Energy Transition Pathways for the 2030 Agenda

SDG 7 Road Map for Mongolia

ESCAP
Economic and Social Commission for Asia and the Pacific

NEXSTEP
National Expert SDG Tool for Energy Planning

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Developed using the National Expert SDG7 Tool for Energy Planning (NEXSTEP)

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*The shaded areas of the map indicate ESCAP members and associate members.**

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GOVERNMENT OF MONGOLIA
MINISTRY OF ENERGY

MU Murdoch University

Foreword: ESCAP

Securing reliable, affordable and sustainable energy services poses a significant challenge for landlocked countries such as Mongolia. Aligning with Sustainable Development Goal 7, the transition to a sustainable, secure and cost-effective energy system can pave the way for the attainment of broader Sustainable Development Goals (SDG). The *New Recovery Policy* of Mongolia seeks to bolster energy security and transition by diversifyingthe energy supply system, with a focus on increasing the contribution of renewable energy to the electricity generation mix.

The United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) extends its gratitude to the Ministry of Energy for the collaborative opportunity in shaping the Road Map for Sustainable Development Goal 7 in Mongolia. Utilizing the National Expert SDG Tool for Energy Planning (NEXSTEP) framework, the Road Map has taken a holistic approach to identifying technological options and enabling policy measures. These measures aim to guide Mongolia in its sustainable energy transition, offering key recommendations such as expanding access to clean cooking technology, enhancing indoor heating technologies, electrifying the transport sector and implementing energy-efficient cooking regulations. The Road Map, developed in consultation with national policymakers and experts, reflects a nuanced understanding of the country's resources and future direction, aligning the energy transition with national development strategies and global goals.

While Mongolia is poised to achieve universal access to electricity in 2024, additional efforts are crucial to provide clean cooking fuel access to nearly half of the population still reliant on polluting cooking fuel alternatives. Prioritizing energy efficiency, especially in the transport sector, is emphasized to reduce dependence on imported petroleum products.

The collaboration between ESCAP and the Ministry of Energy underscores a shared commitment to realizing the energy vision within the Sustainable Development Goals. The Road Map serves as a blueprint for Mongolia's continued prosperity, aiding its recovery from COVID-19 and setting an example for other nations seeking to develop sustainable energy solutions.

ESCAP looks forward to working further with Mongolia to realize the successful implementation of this Road Map in order to foster a secure, sustainable and inclusive energy future.

Armida Salsiah Alisjahbana
Under-Secretary-General of the United Nations and
Executive Secretary of ESCAP

Foreword: Mongolia

I would like to express my heartfelt gratitude to ESCAP and all key stakeholders for their invaluable support to the Government of Mongolia in formulating the Road Map for Sustainable Development Goal 7 (SDG 7). SDG 7 is pivotal in attaining all SDGs and lays the groundwork for a sustainable, long-term energy transition, encompassing various facets of the energy system, such as access to modern and affordable energy, renewable energy, and energy efficiency.

The collaborative effort between the Ministry of Energy and ESCAP in developing the SDG 7 Road Map has provided a significant opportunity to assess Mongolia's progress toward SDG 7 targets and the Nationally Determined Contribution (NDC). Utilizing the National Expert SDG Tool for Energy Planning (NEXSTEP) framework, the Road Map takes an integrated approach to energy transition. It is gratifying to observe that a thorough analysis has been conducted for Mongolia's entire energy sector, and the Road Map presents valuable recommendations for necessary policy adjustments.

The analysis highlights a few remaining gaps in Mongolia that require attention to fortify the energy transition and achieve the targets of SDG 7 and NDC. Moreover, the NEXSTEP analysis recommends a shift toward a heating system with an increased utilization of sustainable energy sources.

I am pleased to acknowledge that this document has emerged from an open, transparent, inclusive, and participatory consultation process involving all stakeholders. The success of this collaboration between ESCAP and the Ministry of Energy underscores our shared commitment to realizing the energy vision outlined in the Sustainable Development Goals. I look forward to continued collaboration with ESCAP in implementing the recommendations as we progress toward the 2030 Agenda for Sustainable Development and beyond.

BAYARMAGNAI Myagmarsuren
Vice Minister
Ministry of Energy

Abbreviations and acronyms

ADB	Asian Development Bank
BAU	business-as-usual
BESS	battery and energy storage system
CBA	cost-benefit analysis
CO_2	carbon dioxide
CPS	current policy scenario
EE	energy efficiency
EERF	Energy Efficiency Revolving Fund
ERC	Energy Regulatory Commission
ESCAP	United Nations Economic and Social Commission for Asia and the Pacific
ESCO	energy services companies
EV	electric vehicle
GDP	gross domestic product
GHG	greenhouse gas
GW	gigawatt
ICS	improved cooking stove
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IPP	independent power producers
IRENA	International Renewable Energy Agency
ktoe	thousand tons of oil equivalent
kWh	kilowatt-hour
LCOE	Levelized Cost of Electricity
LEAP	Low Emissions Analysis Platform
LED	light-emitting diodes
Li-ion	Lithium-Ion
LPG	liquified petroleum gas
MCDA	Multi-Criteria Decision Analysis
MEPS	minimum energy performance standard
MJ	megajoule
MoE	Ministry of Energy
MTF	Multi-Tier Framework
Mtoe	million tons of oil equivalent
MW	megawatt
NDC	nationally determined contributions
NEXSTEP	National Expert SDG Tool for Energy Planning
OECD	Organisation for Economic Co-operation and Development
PP	power plant
PPP	purchasing power parity
RE	renewable energy
SDG	Sustainable Development Goal
SPP	small power producers
TFEC	total final energy consumption
TPES	total primary energy supply
TWh	terawatt-hour
UNEP	United Nations Environment Programme
US$	United States dollar
VSD	variable speed drive
WHO	World Health Organization

Executive Summary

Transitioning the energy sector towards achieving the goals of the 2030 Agenda for Sustainable Development and the objectives of the Paris Agreement presents a complex and difficult task for policymakers. It needs to ensure sustained economic growth, as well as respond to increasing energy demand, reduce emissions, and consider and capitalize on the interlinkages between Sustainable Development Goal (SDG) 7 and the other SDGs. To address this challenge, ESCAP has developed the National Expert SDG Tool for Energy Planning (NEXSTEP).[1] This tool enables policymakers to make informed policy decisions to support the achievement of the targets of SDG 7 as well as those in their Nationally Determined Contributions (NDCs). The initiative has been undertaken in response to the Ministerial Declaration of the Second Asian and Pacific Energy Forum (April 2018, Bangkok), and Commission Resolution 74/9, which endorsed its outcome. NEXSTEP also garnered the support of the Committee on Energy in its second session, with recommendations to expand the number of countries being supported by this tool (ESCAP/CE/2019/4).

The key objective of this SDG 7 Road Map[2] is to assist the Government of Mongolia in assessing whether the existing policies and strategies are well aligned for achieving the SDG 7 and NDCs targets by 2030, and to present a series of options to bridge these gaps. This Road Map presents three core scenarios (business-as-usual (BAU), current policy and Sustainable Development Goal scenarios) that have been developed using national data, which consider existing energy policies and strategies and reflect on other development plans. This Road Map also investigates two ambitious scenarios; the Sustainable Heating by 2030 scenario examines the pathways for Mongolia to transition to a heating system with increased use of sustainable energy sources, as well as to achieve its conditional NDC targets; and the Toward Net Zero Emissions by 2050 scenario offers policymakers a strategic viewpoint on how Mongolia could plan for a carbon-free energy sector in alignment with the global race to net zero carbon.

A. Highlights of the Road Map

Without the presence of multiple enabling frameworks, Mongolia's progress towards achieving the SDG 7 and NDC targets will be challenging. In terms of access to modern energy, Mongolia is likely to achieve universal access to electricity in 2024 based on the historical trend. However, without a concerted effort, Mongolia is unlikely to achieve universal access to clean cooking technology by 2030. One option for Mongolia is to explore the use of high energy efficient induction-type electric cookstoves, particularly in areas where there is sufficient electricity supply.

Mongolia depends heavily on coal for its energy supply and has a low share of renewable energy in the system. In the current policy scenario, renewable energy capacity is expected to be 23.3 per cent, by 2030, falling short of the 30 per cent renewable capacity target, since a significant amount of coal-fired generation will be in operation in Mongolia, whereas the renewable energy share in the total final energy consumption (TFEC) will reach only 1.9 per cent in 2030. Mongolia also needs to strengthen its energy efficiency measures. Following the SDG 7.3 energy efficiency definition, Mongolia's energy intensity is expected to be 5.8 MJ/US$_{2017}$[3] in 2030, which corresponds to an annual improvement of 1 per cent under the current policy scenario. NEXSTEP analysis identifies that by following the SDG scenario, Mongolia can even further lower its energy intensity to 4.5 MJ/US$_{2017}$ by 2030, which corresponds to an annual improvement of 3.6 per cent, thereby aligning with the global energy efficiency improvement rate of 3.4 per cent per annum.

1 The NEXSTEP tool has been specially designed to perform analyses of the energy sector in the context of SDG 7 and the NDCs, with the aim that the output will provide a set of policy recommendations to achieve the SDG 7 and NDC targets.

2 This Road Map examines the current status of the national energy sector and existing policies, compares them with the SDG 7 targets, and presents different scenarios highlighting technological options and enabling policy measures for the Government to consider.

3 MJ/US$_{2017}$ is the energy intensity measured as the total primary energy supply (TPES) in megajoules per US$ of gross domestic product in terms of purchasing power parity (PPP) in 2017.

In addition to a highly efficient energy system, a faster transition towards cleaner energy sources, especially renewables in both electricity and heat generation, will help Mongolia to reach net zero greenhouse gas emissions by 2050. This, however, requires an ambitious effort to switch fossil fuel-based energy systems to renewables. Electrification of existing technologies, such as the transport system and cookstoves, will be critical. A deeper analysis indicates that phasing out coal-fired power plants by 2050 is feasible, since the lifecycle cost of renewables-based power generation is already cheaper than coal-fired energy system.

B. Achieving Mongolia's SDG 7 and NDC targets by 2030

1. Universal access to electricity

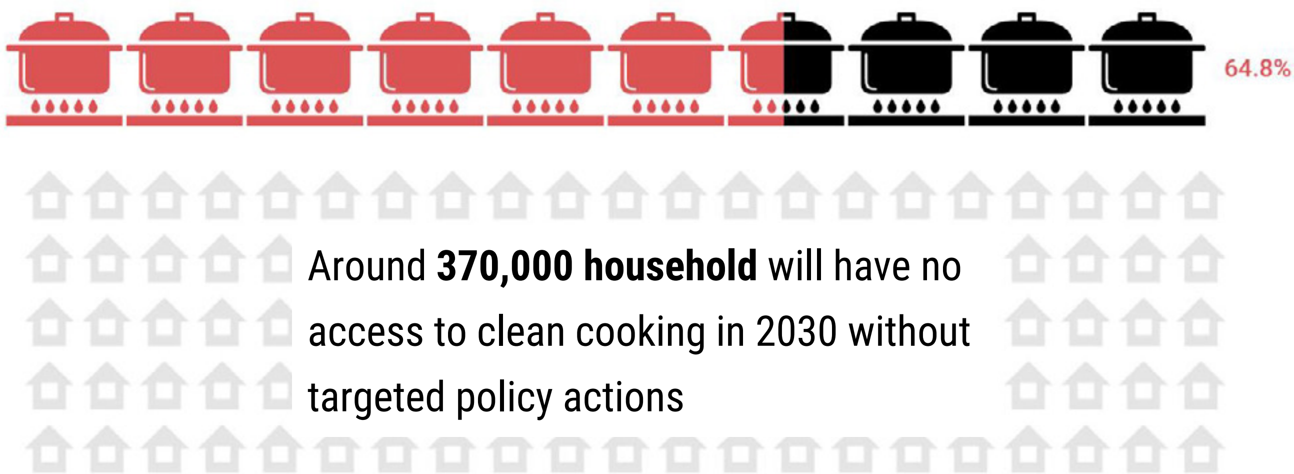
Only 0.5 per cent of Mongolia's population lacked access to electricity in 2021. Based on the current trend, it is expected that Mongolia will close the electricity access gap by 2024. This small proportion of unelectrified households or *gers* can be connected by mini/off-grid systems technologies (i.e., solar mini-grid and solar home systems) to allow faster electrification compared to grid extension.

2. Universal access to clean cooking technology

Under the current policy settings, access to clean cooking is projected to increase from 53.2 per cent, in 2021, to only 64.8 per cent, in 2030 (Figure I), leaving 370,000 households still relying on polluting solid fuel stoves (biomass and charcoal as the primary fuel) in 2030. This will expose a significant population to the negative health impacts arising from indoor air pollution, including non-communicable diseases, such as stroke, ischaemic heart disease, chronic obstructive pulmonary disease, and lung cancer, particularly among women and children (World Health Organization, 2022).

This Road Map suggests using electric cook stoves to close the gap, since this option may provide a better long-term alternative compared to liquified petroleum gas (LPG) stoves. In areas with insufficient electricity supply, improved cook stoves (ICS) can be promoted. With these measures in place under the SDG scenario, the share of electric cook stoves in 2030 will be 75.6 per cent, LPG cookstoves will be 2.6 per cent and ICS will be 21.8 per cent.

Figure I. Mongolia's access to clean cooking under the current policy scenarios (CPS)



Source: Historical trend projection based on the year 2000 access rate data obtained from United Nations Economic and Social Commission of Asia and the Pacific (ESCAP), "Energy Information for the Asia-Pacific Region", Asia Pacific Energy Portal. Available at https://asiapacificenergy.org. The 2021 access rate has been provided by the national consultant (Bright Management Consulting).

3. Renewable energy

The share of modern renewable energy (excluding traditional biomass usage in residential cooking) in TFEC (including non-energy use) was 1.7 per cent in 2021. Based on current policies, the share of renewable energy is projected to increase to 2.8 per cent by 2030. The increase is due to the projected increase in renewable electricity as per the current expansion plan. In the SDG scenario, the share of renewable energy is projected to increase to 5.9 per cent of TFEC in 2030. The additional 3.1 percentage point increase can be attributed to phasing out traditional biomass usage as well as further energy efficiency improvements to reach a lower energy intensity. While the share of renewable energy is increasing, fossil fuels will continue to dominate the energy system in Mongolia. Further measures, such as those discussed in the Sustainable Heating by 2030 scenario, will help increase the renewables share in TFEC significantly.

