentrated in a few exporting countries and subject to volatile prices, renewable energy relies on locally available resources such as sunlight, wind, and water. This reduces exposure to geopolitical risks and fuel price shocks, an advantage that has become increasingly evident amid the global energy crisis of 2021-2023.

The expansion of renewable energy is linked to energy efficiency and sector coupling. Higher shares of renewables increase the value of efficiency improvements, since with a reduced demand, it is easier to meet energy needs with clean sources. At the same time, sector coupling and Power-to-X technologies allow renewable electricity to be used beyond the power sector, for example, in transport, heating, and industry, thereby extending the reach of renewables into parts of the economy that are currently dominated by fossil fuels.

Sector coupling refers to integrating electricity with other energy-consuming sectors, such as industry, transportation, and heating, thereby facilitating decarbonization of the energy system. Applications of sector coupling can be broadly categorised into direct electrification and indirect electrification via Power-to-X (P2X) technology, which converts electrical energy into other energy carriers or products. Direct electrification involves using electricity for low-temperature heating, industrial processes, and electric transport. Indirect electrification encompasses power-to-gas and power-to-liquid technologies for fuel production, as well as power-to-heat applications using electric boilers or heat pumps for district heating systems (Ramsebner et al. 2021). P2X technologies enable the production of gaseous or liquid fuels for applications in sectors that are difficult or inefficient to electrify directly. These include high-temperature industrial processes, chemical production, and long-distance aviation and maritime transport. In other sectors—such as road and rail transport or low-temperature space heating—P2X pathways may compete with direct electrification, rather than complement it (Ramsebner et al. 2021). Among various P2X pathways, low-emissions hydrogen has attracted particular attention, as it offers the potential to decarbonise heavy industry and transport.

Global hydrogen production amounts to approximately 120 million tonnes per year, of which around 95% is derived from fossil fuels (Birol 2019; IRENA 2021). Hydrogen production pathways are commonly distinguished using colour labels. Green hydrogen is produced through electrolysis, a process that uses electricity to split water into hydrogen and oxygen, while pink or purple hydrogen is powered by nuclear electricity. Blue hydrogen is derived from natural gas with carbon capture and storage, whereas grey (natural gas-based) and brown (coal-based) hydrogen remain highly carbon-intensive. Of these pathways, only green and some nuclear-based hydrogen options can achieve near-zero lifecycle emissions (Carlson et al. 2023).

The European Union anticipates hydrogen demand to reach nearly 17 million tonnes by 2030 and is exploring imports from neighbouring regions such as North Africa and Eastern Europe to complement domestic production (Kakoulaki 2021). Achieving such scale will require substantial expansion of renewable electricity generation to supply electrolysers. It is essential to remember that producing green hydrogen requires large amounts of water and renewable energy, thereby limiting when it can be produced (Carlson et al. 2023).

Hydrogen also has implications for energy security. Unlike fossil fuels, which are geographically concentrated, green hydrogen can, in principle, be produced wherever renewable resources are available. Furthermore, hydrogen can contribute to power-system flexibility by enabling long-term energy storage and facilitating sector coupling, for example, by converting surplus renewable electricity into hydrogen during periods of excess supply (Le Coq et al. 2025).

Despite its potential, the emergence of a hydrogen economy is associated with significant risks and uncertainties. These include geopolitical implications, such as shifts in technological leadership, new forms of energy dependence, and competition for critical materials. Market and commercial risks remain substantial, particularly regarding production costs, infrastructure development, and demand evolution (Carlson et al. 2023). Additionally, slow infrastructure development and recurring project cancellations are hindering the growth of green hydrogen, which currently accounts for less than 1% of global production (IEA 2025).

Not specifically mentioned in SDG7, and not directly improving energy access for individuals, hydrogen is a supporting technology for industrial decarbonization and energy security. Hydrogen, and in particular low-emissions hydrogen, is not a universal solution to decarbonisation challenges; nevertheless, it can still play an important role in sectors where direct electrification is not feasible, making it part of Sustainable Development Goal 7 and the broader clean energy transition. By using renewable electricity to decarbonise hard-to-abate sectors, hydrogen can contribute to target 7.2 and support system flexibility.

Renewable energy is not simply one option among many, but a foundational component of SDG7. Its role extends beyond decarbonising electricity generation to reshaping energy access, economic development, and energy security worldwide. Achieving a substantial increase in the global share of renewables therefore requires not only technological progress, but also sustained investment, institutional reform, and international cooperation—especially in regions where the social returns to clean energy are greatest. While hydrogen and sector coupling expand the range of clean energy supply options, SDG7 also depends on reducing the energy required to deliver essential services, i.e. energy efficiency.

Energy efficiency

SDG7 recognises that sustainable energy systems depend not only on expanding energy supply but also on improving the efficiency with which energy is used. This perspective is explicitly articulated in target 7.3, which aims to double the global rate of improvement in energy efficiency by 2030. Reducing energy consumption per unit of economic output is therefore treated as a core component of sustainable development, alongside increasing energy access and the share of renewable energy.

At its core, energy efficiency refers to the ability to deliver the same or higher level of energy services—such as heating, cooling, lighting, mobility, or industrial output—while using fewer energy inputs. It encompasses technological innovation, system design, and behavioural change, including the adoption of efficient appliances, improved building insulation, optimisation of industrial processes, and reductions in transmission and distribution losses.