4. Energy efficiency

SDG 7.3 defines energy intensity as the total primary energy supply (TPES) in megajoules per US$ of gross domestic product (GDP) in terms of purchasing power parity (PPP) in 2017. Energy intensity in Mongolia declined at an average annual rate of 2.4 per cent between 1990 and 2010. A doubling of the 1990-2010 improvement rate is required to achieve the SDG 7.3 target, which requires an average annual rate increase of 4.8 per cent between 2010 and 2030. However, between 2010 and 2021, the annual improvement rate of energy intensity was only around 2.1 per cent. To reach the required 2030 intensity, the annual improvement rate between 2021 and 2030 needs to be around 7.8 per cent, which is quite challenging. Therefore, NEXSTEP analysis suggests that Mongolia's energy intensity target be aligned with the global target of 3.4 per cent annual improvement (IEA, and others, 2023). This corresponds to a 2030 energy intensity target of 4.6 MJ/US$$_{2017}$.

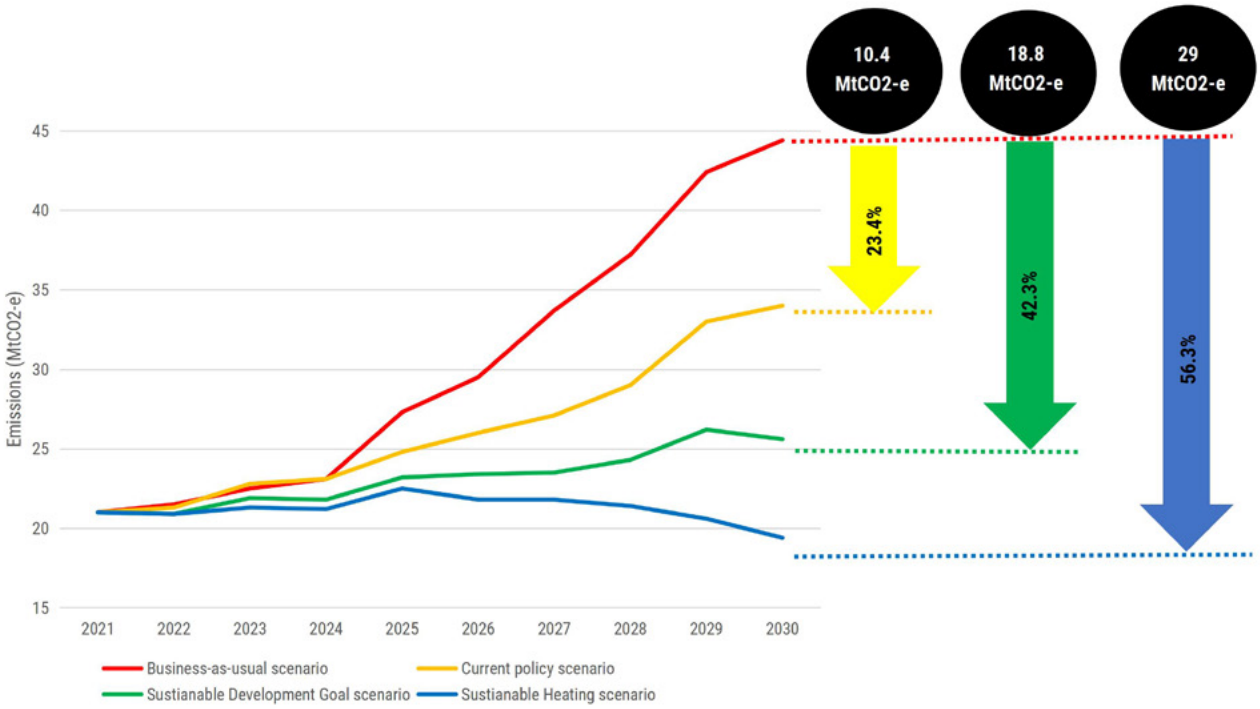
Under CPS, energy intensity is projected to drop to 5.8 MJ/US$$_{2017}$. This translates to a 1 per cent annual improvement rate. Mongolia can further reach an energy intensity of 4.5 MJ/US$$_{2017}$, aligning with the global energy efficiency improvement rate of 3.4 per cent per annum, by implementing some global best practices, such as minimum energy performance standard (MEPS), energy management standards, and green building codes. In addition to this, more efficient end-use technologies, such as electric vehicles and electric cook stoves, would enable additional demand reduction in Mongolia's energy system.

5. Nationally Determined contributions

Mongolia's updated Nationally Determined Contributions (NDC) set ambitious targets to reduce greenhouse gas (GHG) emissions by 30 per cent unconditionally by 2030 (Government of Mongolia, 2022). Subject to international assistance, Mongolia aims to reduce its annual emissions by 44.9 per cent by 2030.

Mongolia will be able to achieve unconditional NDC targets by 2030 under the current policy setting. Emissions will reach 34 $MtCO_2$-e (metric tons of carbon dioxide equivalent) in 2030, which is a 10.4 $MtCO_2$-e (23.4 per cent) reduction compared to the BAU scenario. The decrease in GHG emissions, relative to BAU, is due to the increase in renewable share in electricity supply as per the existing capacity expansion plan. Increasing the implementation of energy saving measures in order to align with the global improvement target of 3.4 per cent will further reduce a significant amount of emissions. In the SDG scenario, total emissions will reach 25.6 $MtCO_2$-e by 2030, corresponding to an 18.8 $MtCO_2$-e (or a 42.3 per cent) reduction compared to the BAU scenario (Figure II).

Figure II. Comparison of emissions, by scenario, 2021-2030



Source: ESCAP.

C. Increasing ambition beyond SDG 7

Although Mongolia could achieve its unconditional NDC targets when aligning with the suggested global improvement rate, more can be done to increase renewables share in TFEC while simultaneously achieving its conditional NDC targets. Mongolia can consider eliminating individual heating technology, that causes pollution, in the residential sector, and improving thermal insulation in the commercial sector by extensive retrofitting. Mongolia should also consider introducing heat pumps, waste-to-energy systems, and electric boilers to reduce its dependency on coal combined heat and power (CHP), and heat-only-boiler (HOB) in district heating systems.

A well-planned and concerted effort must be undertaken by the Government of Mongolia to reach net zero emissions by 2050. Achievement of this target will require decarbonization of the energy sector. This can best be accomplished through the following two steps: (a) decarbonizing the power and heat sectors; and (b) switching all energy consumption to renewables and electricity. Fortunately, the energy system of Mongolia is well-positioned for an accelerated decarbonization effort since many of the required net zero technologies, such as renewable power generation, electric cook stoves and electric vehicles, are mature and readily available. Due to certain technological limitations in the transport sectors, however, a small amount of emissions would still be produced. Therefore, carbon sinks, such as reafforestation, forest management, or other carbon capture approaches should be considered to absorb the remaining carbon emissions.

D. Important policy directions

The Road Map sets out the following four key policy recommendations to help Mongolia achieve its SDG 7 and NDC targets as well as reduce reliance on imported energy sources:

(1) **Address the gap in clean cooking by 2030 through strong policy measures.** Achieving access to clean cooking fuels and technologies seem to be one of the major challenges. Adoption of electric cook stoves and ICS will significantly help improve clean cooking access. The cumulative deployment cost of both technologies would require US$ 30.9 million by 2030. In the long run, the deployment of electric cook stoves will also help Mongolia achieve its net zero emissions target.

(2) **Accelerate the efficiency of energy use in all economic sectors.** Mongolia needs to enhance and strengthen its energy saving measures to align it with the 3.4 per cent global energy efficiency improvement pathway. These can be done by implementing best practices, such as energy management standard, building energy codes, transport mode shifting, and fuel economy improvement, in the years to 2030. Energy management standards, for example, will help organizations to develop a standard operating procedure for more efficient energy use using plan-do-check-act systems. Further efforts can be undertaken to eliminate inefficient and polluting heating technologies while simultaneously improving thermal insulation. These measures will require international assistance since they will deliver a more ambitious target compared to the unconditional commitment.

(3) **Implement fuel switching strategies, including electrification, to accelerate SDG 7 progress and provide multi-fold benefits in the long run.** The electrification of end uses would be critical to decarbonize the entire economy by 2050. Since electrical equipment is more efficient compared to fossil fuel-based equipment, this will significantly reduce fossil fuel demand. Rapid adoption of electric vehicles, for instance, reduces the demand for oil products, hence reducing Mongolia's reliance on imported petroleum fuels. The Government should start setting electric vehicle targets for passenger cars, buses, and freight trucks by 2030. Switching over to electric appliances must be supported by investment in clean energy systems. The need for additional investment in clean energy systems can be limited by an increased adoption of energy efficient measures.

(4) **Decarbonize the power and heating sectors to provide the highest potential in GHG emissions reduction as well as improve energy security.** In both the ambitious scenarios, the projected decrease in grid emissions can realize a substantial overall national GHG emissions reduction. Investments in coal-fired power and heat generation are no longer cost-effective compared with renewables and should be discontinued to avoid emissions lock-in. NEXSTEP analysis suggests that lifecycle costs of renewables, such as hydropower, solar, and wind, are cheaper than coal-fired technologies. The underlying financial risks of investment in coal-fired power plants should not be ignored. Fulfilling the required capacities for net zero scenarios could be challenging technically and economically, yet these investments will help improve energy security through the utilization of indigenous resources.

1. Introduction

1.1. Background

Transitioning the energy sector to achieve the goals of the 2030 Agenda for Sustainable Development and the objectives of the Paris Agreement presents a complex and difficult task for policymakers. It needs to ensure a sustained economic growth, respond to increasing energy demand, reduce emissions as well as consider and capitalize on the interlinkages between SDG 7 and other SDGs. To address this challenge, the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) has developed the National Expert SDG Tool for Energy Planning (NEXSTEP). This tool enables policymakers to make informed policy decisions to support the achievement of the targets of SDG 7, as well as the emissions reduction targets of the Nationally Determined Contributions (NDCs). The initiative has been undertaken in response to the Ministerial Declaration of the Second Asian and Pacific Energy Forum (April 2018, Bangkok), and the Commission Resolution 74/9 which endorsed the meeting's outcome. NEXSTEP also garnered the support of the Committee on Energy in its second session, with recommendations to expand the number of countries being supported by this tool (ESCAP/CE/2019/4). The Ministerial Declaration advises ESCAP to support its member States, upon request, in developing national SDG 7 Road Maps.

The Government of Mongolia has expressed its interest to develop the SDG 7 Road Map to better understand if the existing policies and strategies are well aligned to achieving the SDG 7 targets by 2030. The objective of this SDG 7 Road Map is to assist the Government of Mongolia to develop enabling policy measures to achieve the SDG 7 and NDC targets, as well as set the course of the energy sector on a trajectory towards net zero emissions by 2050.

1.2. SDG 7 targets and indicators

SDG 7 aims to ensure access to affordable, reliable, sustainable, and modern energy for all. It has three key targets, which are outlined below.

- Target 7.1: "By 2030, ensure universal access to affordable, reliable and modern energy services". Two indicators are used to measure this target: (a) the proportion of the population with access to electricity; and (b) the proportion of the population with primary reliance on clean cooking fuels and technology.
- Target 7.2: "By 2030, increase substantially the share of renewable energy in the global energy mix". This is measured by the renewable energy share in TFEC. It is calculated by dividing the consumption of energy from all renewable sources by total energy consumption. Renewable energy consumption includes consumption of energy derived from hydropower, solid biofuels (including traditional use), wind, solar, liquid biofuels, biogas, geothermal, marine, and waste. Due to the inherent complexity of accurately estimating the traditional use of biomass, NEXSTEP focuses entirely on modern renewables for this target.
- Target 7.3: "By 2030, double the global rate of improvement in energy efficiency", as measured by the energy intensity of the economy. This is the ratio of the total primary energy supply (TPES) and GDP. Energy intensity is an indication of how much energy is used to produce one unit of economic output. As defined by the International Energy Agency (IEA), TPES is made up of production plus net imports, minus international marine and aviation bunkers, plus stock changes. For comparison purposes, GDP is measured in constant terms at 2017 PPP.

In addition to the above-mentioned targets, the SDG 7 goal also includes Target 7.A: "Promote access to research, technology and investments in clean energy", and Target 7.B: "By 2030 expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries". These targets are not within the scope of NEXSTEP.

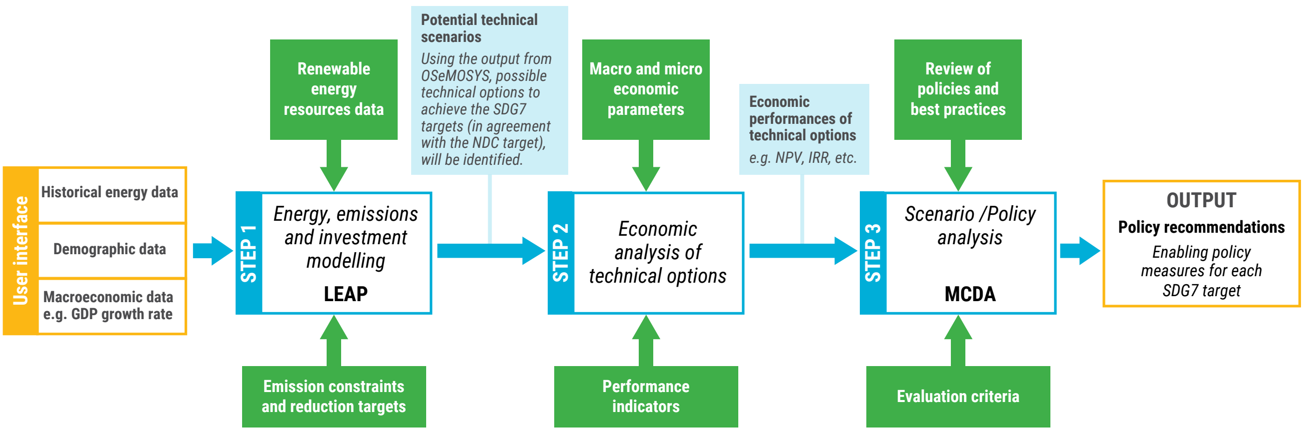
1.3. Nationally Determined Contributions (NDCs)

NDCs represent pledges by each country to reduce national emissions and are the stepping-stones to the implementation of the Paris Agreement. Since the energy sector is the largest contributor to GHG emissions in most countries, decarbonizing energy systems should be given a high priority. Key approaches to reducing emissions from the energy sector include increasing renewable energy in the generation mix and improving energy efficiency. In its NDC document, Mongolia has pledged to reduce GHG emissions by 22.7 per cent (unconditional) compared to BAU, and up to 44.9 per cent (conditional) with international support compared to BAU by 2030.

1.4. NEXSTEP methodology

The main purpose of NEXSTEP is to help design the type and mix of policies that would enable the achievement of the SDG 7 targets and the emissions reduction target (under NDCs) through policy analysis. The tool helps modelling energy, emissions and economics to analyse a range of policies and options for their suitability. This tool is unique in that no other tools look at developing policy measures to achieve SDG 7. One key feature of this tool is the back-casting approach to energy and emissions modelling, which is important in planning for SDG 7 where the trajectory is developed backwards from the (known) 2030 targets to the present day. Figure 1 shows components of the methodology.

Figure 1. Components of the NEXSTEP methodology



Source: ESCAP.

Note: LEAP = Low Emissions Analysis Platform, MCDA = Multi-Criteria Decision Analysis

1.4.1. Energy and emissions modelling

The NEXSTEP analysis begins by developing a model of the energy system for each scenario, defining the technical options in terms of the final energy (electricity and heat) requirement for 2030, possible generation/supply mix, emissions and the size of investment required. The energy and emissions modelling component uses the Low Emissions Analysis Platform (LEAP) tool.[4] This widely used proprietary software is employed by many countries to develop scenarios for the energy sector, conduct policy analysis and develop NDC targets.

1.4.2. Economic analysis

The second step builds on the selection of appropriate technologies through an economic optimization process which identifies the least-

4 The Low Emissions Analysis Platform (LEAP) tool has been developed by the Stockholm Environment Institute, and is available at https://leap.sei.org/

cost energy supply options for the country. A comparative assessment of selected power generation technologies is done using the Levelized Cost of Electricity (LCOE) as an economic indicator. This provides policymakers with insights into the costs and benefits of the economically attractive technology options, allowing better allocation of resources and better-informed policy decisions. While the economic analysis has been kept to a simple level, it contains enough information to support the policy recommendations provided in this Road Map. Some key cost parameters used in this analysis are: (a) capital cost, including land, building, machinery, equipment, and civil works; and (b) operation and maintenance cost, comprising fuel, labour, and maintenance costs.

1.4.3. Scenario analysis

The scenario analysis evaluates and ranks scenarios, using the Multi-Criteria Decision Analysis (MCDA) tool, with a set of criteria and weights assigned to each criterion. Although the criteria considered in the MCDA tool can include the following, stakeholders may wish to add/ remove criteria to suit the local context:

- Access to clean cooking fuel;
- Energy efficiency;
- Share of renewable energy;
- Emissions targets in 2030;
- Alignment with the Paris Agreement;
- Fossil fuel subsidy phased out;
- Price of carbon;
- Fossil fuel phase-out;
- Cost of access to electricity;
- Cost of access to clean cooking fuel;
- Investment cost of the power sector;
- Net benefit from the power sector.

This step is performed using the NEXSTEP online portal,[5] as a means to suggest the best way forward for the countries by prioritizing the scenarios. Stakeholders can update this scenario ranking using a different set of criteria and their weights. The top-ranked scenario from the MCDA process is used to inform the Government on the best possible energy transition pathway for the country.

1.5. Data sources

The primary source of data collection has been from Government databases and reports. Some data have been collected directly from Government agencies through formal letters of request from the Ministry of Energy (MoE). In a few instances where Government data were unavailable, such as resource potential data, research papers and analyses have been consulted. The final dataset has been presented to and approved by the MoE.

5 The NEXSTEP portal is available at https://nexstepenergy.org/

2. Country overview

2.1. Demographic and macroeconomic profile

Mongolia is a landlocked country in East Asia, bordered by China to the south and the Russian Federation to the north. The country occupies a total area of 1,564,116 km^2. Mongolia has a wide seasonal temperature variation, where the temperature can be as high as 38°C (Celsius) in summer and as low as -37°C in winter. In most places, the winter season is long and lasts around eight months.

In 2021, the country had a population of 3.31 million people, with an estimated 0.92 million households which amounted to an average of 3.6 persons per household.[6] According to the 2020 census, around 38.1 per cent of the households are living in the traditional *ger*.[7] The annual population growth rate was around 2 per cent between 2010 and 2021. The urbanization rate, in 2021, was around 66.6 per cent.[8] The country's capital, Ulaanbaatar, is the most populous city with around 1.64 million people.

Mongolia's GDP, in 2021, was estimated at $13.75 billion (constant 2015 US$). The annual GDP growth rate was around 8 per cent between 2010 and 2019. However, GDP growth was heavily affected in 2020 due to the impacts of the COVID-19 pandemic, resulting in a contraction of 4.6 per cent that year. In 2021 and 2022, the GDP growth bounced back to 1.6 per cent and 4.8 per cent, respectively. According to the forecast by the Asian Development Bank, GDP growth is expected to be 5.4 per cent in 2023, which will further rise to 6.1 per cent by 2024 (ADB, 2023).

2.2. Energy sector overview

2.2.1. National energy profile in the baseline year 2021

The following details describe the estimated national energy consumption using data collected with a bottom-up approach, such as activity level and energy intensity for the different sectors. The bottom-up estimation is generally in agreement with the national energy statistics in terms of total energy supply and total final energy consumption by fuel type. The baseline year of 2021 has been chosen based on the latest year for which all data points are available.

Energy demand: In 2021, the total final energy consumption (TFEC)[9] was around 4 Mtoe (Figure 2). Most of the demand came from the industry sector (32.9 per cent), followed by the residential sector (27.9 per cent). The third largest consumption was in the transport sector, estimated at 25.5 per cent or 1.02 Mtoe. The commercial sector consumed 13.3 per cent energy, and the agriculture sector consumed 0.4 per cent.

In terms of fuel usage in TFEC, oil products contributed the highest amount (35.1 per cent). The transport sector, which operated predominantly with internal combustion engine vehicles, was the main consuming sector for oil products. Heat demand accounted for 32.5 per cent of energy consumption in Mongolia followed by electricity at 16.5 per cent. Coal and natural gas accounted for 12.5 per cent and 0.4 per cent of energy demand, respectively. In terms of biomass, traditional biomass use was around 3 per cent and was consumed mainly in the residential sector.

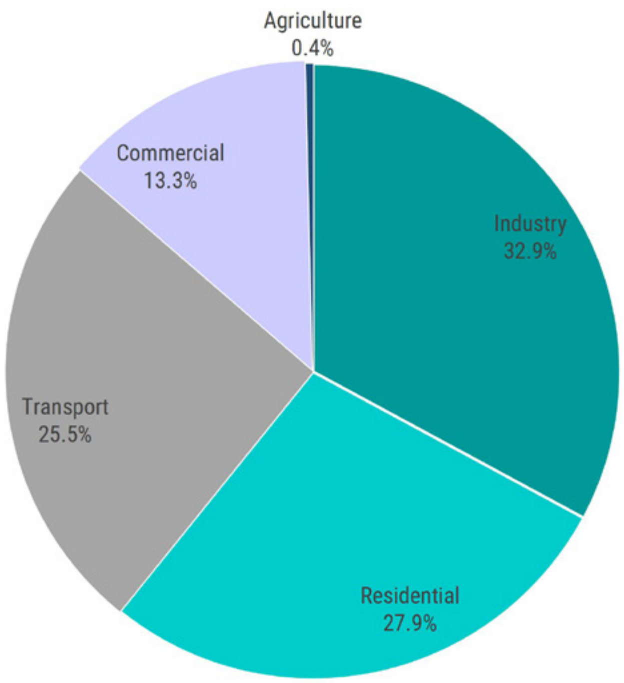
6 Based on the data provided by Ministry of Energy through national consultants.

7 Ger is a circular tent-like dwelling, composed of a wooden frame with a felt covering. It is traditionally used by nomadic herders although some people occupy gers permanently.

8 Based on the data provided by Ministry of Energy through national consultants.

9 This includes residential, commercial, industry, transport, and agriculture sectors.

Figure 2. Total final energy consumption by sector in 2021



Source: ESCAP.

There are four energy-intensive industries in Mongolia, which are (1) food and beverages, (2) mining, (3) cement and non-metallic quarry products, and (4) iron and steel. These industries together consumed 87.2 per cent of industrial energy demand. The remaining was consumed in textile and leather, machinery and transport equipment, pulp and paper, wood and wood products, fertilizer and chemical, communication, and other processing industry.

In the residential sector, around 80.3 per cent of energy was consumed for heating purposes (0.9 Mtoe). Heating demand in Mongolia is quite high as the country experiences a long and very cold winter season. Such a high share of residential heating demand was supplied mainly by district heating (53 per cent), coal boilers (27.7 per cent), biomass furnaces (13.8 per cent), and electric heaters (5.5 per cent). Cooking activities consumed around 10.5 per cent of residential energy demand. In terms of electricity, around 0.17 Mtoe was utilized to power household appliances. Of this, oven and kitchen appliances consumed 40.1 per cent, lighting consumed 21.6 per cent, televisions consumed 16.8 per cent, refrigeration consumed 10.2 per cent, and the remaining 11.3 per cent was used for washing machines, irons, and other appliances.

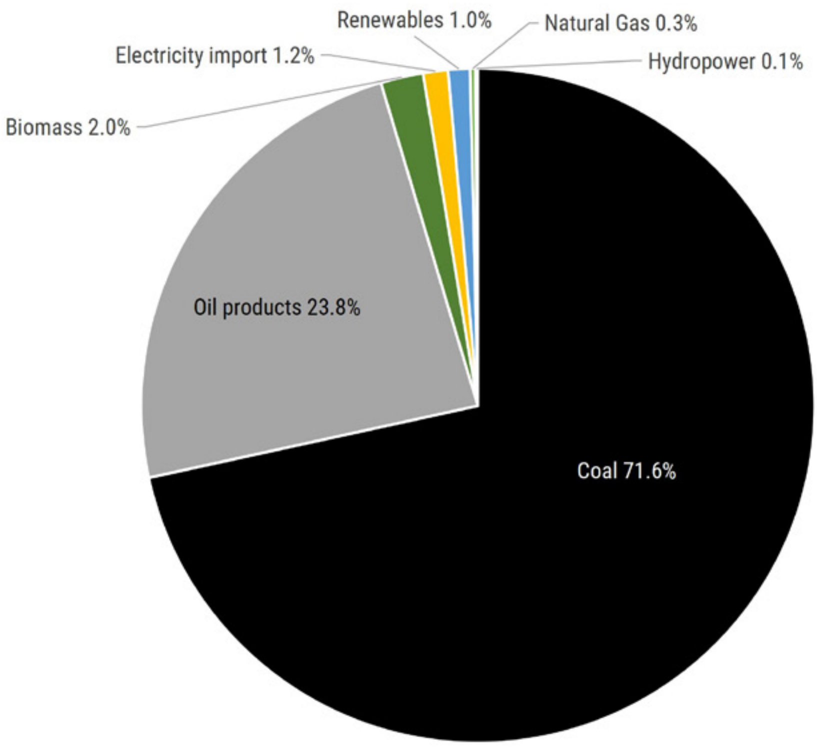
In the transport sector, 88.5 per cent of energy, or 0.9 Mtoe, was consumed by road transport. The remaining went to the rail transport (0.1 Mtoe), and the aviation sector (0.02 Mtoe). In the road transport category, 50.2 per cent was used for passenger cars, and 25.9 per cent of energy was used by freight trucks. Buses accounted for 16.5 per cent while freight vans accounted for 5.3 per cent of energy demand. The remaining 2.1 per cent was for motorcycles and taxis.

In the commercial sector,[10] both private offices and Government buildings accounted for 43.4 per cent of the energy demand followed by educational institutions at 25.6 per cent. Supermarkets, shopping centres, and hotels together consumed 18.5 per cent of commercial energy demand. The remainder was used by health-care facilities and worship centres.

10 The commercial sector analysis is based on floor space occupied by the sector and the energy intensity per square metre.

Primary energy supply: The total primary energy supply (TPES), in 2021, was around 5.9 Mtoe (Figure 3). The energy supply mix was as follows: coal at 71.6 per cent, oil products at 23.8 per cent, and natural gas at 0.2 per cent. Biomass, renewables, and hydropower altogether accounted for 3.1 per cent. The remaining was imported electricity.

Figure 3. Total primary energy supply by sector in 2021



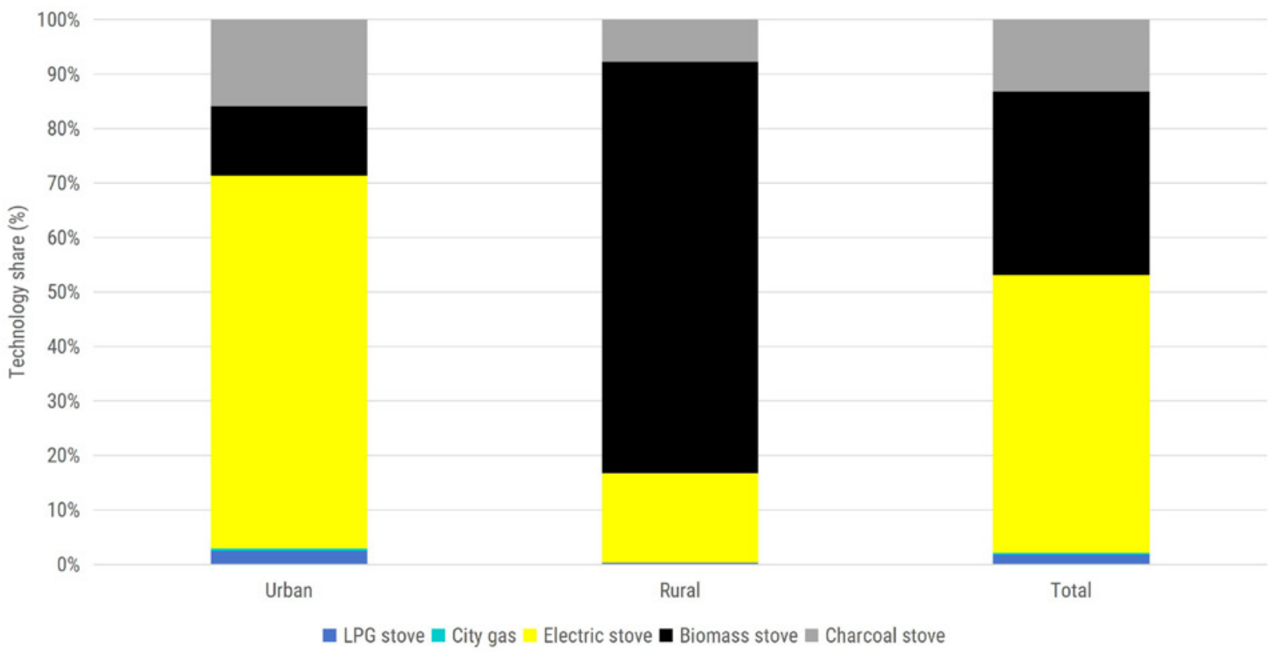
Source: ESCAP.