The energy efficiency concept ties back into the discussions on energy poverty; there are studies focusing on Spain (Aranda et al. 2017), China (Dong et al. 2022), and Greece (Boemi & Papadopoulos 2019) showing that income inequality and energy poverty can be alleviated by improved energy efficiency. Heating efficiency in buildings is a particular concern for households with low incomes and high energy costs, specifically those facing energy poverty (Li et al., 2021). Houses without proper insulation require more energy for heating; housing renovation projects improve buildings' energy efficiency, thereby helping to reduce heating costs for those already struggling with energy poverty. At the system level, efficiency improvements reduce overall energy demand, thereby lowering pressure on generation capacity and infrastructure investment, limiting fossil fuel consumption, and supporting the transition towards low-carbon energy systems.

Energy efficiency also plays a critical role in enabling the large-scale integration of renewable energy into power systems. Lower demand levels reduce the share of electricity that must be supplied by variable renewable sources such as wind and solar, thereby contributing to system stability and operational flexibility. Digital technologies, including smart meters, demand-side management tools, and automated control systems, further enhance these effects by enabling more responsive and optimised consumption patterns. As a result, improvements in energy efficiency and the deployment of renewable energy technologies are mutually reinforcing elements of sustainable energy transitions.

From an environmental perspective, energy efficiency is frequently described as the "first fuel" of energy policy, reflecting the idea that the cleanest and least costly unit of energy is the one that is not consumed. Efficiency gains reduce greenhouse gas emissions and local air pollutants, contributing to climate mitigation and public health objectives. From an economic standpoint, improved efficiency lowers energy expenditures for households, firms, and governments, freeing financial resources for other development priorities. Moreover, investments in energy efficiency generate employment opportunities in areas such as building retrofitting, manufacturing of efficient technologies, and industrial optimisation, thereby linking SDG7 with broader goals related to economic growth and decent work (IEA 2025c).

Progress in energy efficiency is commonly assessed using indicators such as energy intensity, defined as energy consumption per unit of gross domestic product. Declining energy intensity reflects the decoupling of economic growth from energy use, a key objective of sustainable development. Achieving sustained improvements in efficiency requires coherent and comprehensive policy frameworks, including minimum energy performance standards, energy efficiency labelling schemes, financial incentives, regulatory instruments, and capacity-building measures. International cooperation and technology transfer play an important role in enabling developing countries to adopt and deploy efficient energy systems (IEA 2025c).

A substantial share of efficiency gains can be achieved through improvements in household and industrial appliances. Minimum energy performance standards eliminate the least efficient products from the market and ensure gradual improvements in average efficiency, while energy labels aim to inform consumers and influence purchasing decisions. Financial incentives, such as rebates or vouchers, can help offset the high upfront costs of efficient appliances. However, the effectiveness of these instruments depends strongly on policy design, electricity prices, and consumer behaviour. Empirical evidence shows that consumers often undervalue long-term energy savings and place disproportionate weight on upfront costs, leading to persistent underinvestment in energy efficiency despite favourable lifetime economics (IEA 2025c).

The aggregate consequences of such behaviour are significant. Efficiency improvements have the potential to substantially moderate global electricity demand growth, particularly in an increasingly electrified economy characterised by rising cooling needs, industrial expansion, and rapid growth in data centres and digital services. Without sustained progress in efficiency, the costs and challenges of meeting future electricity demand would increase markedly.

From a system-wide perspective, energy efficiency is essential for maintaining the reliability and economic efficiency of electricity systems (IEA 2025c). Electricity demand must be matched with supply in real time, and peak demand periods often require costly generation capacity. Reducing demand through efficiency measures lowers peak loads and reduces reliance on expensive, carbon-intensive peaking power plants that operate for only a limited number of hours per year. In this sense, efficiency improvements often represent a more economically rational solution than expanding rarely used generation assets.

Beyond reducing total energy use, modern energy systems increasingly depend on when electricity is consumed rather than how much. Demand flexibility allows consumers to shift electricity use in response to price signals or system conditions, thereby complementing efficiency improvements. Demand response programmes, supported by smart metering infrastructure, enable households and firms to reduce or shift consumption during periods of high demand in exchange for financial compensation. Technological developments are increasingly integrating efficiency and flexibility, as smart appliances can automatically adjust their operation to electricity prices and grid conditions, reducing the need for active consumer engagement (Le Coq et al. 2025).

Overall, energy efficiency is not merely a technical component of SDG7, but a strategic element that underpins affordable, reliable, and sustainable energy systems, helping to alleviate energy poverty. Often described as the "first fuel," it delivers multiple social, economic, and environmental co-benefits, including lower costs, reduced emissions, enhanced energy security, and improved system reliability. At the same time, energy efficiency is not a static achievement but a continuous process that requires sustained policy attention, technological innovation, and active consumer participation. As energy systems become more electrified and complex, energy efficiency will remain essential for achieving the objectives of SDG7.

Summary

Sustainable Development Goal 7 captures a fundamental challenge of the twenty-first century: how to provide modern energy for all while transforming energy systems to be environmentally sustainable, affordable, and resilient. This chapter has demonstrated that progress toward SDG7 relies on the interplay of energy access, renewable energy, and energy efficiency, supported by enabling technologies such as sector coupling and low-emission hydrogen. While access to electricity and clean cooking remain the most urgent priorities in many parts of the world, deep decarbonization of industry, transport, and power systems is essential to align energy systems with climate goals. No single technology can deliver this transition. Instead, achieving SDG7 requires coordinated investment in infrastructure, innovation, policy frameworks, and international cooperation, ensuring that the global energy transition is not only technologically feasible but also socially inclusive and economically just.

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