Electricity and heat generation: Total installed power generation capacity in 2021 was 1,559 MW. In terms of capacity mix, coal combined heat and power (CHP) accounted for 81.1 per cent of the capacity. Renewables accounted for 18.3 per cent of capacity of which wind was 10 per cent, solar was 6.7 per cent, and hydro and mini hydro was 1.6 per cent. Total electricity generation in 2021 was 7.9 TWh. Thermal power plants accounted for 89.8 per cent of power generation, in TWh, while the remainder came from renewable energy. Total heat generation in 2021 was 1.35 Mtoe. In terms of district heating, coal CHP accounted for 79.5 per cent while the remainder came from coal-fuelled heat-only-boiler (HOB).

2.2.2. Status of SDG 7 targets in the base year 2021

Access to modern energy: The rate of electrification in Mongolia was 99.5 per cent in 2021. Hence, Mongolia is very much on track to achieve universal access to electricity by 2030. However, access to clean cooking fuels and technologies was measured at 53.2 per cent in 2021. The remaining 46.8 per cent of the population, which corresponds to 0.43 million households, still relied on polluting charcoal and biomass stoves as their primary cooking technologies. In households with clean cooking technologies, electric cook stoves were the most dominant primary clean cooking technology, with an estimated share of 51 per cent, followed by a small proportion of liquefied petroleum gas (LPG) and city gas stoves. Figure 4 shows the distribution of different cooking fuels and technologies in 2021.

Figure 4. Clean cooking access share



Source: ESCAP.

Renewable energy share in the total final energy consumption (TFEC): Renewable energy delivered approximately 4.7 per cent of TFEC in 2021, which is equivalent to 3.1 per cent of TPES. This includes traditional biomass usage in the residential sector. If the traditional biomass is excluded, the renewable share would be 1.7 per cent of TFEC. While endowed with an abundance of renewable energy potential, Mongolia still relies highly on fossil fuels (i.e., coal and oil) to meet its stationary and mobile energy demands.

Energy intensity: Energy intensity under SDG 7.3 is defined as the total primary energy supply (TPES) in megajoules per US$ of gross domestic product in terms of purchasing power parity in 2017 (MJ/US$$_{2017}$). Mongolia's energy intensity in 2021 was estimated to be 6.3 MJ/US$$_{2017}$.

GHG emissions: The energy sector emissions, from the combustion of fossil fuel, were calculated based on IPCC Tier 1 emission factors assigned in the LEAP model and expressed in terms of 100-year global warming potential (GWP) values. GHG emissions from the energy sector were estimated at 21 MtCO_2-e in 2021. Emissions from power generation were the largest at 12.5 MtCO_2-e while the emissions attributable to HOB district heating were estimated at 2.0 MtCO_2-e. The transport sector released 3.1 MtCO_2-e of emissions, arising from direct fuel combustions in internal combustion engines, and the residential sector accounted for 1.7 MtCO_2-e from fuel combustions for cooking and heating. Industrial sector emissions were 1.6 MtCO_2-e. The remaining emissions were attributable to commercial, agriculture, and other sectors.

2.2.3. National energy policies, plans, strategies and institutions

Mongolia's energy sector is governed by several stakeholders. These include the Ministry of Energy (MoE), the Energy Regulatory Commission (ERC), National Dispatching Centre (NDC), independent power producers (IPPs), and distribution companies. MoE is responsible for the planning, management, and coordination of the energy sector. The ERC regulates the generation, transmission, distribution, dispatching and supply of energy. Meanwhile, the NDC is the operator of the national power system and the owner of the existing electricity management system which used to monitor and control the energy grid.

Mongolia's energy sector development is guided by several national policies and articles of legislation. These have been used as guiding references for the NEXSTEP modelling in order to better understand the country context, and to develop recommendations in adherence to the Government's overarching direction. Where applicable, the currently implemented and adopted policies or regulations are considered in the current policy scenario, in order to identify gaps in achieving the SDG 7 targets.[11] The key policies and strategic documents consulted are detailed below.

- **The Law of Mongolia on Energy (No. 6, 2001)** (Mongolia, Ministry of Energy, 2015) governs relationships concerning energy generation, transmission, distribution, dispatching and supply activities, construction of energy facilities, and energy consumption that involves utilization of energy resources.
- **The Law of Mongolia of 2007 on Renewable Energy** (Mongolia, Ministry of Energy, 2007) aims to regulate relations concerning generation and use of energy utilizing renewable energy sources. It applies to legal entities, which buy and/or sell electricity and/or heat generated by using renewable energy sources within the territory of Mongolia. Unless otherwise stated, this Law shall not apply to renewable energy power sources, which are designed for consumer's own use only.
- **Law on Energy Conservation of 2015** (Energy Regulatory Comission, 2015). This Law serves to provide for the efficient use of energy and its conservation, and for matters connected therewith or incidental thereto. It deals, among others, with powers given to the State Authorities, with the rights and obligations of energy consumers, and with energy conservation services.
- **Mongolia Green Development Policy** (Ministry of Environment, Green Development and Tourism, 2014) set a target to reduce GHG in the energy sector by increasing energy efficiency (EE) by 20 per cent in 2030. It also confirms the target to reduce heat losses in buildings by 20 per cent and 40 per cent in 2020 and 2030, respectively, compared to 2010 levels, through the introduction of green solutions, such as EE and advanced technologies and standards, green building rating systems, and energy audits, as well as the implementation of favourable legal and economic incentives.
- **New Recovery Policy 2021** (NRPA, 2024) aims to strengthen Mongolia's economic independence, reduce negative impacts of the COVID-19 pandemic on the economy, and address development barriers. For the energy sector, it highlights the following five key issues:
  a) Establish new energy sources and transmission and distribution networks, and enhance the reliability of energy production and supply;
  b) Develop renewable energy facilities, including building storage facilities, to ensure the reliability and stability of the integrated energy system;
  c) Where possible and appropriate, transfer the energy sector to an independent financial and economic system;
  d) Ensure the preparation of the high voltage aerial transmission lines and substations for connecting to renewable energy sources and network within the north-east Asian integrated energy grid; and
  e) Boost the construction of a natural gas pipeline from the Russian Federation to the People's Republic of China through the Mongolian territory.
- **Mongolia Sustainable Development Vision 2030** (State Great Hural of Mongolia, 2016) aims at integrating the Sustainable Development Goals framework into Mongolian national policymaking. The first phase (2016-2020) is to increase the share of renewable energy (RE) in the total energy consumption to 20 per cent, and initiate preparation for the construction of a nuclear power plant; the second phase (2021-2025) is to increase the share of RE in the total energy consumption to 25 per cent and complete the preparation for a nuclear power plant; and the third phase (2026-2030) seeks to increase the share of RE in the total energy consumption to 30 per cent and commission a nuclear power plant.
- **Mongolia "Vision-2050" Long-Term Development Policy of Mongolia** (State Great Hural, 2020) aims to improve the well-being of Mongolia's population and will be carried out

11 Only policies with concrete measures are considered in the scenario modelling for the current policy scenario. Plan/strategy policy documents without concrete measures enforced are not considered but are compared with scenario result findings.

over three different periods 2020-2030, 2031-2040, and 2041-2050. In the energy sector, there are objectives to develop an independent, integrated energy system, to shift to a smart system for the mixed use of renewable energy sources, and to become an energy exporter. From 2031 onwards, the plan is to transfer energy consumption of *ger* area and green zone households to renewable energy sources and provide opportunities to supply electricity generated by households to the central grid. There are also plans to introduce eco-electric public transportation to reduce greenhouse gas emissions.

- **Mongolia's Updated Nationally Determined Contributions (NDCs)** (Government of Mongolia, 2022) set a mitigation target; a 22.7 per cent reduction in total national greenhouse gas (GHG) emissions by 2030, compared to the projected emissions under a business-as-usual scenario for 2010. In addition, if conditional mitigation measures, such as carbon capture and storage and waste-to-energy technology, are implemented, then Mongolia could achieve a 27.2 per cent reduction in total national GHG emissions. Along with that, actions and measures to remove GHG emissions from forests have also been determined, which sets the total mitigation target of Mongolia to 44.9 per cent of GHG emissions reduction by 2030. The energy sector target for emissions reduction is 11.26 $MtCO_2$-e, in which 8.34 $MtCO_2$-e will come from the power and generation sector through the utilization of renewable energy, and the efficiency improvement of energy generation, transmission, and distribution.

2.2.4. National energy resources and potentials

Coal is the main fuel used for electricity and heat generation in Mongolia. Mongolia's coal resources, estimated around 173 billion tons are distributed across 15 coal basins. The proven reserves were estimated at 12 billion to tons in 2018, of which 2 billion is coking coal (Mongolia, Ministry of Energy, 2018). Most of the reserves are located around Gobi desert and eastern regions of the country. Mongolia has limited oil reserves and has not been operating any domestic oil refinery. Therefore, the country has been a net importer of oil products. Mongolia's demand for oil products was met by importing around 2 million tons of petroleum products in 2019. Despite showing a slight drop during the COVID-19 pandemic, further increase is expected in the coming years (Petro Matad Limited, 2023).

Mongolia has abundant solar, wind, and hydro potential, and substantial experience with solar photovoltaics (PV) and wind technologies. There are plans to further increase solar PV and wind deployment in the next few years. Mongolia has a daily average of solar insolation is around 4.3 – 4.7 kWh/m^2 (Mongolia, Ministry of Energy, 2018). Overall solar resources are estimated at 700 GW (Mongolia, Ministry of Energy and World Bank, 2022). There is also considerable potential for wind energy resource in Mongolia. Around 10 per cent of the total land area can be classified as an excellent location for the deployment of utility-scale wind power, particularly in the western and central regions. The power density is around 400 to 600 W/m2 (watts per square metre), and the wind resource can supply between 400 GW to 1,100 GW installed capacity (Mongolia, Ministry of Energy, 2018; Mongolia, Ministry of Energy and World Bank, 2022). In terms of hydro, there is a theoretical potential of 6.2 GW, of which more than 1 GW has been identified including those in the Hovd river system and the Selenge river system (Mongolia, Ministry of Energy, 2018). Despite having hydropower resources, not many hydropower projects have been developed.

Geothermal energy in Mongolia has been not fully explored and developed, but it shows a promising source of energy particularly for heating purposes. The data availability for geothermal potential in Mongolia is uneven and limited, although some studies have estimated that the geothermal potential is distributed in the Khangai region as well as in Khentii, around the Khubsugul Mongol Altain plate forms, and in the Dornod-Dariganga and Orkhon-Selenga regions (IRENA, 2023). IRENA (2023) suggests that geothermal potential for district heating in Mongolia can be found at a depth between 1000 to 3000 metres with temperature between 60°C to 80°C.

Mongolia has limited biomass resources of which solid wood waste and mill waste residues are the most feasible options (IRENA, 2023). Waste incineration plants can also be alternatives for district heating while simultaneously removing waste management problems. It is predicted that the heat production potential from waste incineration will be between 2.2 and 2.9 TWh

(IRENA, 2023). Table 1 presents a strengths, weaknesses, opportunities, and threats (SWOT) analysis of renewable energy resources in Mongolia.

Table 1. SWOT analysis of renewable energy resources in Mongolia

	Strengths	Weaknesses	Opportunites	Threats
Hydro energy (large and mini)	- Endowed with water resources - Already established technology	- Seasonal variability	- Developers in the market already exist	- Disturbance in biodiversity - Long development time for large hydro
Solar energy	- Abundant resource availability - Already established technology	- Challenges in identifying suitable land area for large scale solar plants	- Huge potential to meet the supply and demand gap - Reduction in GHG emissions	- High upfront cost
Wind energy	- Moderate potential availability of suitable sites with adequate wind speeds	- Sparsely distributed potential and very geographic specific	- Windy areas in west and central region - Reduction in GHG emissions	- High upfront cost
Geothermal and heat pump	- Many hot water springs	- Sparsely distributed potential and very geographic specific	- Potential to meet the heating demand gap	- Very high capital cost
Biomass and waste energy	- Mill residues and wastes are available to some extent	- Limited availability of biomass resources	- Possibile to retrofit old thermal power plant	- Very high capital cost

3. Modelling assumptions

This chapter presents an outline of the scenarios considered by NEXSTEP, together with the key demographic and macroeconomic assumptions used in modelling Mongolia's energy system.

3.1. Scenario definitions

NEXSTEP is designed for scenario analysis, using the LEAP modelling system to enable energy specialists to model energy system evolution based on current energy policies. The baseline year 2021 was chosen, as it is the most recent year with sufficient data information for modelling. In the NEXSTEP model for Mongolia, five scenarios have been developed. These include three core scenarios: (a) business-as-usual (BAU) scenario; (b) current policy scenario (CPS); and (c) Sustainable Development Goal (SDG) scenario. In addition, two further scenarios: (d) Sustainable Heating by 2030 scenario; and (e) Towards Net Zero Emissions by 2050 scenario, have been developed to present technological options and policy measures that would be required for Mongolia to transition beyond 2030.

3.1.1. Business-as-usual (BAU) scenario

This scenario hypothetically projects energy demand and emissions trajectory based on historical improvement, and in the absence of any new actions or policies. While this scenario is not a practically true scenario, since there will be policies and plans implemented along the way, it is helpful in comparing the emissions trajectories. In this scenario, the final energy demand is met by a fuel mix reflecting the current shares in TFEC, with the trend extrapolated to 2030.

3.1.2. Current policy scenario (CPS)

Inherited from the BAU scenario, this scenario considers initiatives implemented or scheduled to be implemented during the analysis period of 2021-2030 in establishing its baseline performance, with reference to the SDG 7 and NDC targets, as well as national targets for energy efficiency improvement and renewable energy share. Otherwise, the energy intensities from different demand sectors are assumed constant throughout the analysis period. Only policies with concrete measures are considered in this scenario. Plans, strategies and policies that are unlikely to be implemented are not considered but are compared with scenario results and findings later in this Road Map.

3.1.3. SDG scenario

The SDG scenario builds on the current policy scenario to provide recommendations for achieving the SDG 7 targets. This scenario aims to achieve the SDG 7 targets, including universal (100 per cent) access to electricity and clean cooking fuel, substantially increasing the renewable energy share, and doubling the rate of energy efficiency improvement. For clean cooking, different technologies (electric cooking stoves, LPG cooking stoves, and improved cooking stoves) have been assessed, with subsequent recommendation on the uptake of the most appropriate technology. Energy intensity has been modelled to help achieve the SDG 7 target. It also allows the achievement of the unconditional NDC target by 2030.

3.1.4. Sustainable Heating by 2030 scenario

Like the SDG scenario, the Sustainable Heating by 2030 scenario also aims to achieve the SDG 7 targets. In addition, these scenarios look at increasing the socioeconomic and environmental benefits for the country from raising its ambition beyond the SDG 7.3 target and meeting its conditional NDC target. This scenario explores measures that can be undertaken to reduce the heating demand and increase the renewable energy share in the provision of heating.

3.1.5. Towards Net Zero Emissions by 2050 scenario

This scenario explores technological interventions, timeframes of implementation of different measures and technologies, and policy frameworks that would be needed if Mongolia would like to make a plan for net zero emissions by 2050.

3.2. Assumptions

The energy demand is estimated by using the activity level and energy intensity in the LEAP model. The demand outlook throughout the NEXSTEP analysis period is influenced by factors such as annual population growth and annual GDP growth. The assumptions used in the NEXSTEP modelling are further detailed in Annex II, while Table 2 provides a summary of key modelling assumptions for the three main scenarios (i.e., BAU, CPS and SDG scenarios).

Table 2. Important factors, targets and assumptions used in NEXSTEP modelling

<table>
<tr><th>Parameters</th><th>Business-as-usual scenario</th><th>Current policy scenario</th><th>Sustainable Development Goal scenario</th></tr>
<tr><td>Economic growth</td><td colspan="3">US$ 446.2 million in 2020, assumed growth rate of 6 per cent per annum.</td></tr>
<tr><td>Population growth</td><td colspan="3">2 per cent per annum.[14]</td></tr>
<tr><td>Urbanization rate</td><td colspan="3">67 per cent in 2021, growing to 68.8 per cent in 2030.[15]</td></tr>
<tr><td>Commercial floor space</td><td colspan="3">Assumed annual energy consumption is increasing at the same growth rate as GDP.</td></tr>
<tr><td>Industrial activity</td><td colspan="3">Industrial activities are assumed to grow at the same rate as GDP.</td></tr>
<tr><td>Transport activity</td><td colspan="3">Passenger transport activities and freight transport activities are assumed to be growing at the same rate as GDP per capita growth.</td></tr>
<tr><td>Residential activity</td><td colspan="3">The appliance ownership for electrical appliances is projected to grow at a rate like the growth in GDP.</td></tr>
<tr><td>Access to electricity</td><td colspan="3">Projected access is based on the historical penetration rate between the 2000-2020 period. 100 per cent access to electricity in the rural area can be achieved in 2024.</td></tr>
<tr><td>Access to clean cooking fuels</td><td colspan="2">Projected access is based on the historical penetration rate between the 2000-2020 period.</td><td>100 per cent clean cooking access rate to achieve the SDG 7 target.</td></tr>
<tr><td>Energy efficiency</td><td>Additional energy efficiency measures not applied.</td><td>Improvement based on current policies.</td><td>Global target of energy intensity adopted.</td></tr>
<tr><td>Power plant</td><td>Considers 2021 RE share in power generation and grid emissions.</td><td>Considers capacity expansion provided by the MoE.</td><td>Considers capacity expansion to reach at least 30 per cent RE share.</td></tr>
</table>

12 Based on the projection from Asian Development Bank (ADB), "Economic forecasts for Mongolia", 2023.

13 Based on the projection from State Great Hural of Mongolia, "Mongolia Sustainable Development Vision 2030", Ulaanbaatar, 2016.

14 Calculation based on the historical population data.

15 This assumes that the rate of urbanization grows at an annual rate of 0.29 per cent, with reference to the national historical urbanization growth from 2010 to 2020.

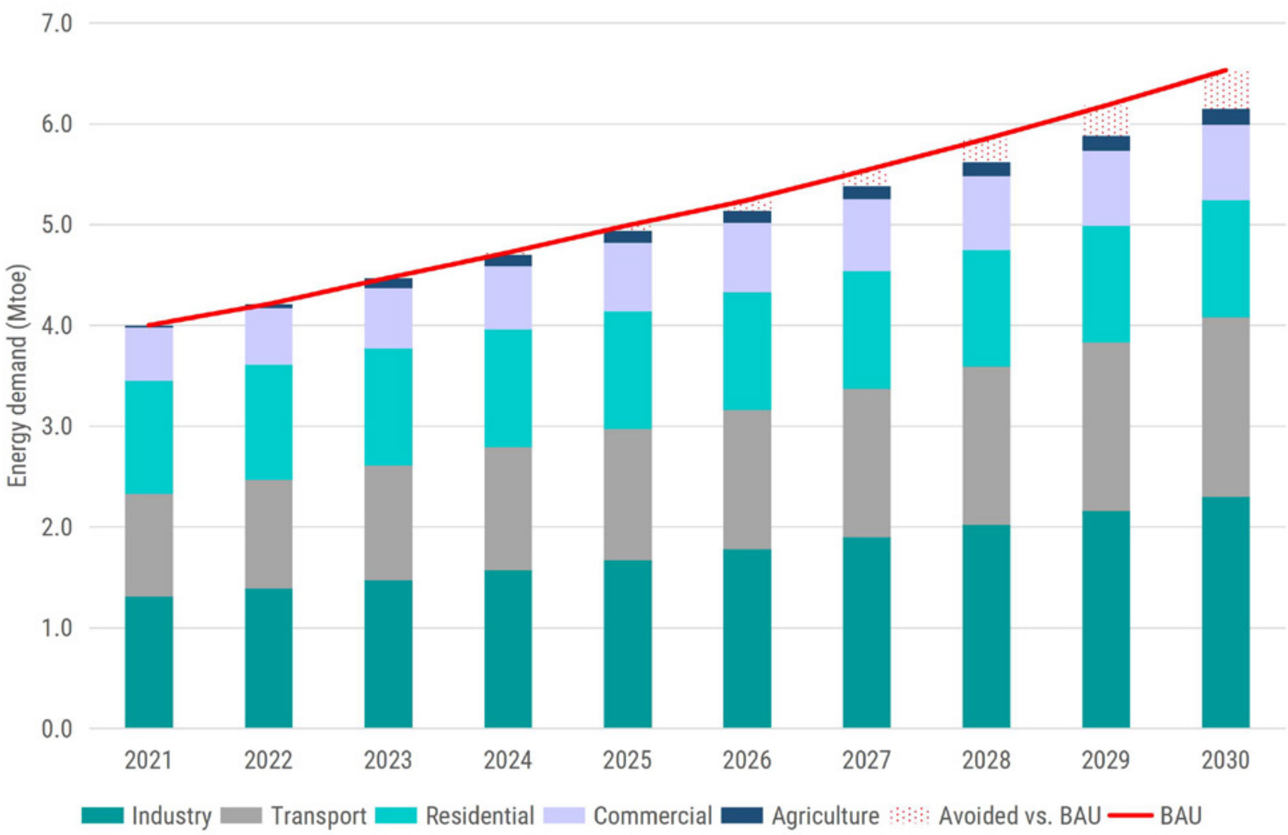
4. Energy transition outlook in the current policy scenario

This chapter presents key results of modelling under the NEXSTEP's current policy scenarios, focusing on impacts in key areas of the economy and the energy sector.

4.1. Energy demand

Under the current policy setting, the demand for total final energy is expected to increase from 4 Mtoe in 2021 to 6.2 Mtoe in 2030, an average annual growth rate of 4.9 per cent. In 2030, the industry sector will remain the largest energy consuming sector with 37.3 per cent, while the transport sector share will be 29 per cent. The residential sector consumption will be at 18.9 per cent, followed by the commercial sector at 12.2 per cent. The agriculture sector will account for 2.6 per cent of energy demand. Figure 5 shows the forecast of TFEC by sector under the CP scenario.

Figure 5. Energy demand outlook in the current policy scenario 2021 - 2030



Source: ESCAP.

4.1.1. Industry sector

The industrial sector will continue to dominate Mongolia's TFEC, with a 37.3 per cent share in 2030. It will consume 2.3 Mtoe in 2030, an annual growth of 6.4 per cent, up from 1.3 Mtoe in 2021.

Within the industrial sector, it is projected that 30.1 per cent of energy will be consumed by the food and beverage industry. Mining industry will account for 28.8 per cent of industrial energy demand, followed by cement and non-metallic quarry products at 18.8 per cent. Iron and steel industry will account for 9.4 per cent of energy demand. The remaining 12.9 per cent will be consumed across seven industries, including machinery and transport equipment, pulp and paper, and textile and leather industry.

4.1.2. Transport sector

The transport sector will consume 1.8 Mtoe in 2030, an annual growth of 6.4 per cent, up from 1 Mtoe in 2021. Road transportation will account for 88.5 per cent of energy demand in the transport sector. The water transport and aviation sectors will consume around 10 per cent and 1.5 per cent energy demand, respectively. The Government has introduced electric vehicle targeting on public transport under the *Vision-2050* document (State Great Hural, 2020). Unfortunately, there is no specific target on its penetration rate and the EV plan will be implemented from 2031 onwards.

4.1.3. Residential sector

Energy demand in the residential sector will increase from 1.1 Mtoe in 2021 to 1.2 Mtoe in 2030, with an annual growth of 0.4 per cent. The low annual growth rate value is expected due to low population growth combined with improvement in energy efficiency in the residential sector. Around three quarters of energy demand will be used for heating, while 11.9 per cent will be consumed for cooking. The remaining 13.1 per cent will be consumed to power electric appliances.

Mongolia experiences a long and cold winter season, hence the heating demand is quite high. The Government targets reducing heat losses in buildings by 20 per cent and 40 per cent in 2020 and 2030, respectively, compared to 2010 levels. Under the NDC document (Government of Mongolia, 2022), the Government plans to insulate old precast panel buildings in urban centres since the heat loss in precast buildings is very high because of thin walls and wooden-framed windows. While theoretically external insulation can save annual energy demand by up to 36 per cent, actual savings can be lower depending on the building's condition. According to an energy audit conducted in February 2021 on the 16 retrofitted buildings by the Municipality of Ulaanbaatar, the achieved energy savings only ranged from 21 per cent to 27 per cent (Yang, Lao, and Bayasgalan, 2022). It is expected that the energy saving in the residential sector will be around 0.2 Mtoe in 2030.

4.1.4. Commercial and agriculture sector

Total energy consumption in the commercial sector will increase from 0.5 Mtoe in 2021, at an average annual growth of 3.9 per cent, to 0.8 Mtoe in 2030. It is expected that there will be a 0.2 Mtoe energy demand reduction in this sector assuming that the Government implements measures to reduce heat loss by improving external insulation. The agriculture sector will consume 0.2 Mtoe of energy in 2030. Table 3 summarizes energy efficiency measures modelled in the current policy scenario and corresponding energy reduction opportunities in different sectors.

Table 3. Energy efficiency measures and energy demand reduction opportunities in the CP scenario compared to BAU scenario by 2030

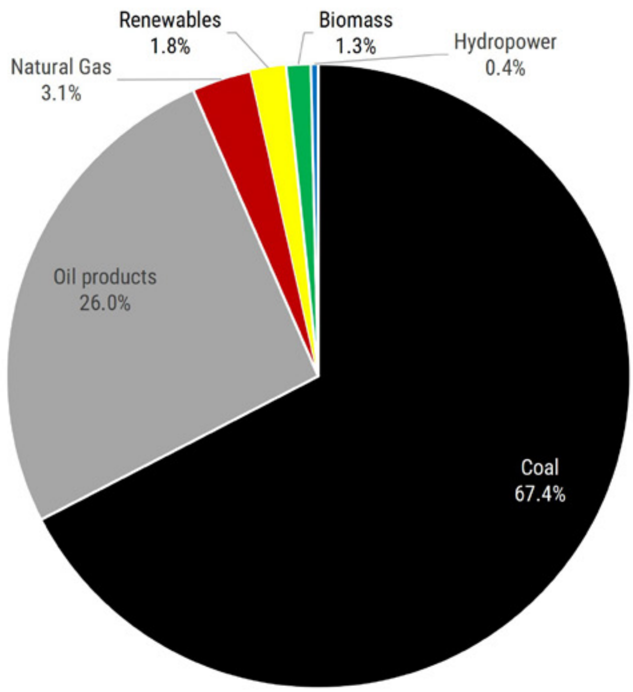
Sector	Measure	Energy demand reduction (ktoe)
Residential	Insulation old precast panel buildings in urban centres	197
Commercial	External insulation improvement of commercial buildings	178
Total		**375**

4.2. Energy supply outlook

Primary energy supply

In the current policy scenario, TPES is forecasted to increase from 5.9 Mtoe in 2021 to 9.4 Mtoe in 2030. The fuel shares in 2030 (Figure 6) will still be dominated by fossil fuel: coal 6.6 Mtoe (67.4 per cent); oil products 2.5 Mtoe (26 per cent); and natural gas 0.3 Mtoe (3.1 per cent). The remainder will be for biomass 0.1 Mtoe (1.3 per cent), hydropower 0.04 Mtoe (0.4 per cent), and other renewables at 0.2 Mtoe (1.8 per cent).

Figure 6. Total primary energy supply by fuel type in 2030 in the CP scenario



Source: ESCAP.

Electricity and heat generation

To assure sustainability of the energy sector development and create the basis for enhanced deployment of renewables in the future, Mongolia has set a target to increase the RE share in electricity generation capacity to 30 per cent in 2030. However, there is no specific renewables target for heat generation.

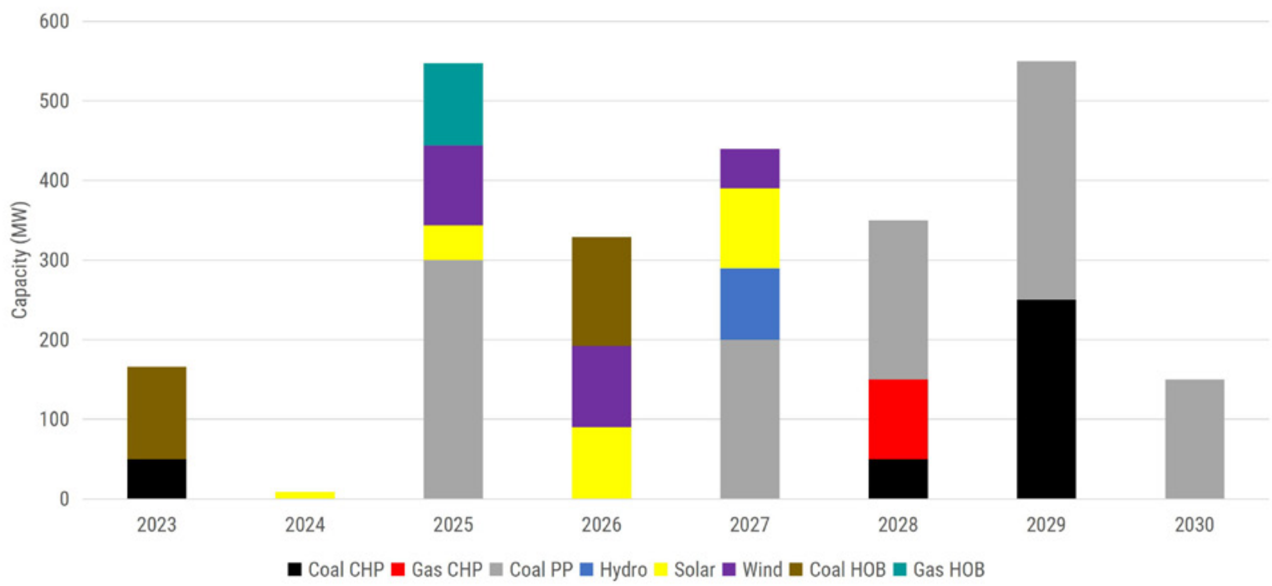
According to the capacity expansion plan provided by the MoE, the installed power generation capacity for Mongolia is forecasted to be 3,744 MW. Fossil fuels will continue to dominate installed capacity at 76.7 per cent, while renewables share will be 23.3 per cent. Although the renewable energy capacity share has increased from 18.3 per cent in 2021, the share will nonetheless fall short from the target of 30 per cent. This is because a significant amount of coal-fired generation will still be operational in Mongolia (Table 4 and Figure 7).

Electricity generation is expected to rise from 7.9 TWh, in 2021, to 16.1 TWh in 2030. The renewable energy share in electricity supply will increase from 10.1 per cent, in 2021, to 15 per cent in 2030. The total electricity requirement (considering both final energy demand as well as transmission and distribution losses) in the CP scenario, by 2030, would be 13.5 TWh. District heating generation is expected to rise from 15.7 TWh, in 2021, to 22.8 TWh in 2030, coming from fossil-fuelled generation (both CHP and HOB). There is no renewable energy system planned for the heating sector in Mongolia. The total heat requirement (considering both final energy demand as well as distribution losses) in the CP scenario would be 20.8 TWh, by 2030.

Table 4. Power and heat capacity expansion plan by fuel type

Fossil fuels		
Combined heat and power(CHP)	**Coal power plant (PP)**	**Heat only boiler (HOB)**
50 MW Choibalsan (coal extension) 100 MW CHP-2 (gas extension) 300 MW CHP-3 (coal extension)	300 MW Buuruljuut (new) 400 MW Baganuur (new) 450 MW Tavan Tolgoi (new)	116 MW Amgalan (coal extension) 87 MW Dunjingarav (coal new) 50 MW Ikh Zasag (coal new) 70 MW NC-10 (gas new) 30 MW Zaisan (gas new)
Fossil fuels		
Solar	**Wind**	**Hydro**
9 MW Luxstream (new) 24 MW Newcom (new) 20 MW Darkhan Selenge (new) 30 MW San Road Trade (new) 30 MW Solar Power Mongolia (new) 30 MW Uni Solar (new) 50 MW Moshe Eco Energy (new) 50 MW San Steppe (new)	100 MW AB Wind 102 MW Clean Tech 50.4 MW Idiner Global	90 MW Erdeneburen (New)

Figure 7. Power and heat capacity expansion plan 2023 - 2030

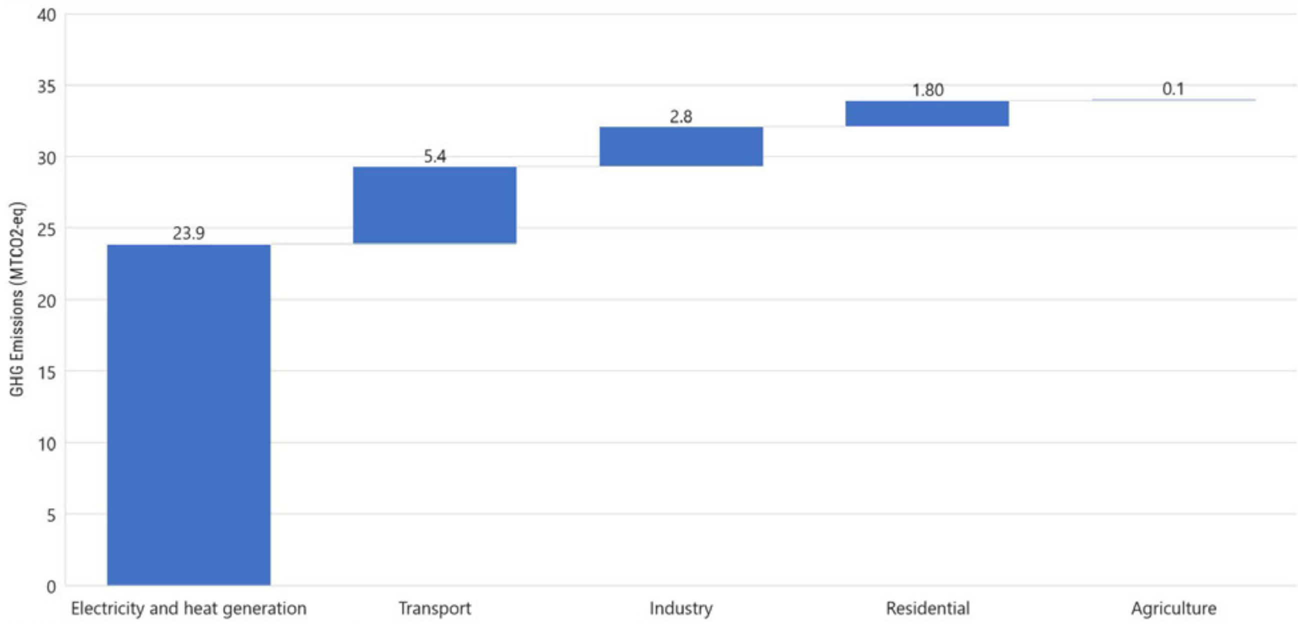


Source: ESCAP.

4.3. GHG emissions

In the BAU scenario, emissions are expected to be 44.4 $MtCO_2$-e by 2030. GHG emissions are projected to reach 34 $MtCO_2$-e by 2030, which is a decrease of 10.4 $MtCO_2$-e or 23.4 per cent compared to BAU, meeting the unconditional energy target of 22.7 per cent. This reduction is attributable mainly to the Government's plan for increasing renewable energy in power generation. Most emissions will come from electricity and heat generation (70.4 per cent), followed by the transportation sector (15.8 per cent), and the industry sector (8.2 per cent). The remaining emissions will be shared by residential, commercial and agriculture sector. Figure 8 shows the emissions distribution by sector in 2030.

Figure 8. Distribution of emissions by sector in 2030 in the CP scenario



Source: ESCAP.

Note: Commercial sector emissions are excluded from the figure since the values are very low.

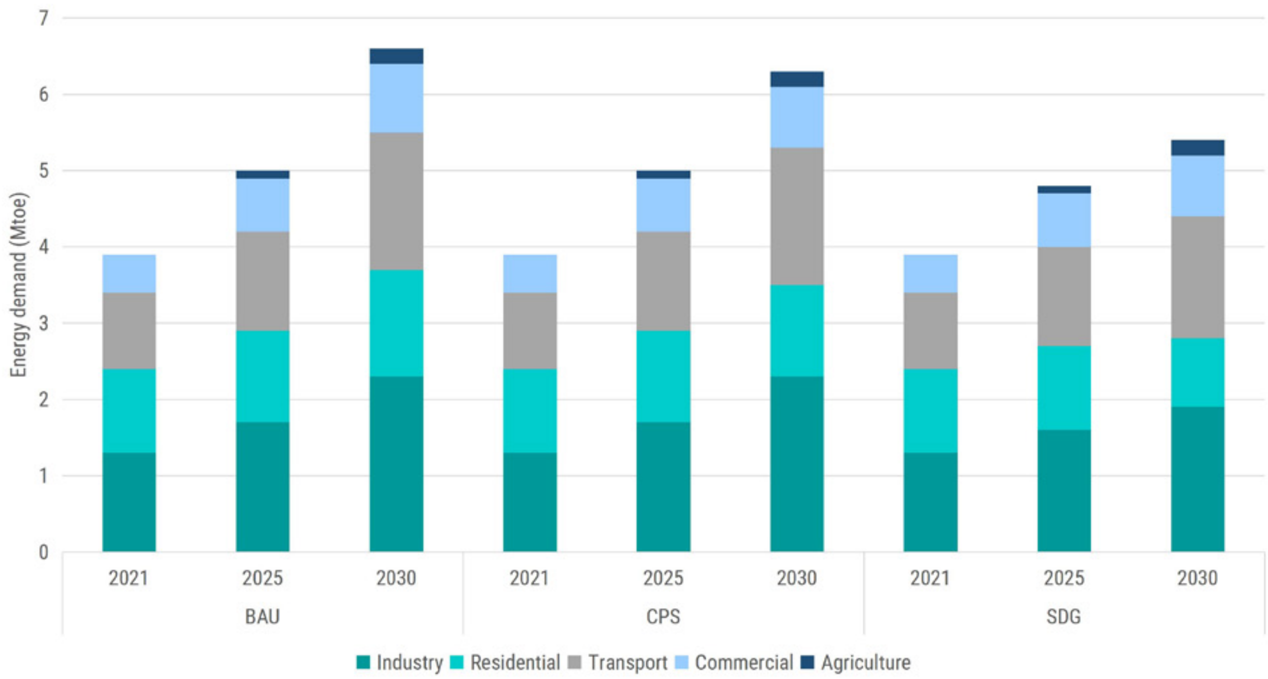
5. SDG scenario: An assessment of SDG 7 targets and indicators

This chapter begins with a concise overview of the energy demand projections under the SDG scenario. Later, the results are evaluated against the SDG 7 and NDC targets, along with other relevant indicators. This evaluation is based on the outputs from the NEXSTEP analysis, aiming to spotlight any policy gaps in Mongolia's current energy policies. To conclude, the future energy supply outlook is presented.

5.1. Energy demand outlook

In this scenario, TFEC increases to 5.2 Mtoe in 2030, which is a 1.3 Mtoe reduction compared to the BAU scenario (an additional 0.9 Mtoe demand reduction compared to CPS). This reduction is due to additional energy efficiency modelled to ensure the achievement of the SDG 7.3 target. In 2030, the industry sector will have the largest share of TFEC at 1.9 Mtoe (35.8 per cent), followed by the transport sector at 1.6 Mtoe (30 per cent). Residential and commercial sectors will account for 0.9 Mtoe (16.8 per cent), and 0.8 Mtoe (14.4 per cent), respectively. The agriculture sector will account for 0.2 Mtoe (3.1 per cent). Figure 9 shows the total final energy consumption by scenario in 2030.

Figure 9. Comparison of energy demand between BAU, CPS and SDG scenarios



Source: ESCAP.

Note: BAU = Business-as-usual, CPS = Current policy scenario, SDG = Sustainable Development Goal

5.2. SDG 7 targets

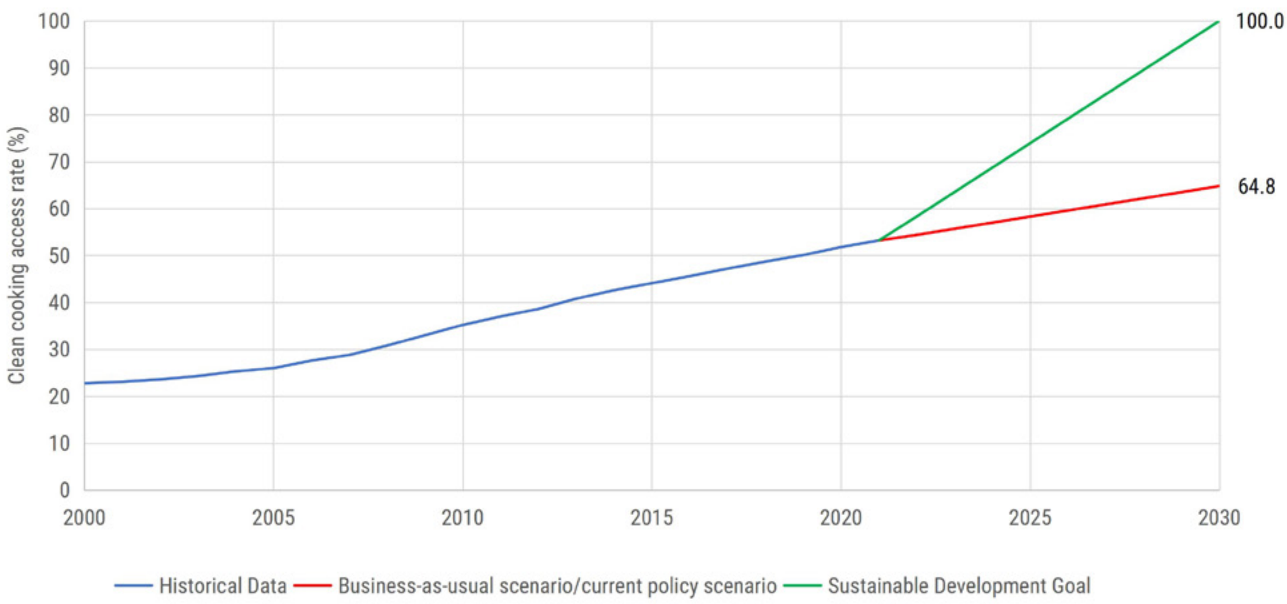
5.2.1. Access to electricity

The electrification rate in Mongolia was already 99.5 per cent in 2021. Significant progress has been made in the last decade including the electrification of herding households in rural areas through the National 100,000 Solar Ger (Yurt) Electrification Programme (2000-2012). The current trend indicates that Mongolia will reach 100 per cent access to electricity by 2024. The Road Map proposes that decentralized renewable electricity systems, such as solar mini-grids and solar home systems, be provided to the remaining unconnected households. The ease of implementation, compared to extending the grid infrastructure, should allow the 100 per cent electrification target to be reached.

5.2.2. Access to clean fuels and technologies for cooking

Mongolia has made progress towards clean cooking, increasing from 22.8 per cent in 2000 to 53.2 per cent in 2021. As of 2021, 46.8 per cent of people relied on polluting cooking technologies, specifically biomass and charcoal. Under the current policy scenario, access to clean cooking fuels and technologies will reach only 64.8 per cent in 2030, leaving 370,000 households relying on inefficient and hazardous cooking fuels and technologies. Under the SDG scenario, the clean cooking access rate is set to achieve universal access (100 per cent) by 2030 (Figure 10).

Figure 10. Mongolia's access to clean cooking in the BAU/CPS and SDG scenarios

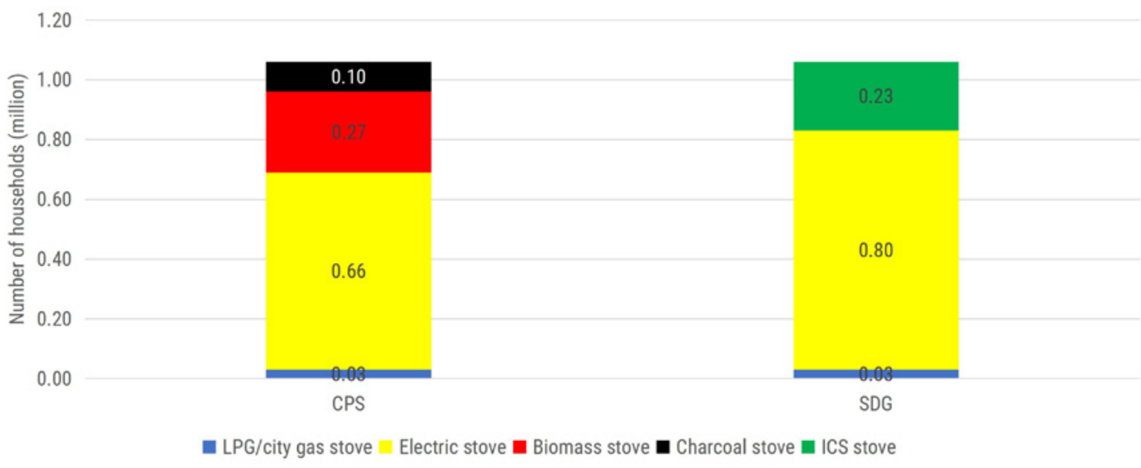


Source: ESCAP.

Note: BAU = Business-as-usual, CPS = Current policy scenario, SDG = Sustainable Development Goal

The NEXSTEP analysis indicates that electric cook stoves would be the most appropriate solution for Mongolia to provide access for 370,000 households by 2030 due to cost and environmental effectiveness since the technology is readily available in the country (Figure 11). The annualized cost of electric cook stoves will be around $74 per unit while the LPG cookstove will be around $113 per unit (Table 5). ICS stoves, however, can play an intermediary role in the area where electric cook stoves may not be suitable for households using off-grid electricity systems, as the appliance requires substantial power supply capacity. Once this measure is in place, the share of households with electric stoves will be around 75.6 per cent while those with ICS and LPG/city gas stoves will be around 21.8 per cent and 2.6 per cent, by 2030, under the SDG scenario, respectively. Box 1 explains the basis for evaluation of clean cooking technologies. Annex IV summarizes the cost and technical assumptions used in the economic analysis.

Figure 11. Share of clean cooking technologies by 2030 under CPS and SDG scenarios



Source: ESCAP.

Note: CPS = Current policy scenario, SDG = Sustainable Development Goal

Table 5. Annualized unit cost of cooking technologies

Technology	Annualized unit cost
Electric cooking stove	$ 74
Improved cooking stove (ICS)	$ 88
LPG stove	$ 113

Box 1. Evaluation of clean cooking technologies

Electric cook stoves

Electric cooking technology is classed as Level 5 in the World Bank Multi-Tier Framework (MTF) for Indoor Air Quality Measurement. Electric cook stoves are more efficient than other cook stoves, including gas stoves. Electric cook stoves can generally be divided into two types – solid plate and induction plate. While solid plate cook stoves use a heating element to transmit radiant energy to the food and reach about 70 per cent efficiency, induction plate cook stoves, on the other hand, use electromagnetic energy to directly heat pots and pans, and can be up to 90 per cent efficient.

Improved cook stoves

ICS programmes initially require strong advocacy to promote adoption, after which they require ongoing follow-up, monitoring, training, maintenance and repairs in order to facilitate continuing usage. In addition, based on the World Health Organization (WHO) guidelines[a] for emissions for clean cooking, only certain types of ICS technology comply, particularly when considering the fact that cook stove emissions in the field are often higher than they are in laboratory settings used for testing. Tier 3+ ICS, which meets the WHO clean cooking guidelines, has the potential to reduce GHG emissions and provide socioeconomic and health benefits, when it is promoted in carefully planned programmes.

LPG cook stove

LPG is constrained due to fuel import dependency and supply chain challenges. LPG cook stoves generate lower indoor air pollution compared to ICS. They are classified as Level 4 in the World Bank Multi-Tier Framework (MTF)[b] for cooking exposure and reduce indoor air pollution by 90 per cent compared to traditional cook stoves.

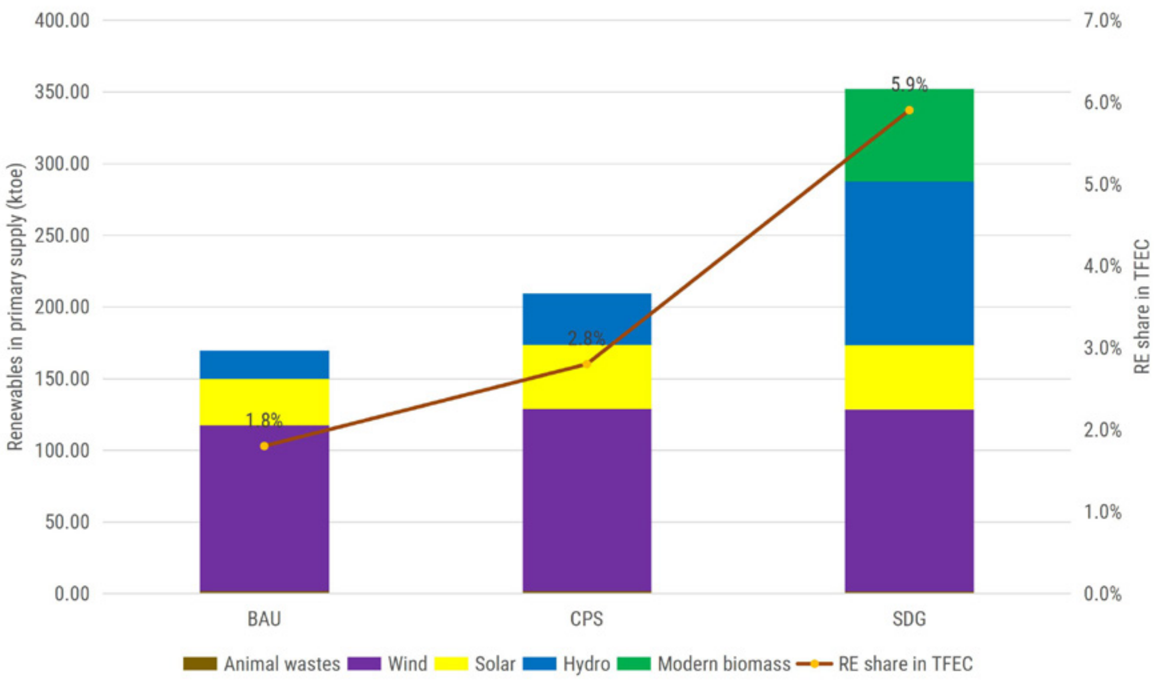
a World Health Organization, "Defining clean fuels and technologies", 2024. Available at https://www.who.int/tools/clean-household-energy-solutions-toolkit/module-7-defining-clean

b Energy Sector Management Assistance Program (ESMAP), "Multi-tier Framework for Energy Access (MTF)", 2023. Available at https://www.esmap.org/mtf_multi-tier_framework_for_energy_access

5.2.3. Renewable energy

SDG 7.2 does not have a quantitative target, but suggests a "substantial" increase of the renewable energy share in TFEC. The share of renewable energy in TFEC, in 2030, will be 1.8 per cent in the BAU scenario, which is expected to grow to 2.8 per cent in the current policy scenario (Figure 12). This increase is largely driven by the increase in the renewable energy share in power generation as stipulated in the current capacity expansion plan. The renewable energy share in TFEC is further increased to 5.9 per cent in the SDG scenario, resulting from increased energy efficiency measures as well as switching from biomass-based cook stoves to electric cook stoves. Despite the increase in renewable energy share in TFEC, the energy system in Mongolia will still be dominated by fossil fuels.

Figure 12. Renewable energy in TPES and TFEC in 2030



Source: ESCAP.

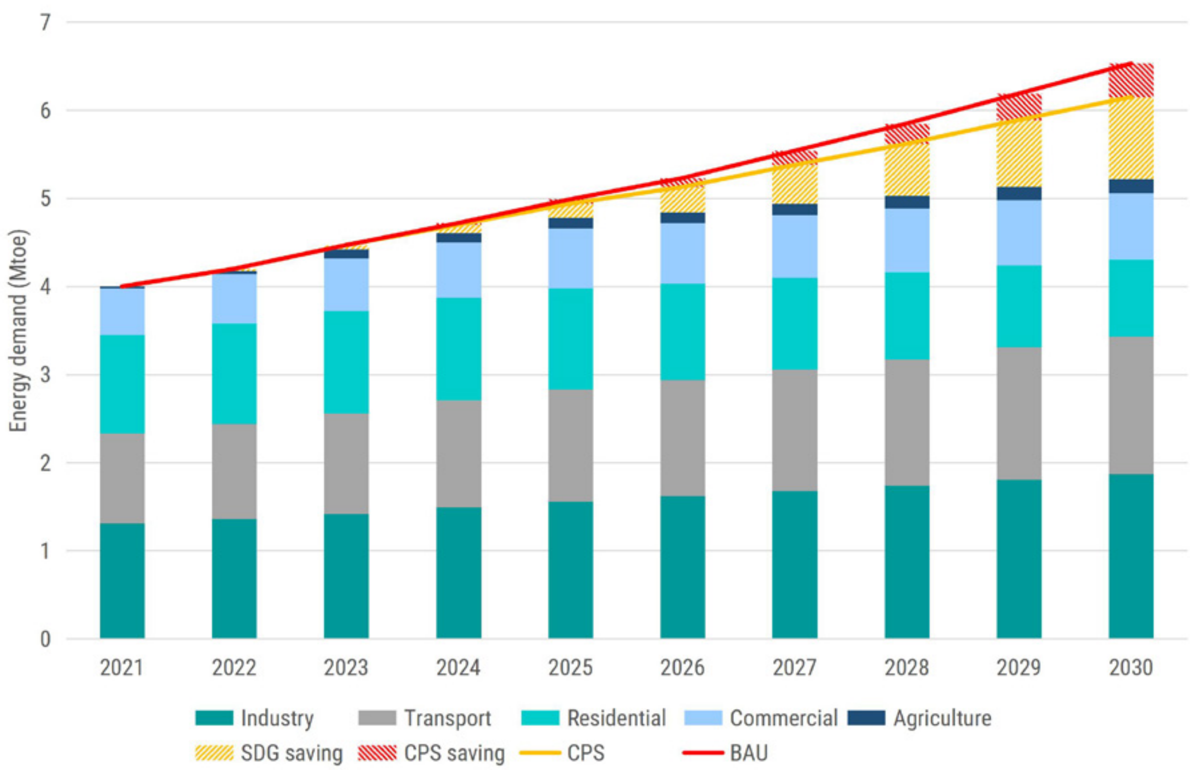
Note: BAU = Business-as-usual, CPS = Current policy scenario, SDG = Sustainable Development Goal

5.2.4. Energy efficiency

Under the SDG 7.3 target, energy intensity is defined as the total primary energy supply (TPES) in megajoules per US$ of gross domestic product in terms of power purchase parity in 2017. Energy intensity in Mongolia declined at an average annual rate of 2.4 per cent between 1990 and 2010. A doubling of the 1990-2010 improvement rate is required to achieve the SDG 7.3 target, which requires an average annual rate increase of 4.8 per cent between 2010 and 2030. However, between 2010 and 2021, the annual improvement rate was only around 2.1 per cent. To reach the expected 2030 intensity, the annual improvement rate between 2021 and 2030 must be around 7.8 per cent, which is quite challenging. Therefore, NEXSTEP analysis suggests that Mongolia's energy intensity target be aligned with the global target of 3.4 per cent annual improvement (IEA, and others, 2023). This corresponds to a 2030 energy intensity target of 4.6 MJ/US$$_{2017}$.

Under the CP scenario, Mongolia's energy intensity in 2030 was estimated to be 5.8 MJ/US$$_{2017}$ - a reduction from 6.3 MJ/US$$_{2017}$ in 2021. The annual improvement rate is expected to be only 1 per cent, between 2021 and 2030, due to limited implementation of energy efficiency measures. The NEXSTEP analysis finds that Mongolia can further reduce energy intensity to 4.5 MJ/US$$_{2017}$, to align with the global energy efficiency target of 3.4 per cent annual improvement for SDG 7. This requires 1.3 Mtoe of energy demand reduction compared to the BAU scenario. Figure 13 shows additional energy saving opportunities under the SDG scenario, compared to the CPS and BAU scenarios.

Figure 13. Energy saving potential in different sectors and subsectors under the SDG scenario compared to the CPS and BAU scenarios



Source: ESCAP.

Note: BAU = Business-as-usual, CPS = Current policy scenario, SDG = Sustainable Development Goal

5.2.5. Industry sector

In the SDG scenario, the industrial sector will consume 1.9 Mtoe in 2030, a reduction of 0.4 Mtoe compared to CPS. The industrial sector is the largest energy consuming sector in Mongolia. With that, a significant amount of energy savings can be expected through the adoption of energy efficiency measures and industrial best practices across different industry subsectors. To achieve this, there are several pathways that can be implemented in Mongolia (see Box 2). NEXSTEP suggests that the Government may enforce energy management standards, energy audits, and equipment standards and labelling in the industrial sector as a starting point. For example, electric motors have been used widely in the industry sector. It is estimated that at least 15 per cent of electricity savings can be achieved by just doing motor replacement, oversizing correction, variable speed drive (VSD) installation, and digitization (de Almeida, Ferreira, and Fong, 2023). The Mongolian Government might also improve thermal insulation in the industry sector. It is estimated that at least 21 per cent of heating demand can be reduced through this approach (Table 6).

Box 2. Energy efficiency measures in the industry sector

The areas of potential savings that are generally present in different industry subsectors include (but not limited to) the following:

- Improvement in motor loading.
- Replacement of old and rewound motors.
- Installation of capacitor banks and increasing efficiency of existing capacitor banks.
- Improvement in combustion efficiency of boilers.
- Regular cleaning and maintenance of boiler equipment (i.e. condenser pipes).
- Installation of more efficient electric motors.
- Improvement of the steam distribution system including leakage control and insulation improvement.
- Electricity load management.
- Minimization of energy losses by partition of cooling areas, installation and effective use of air curtains.
- Minimization of heat losses from the boiler (or kilns for the cement sector).
- Condensate and waste heat recovery.

In addition, various policy measures can be considered for accelerating the green transformation through a range of policy measures. These may include market instruments (i.e., subsidies or taxes), emissions caps and trade systems (e.g., the European Union Emissions Trading Scheme) or regulatory instruments. The Practitioner's Guide to Strategic Green Industrial Policy by Partnership for Action on Green Economy (PAGE)[16] provides industrial policymakers with tools and information for developing a strategic green industry policy (SGIP).

16 See Partnership for Action on Green Economy (PAGE), "Practitioner's guide to strategic green industrial policy", United Nations Industrial Development Organization, 2016. Available at https://www.unido.org/sites/default/files/2016-11/practitioners_guide_to_green_industrial_policy_1__0.pdf

Table 6. Additional energy saving in the industry sector under the SDG scenario by 2030, compared to BAU

Sector	Measure	Energy demand reduction in 2030 (ktoe)
Industry – Energy audit and energy efficiency improvement	Improvement of 15 per cent efficiency of electrical demand and 21 per cent of thermal demand in four major industries	
	Mining	166
	Food and beverages	141
	Cement and non-metallic products	75
	Iron and steel	45
Total		**427**

5.2.6. Transport sector

In the SDG scenario, the transport sector will consume 1.6 Mtoe in 2030, which is an additional reduction of 0.2 Mtoe compared to BAU (Table 7). Road transportation will account for 86.8 per cent of energy demand of the transport sector's energy demand. Water transport and aviation will consume around 11.4 per cent and 1.8 per cent, respectively.

The Government has considered introducing electric vehicle (EV) targeting in public transportation under the Vision 2050 document although no penetration target has been introduced and the implementation will be in the next decade (State Great Hural, 2020). In this scenario, NEXSTEP suggests that the Government accelerate the implementation of electric vehicle in road transport and put a penetration target. In terms of passenger transport, the Government can adopt a 20 per cent EV penetration target rate for passenger cars, and 5 per cent for passenger buses to be achieved by 2030. The target for passenger cars must be higher since a significant amount of energy demand is used by this category.

The Government may initially replace the public fleet with electric vehicles before promoting electric vehicles to wider population. Additionally, the Government can promote voluntary measures, such as routine maintenance and inspection, to improve the fuel economy of gasoline cars from 8.3 kilometres per litre (km/l) to 10 km/l, and the fuel economy of diesel cars from 10 km/l to 11 km/l.

In terms of freight transport, electrification of heavy trucks is challenging because of the competition with the long range of diesel trucks. However, it is expected that electrification of freight trucks might also become an economically feasible option in the long-term. NEXSTEP suggests that a 10 per cent adoption rate of electric trucks should be considered, while simultaneously adopting 20 per cent of hybrid trucks to improve the energy efficiency in this category. In terms of infrastructure, the Government may start developing the charging facilities in Ulaanbaatar area first since the mobility is concentrated in the capital region. See Box 3 for information on electric vehicles.

Table 7. Additional energy saving in the industry sector under the SDG scenario by 2030, compared to BAU

Sector	Measure	Energy demand reduction (ktoe)
Passenger cars	Electric cars penetration by 20 per cent in 2030	194
Passenger buses	Electric buses penetration by 5 per cent in 2030	6
Freight trucks	10 per cent of electric trucks and 20 per cent of hybrid trucks penetration in 2030	24
Total		**224**

Box 3. Electric vehicles gain global interest

Electric vehicles have garnered great interest globally, growing exponentially during the past decade. Electric car sales passed 2 million globally in 2019, with a projected compound annual growth rate of 29 per cent through to 2030.[a] Various government policies have been introduced that directly or indirectly promote the adoption of electric vehicles as a means to achieve environmental and climate objectives. For example, 17 countries have stated their ambition to phase out internal combustion engines before 2050, while the European Union's stringent CO_2 emissions standard has accelerated the adoption of electric vehicles.[b]

Despite supply chain bottlenecks and the ongoing COVID-19 pandemic, electric car sales hit a new high in 2021. Sales nearly doubled to 6.6 million, representing a world sales share of approximately 9 per cent, compared to 2020, increasing the total number of EVs on the road to 16.5 million. In 2021, the sales share of EVs rose by 4 percentage points. China had the most sales in 2021, tripling those of 2020 with 3.3 million sales, followed by Europe with 2.3 million sales, an increase from 1.4 million in 2020. In 2021, 630 000 EVs were sold in the United States, doubling their market share to 4.5 per cent. Electric car sales increased more than twice as much in emerging nations, although they are still relatively small.[c]

Vehicles are not considered to be electric vehicles if they have an electric motor that assists the conventional internal combustion engines, but which cannot be charged. The following categories may be considered as EV: (1) battery electric vehicle (BEV); (2) plug-in hybrid electric vehicle (PHEV); and (3) fuel cell electric vehicle (FCEV).

a Michael Woodward, and others, "Electric vehicles: Setting a course for 2030", Deloitte Insights, 28 July 2020. Available at https://www2.deloitte.com/uk/en/insights/focus/future-of-mobility/electric-vehicle-trends-2030.html

b IEA, "Electric Vehicles", 2022. Available at https://www.iea.org/reports/electric-vehicles

c Ibid.

5.2.7. Residential sector

Energy demand in the residential sector will reduce from 1.1 Mtoe in 2021 to 0.9 Mtoe in 2030, a 0.3 Mtoe reduction compared to CPS, and 0.5 Mtoe reduction compared to BAU. In addition to achieving a 100 per cent access to clean cooking, phasing-out inefficient cooking technologies by efficient electric cook stove (e.g., induction type) might help to reduce cooking demand since this technology is more efficient compared to other stoves. The improved cooking stoves (ICS) can be promoted in some households where access to sustainable and reliable supply of electricity is limited. ICS is also more efficient compared to the use of traditional biomass for cooking. To reduce the electricity demand, adoption of MEPS will be beneficial to reduce the electricity consumption for lighting, refrigeration, and televisions (the three appliances with the largest energy consumption).

According to 2020 census, 58.6 per cent of dwellings are still using wooden walls and windows (National Statistics Office, 2021). Consequently, the heating demand is quite high in the long and cold winter season. The plan for insulation improvement in urban centres can be further extended to rural areas in order to increase thermal efficiency in rural regions. Apart from improving thermal insulation, the replacement of inefficient and polluting individual heating technologies must be considered. The utilization of individual furnaces must be limited to reduce at least half of the coal and fuelwood consumption in the residential sector. These must be replaced by more sustainable heating technology, such as electric heating and/or district heating. In households where district or electric heating may not be available, high efficiency, low emission (HELE) heating stoves can be promoted.

HELE heaters are the appropriate heating technology that should be promoted for rural households. These heaters reduce fuel consumption by 40 per cent due to their higher efficiency, while also keeping a larger area of homes warm. Indoor air pollution is reduced significantly which ultimately reduces the negative impacts on health. For example, a World Bank study has seen the mean PM2.5 exposure decrease 65 per cent from 92.3 μg/m^3 to 32.4 μg/m^3 (World Bank, 2019). This meets the WHO interim target, IT-1 of 35 μg/m^3, for annual mean concentration of PM2.5 (World Health Organization, 2014). The results also show that the CO_2 exposure dropped below the WHO air quality guidelines.

More can be done to raise community awareness of the benefits of HELE heating technology. Similar to promoting clean cooking technologies, a participatory approach with key stakeholders, together with frequent monitoring, evaluation and feedback should be pursued to ensure a successful implementation of programmes. In addition, the sustainable heating issues should garner more attention and have a place in national policies and plans. In the long term, progressing towards electric heating should be considered, as the affordability of households increases.

Table 8. Additional energy saving in the residential sector under the SDG scenario by 2030, compared to CPS

Sector	Measure	Energy demand reduction in 2030 (ktoe)
Residential cooking	Phasing out inefficient cookstoves by electric cookstoves and ICS	13
Residential – Thermal building envelope and insulation	Thermal retrofitting in urban areas and insulation improvement in rural areas	334
Residential – Heating technology	Limit the use of raw coal in urban areas and switch to the use of improved fuel. Introduction of improved biomass heating in rural areas to reduce coal and fuelwood heating by half.	107
Residential MEPS lighting	Promote the adoption of EE lighting	16
Residential MEPS refrigeration	Promote the adoption of EE refrigeration	5
Residential MEPS television	Promote the adoption of EE television	5
Total		**480**

5.2.8. Commercial sector

In the SDG scenario, the commercial sector will consume 0.8 Mtoe in 2030 a reduction of 0.2 Mtoe compared to CPS. To achieve this, NEXSTEP suggests that the Government adopt green building measures in the commercial sector (see Box 4 for more information) through setting up a green building code, which mandates a set of minimum building standards. This shall ensure sustainable building designs for the upcoming buildings. Moreover, this can be equally applied to existing buildings scheduled for retrofitting. This amounts to an estimated reduction of 0.2 Mtoe.[17] Notwithstanding, one possibility in promoting sustainable measures in existing buildings is the high upfront cost to conduct energy audit and the subsequent implementation of measures. The Government should consider providing financial incentives, while simultaneously raise energy conservation awareness among the public.

Box 4. Policy options for a more sustainable building sector

The building sector contributes significantly to the global energy consumption and GHG emissions. This calls for the adoption of green building measures and designs in new and existing building stocks to allow energy savings and rapid GHG emissions reduction to meet the Paris Agreement. A 'green' building can be defined as *a building that has design, construction and operational practices that significantly reduce or eliminate its negative impact on the environment and its occupants, (GBCA, 2024).*[a] Green building adoption can be made obligatory through the implementation of building codes or promoted with certification/rating systems.

Building code is a comprehensive set of mandatory minimum building standards. One example is the 2018 International Green Construction Code (IGCC), developed to aid government jurisdictions in administering minimum requirements covering the design, construction and operation of buildings (ICC, 2021).[b] Another implemented green building code by state jurisdiction is the California Green Building Standards Code (CALGreen) (State of California, 2021).[c] *Certification systems or rating tools*, which provide third-party assessment and confirmation that a building meets certain green requirements or standards, are also widely used. Examples are the LEED (Leadership in Energy and Environmental Design) rating system and Australia's Green Star Buildings rating tool. For instance, the Green Star certification has been given to almost 3,000 buildings with an average reduction of 56 per cent (Green Building Council of Australia, 2020).[d]

a Green Building Council of Australia, "What is green building?", 2024. Available at https://new.gbca.org.au/about/what-green-building/

b International Code Council (ICC), "International Green Construction Code (IgCC)", 2021. Available at https://www.iccsafe.org/products-and-services/i-codes/2018-i-codes/igcc/

c State of California (2018). *CALGreen*. Available at https://www.dgs.ca.gov/BSC/CALGreen

d Green Building Council of Australia (2020). A year in focus 2019-2020. December. Available at https://gbca-web.s3.amazonaws.com/media/documents/green-star-in-focus-2020-final-spreads-sml.pdf

Table 9. Additional energy saving in the commercial sector under the SDG scenario by 2030, compared to CPS

Sector	Measure	Energy demand reduction (ktoe)2030
Private office and government building	Green building code to ensure improvement in the external insulation of commercial buildings to achieve at least 21 per cent energy saving in heating	81
Shopping mall		28

17 This assumes a 21 per cent energy savings potential. However, energy savings potential is building-specific, depending on the baseline design, climate and energy efficiency measures.

Sector	Measure	Energy demand reduction (ktoe)2030
Hotel	Green building code to ensure improvement in the external insulation of commercial buildings to achieve at least 21 per cent energy saving in heating	1
Health-care facilities		21
Educational institutions		47
Others		0.01
Total		**178**

5.3. Energy Supply Outlook

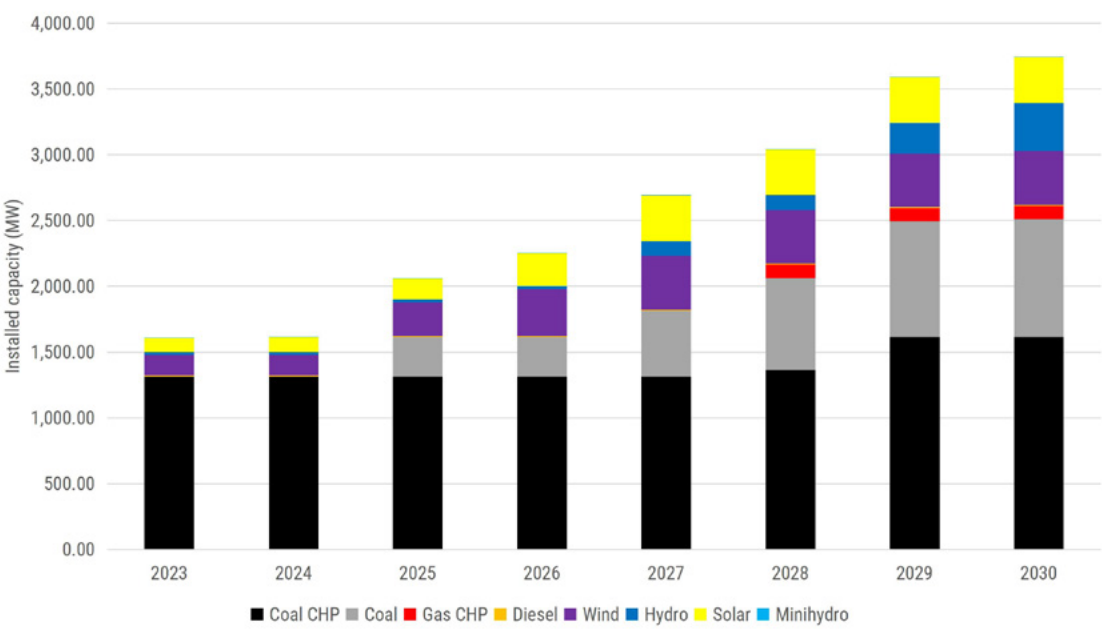
Primary energy supply

In the SDG scenario, the TPES is forecasted to increase from 5.9 Mtoe in 2021 to 7.4 Mtoe in 2030. The fuel shares in 2030 are projected with coal at 4.8 Mtoe (65.1 per cent), oil products at 2 Mtoe (27.1 per cent), and natural gas at 0.3 Mtoe (3.6 per cent). The remaining share will be for biomass at 0.1 Mtoe (1.4 per cent), hydropower at 0.11 Mtoe (1.6 per cent), and other renewables at 0.2 Mtoe (2.3 per cent). The 2 Mtoe supply reduction, compared to the CP scenario, comes from the additional energy efficiency improvements as discussed in Chapter 4. Additionally, since the electricity demand decreases, the fuel consumed in power generation declines as well.

Electricity and heat generation

In 2030, the installed power generation capacity would be similar to the CP scenario at 3,744 MW. However, in this scenario the capacity of coal power plant is reduced by 253 MW while the capacity of hydropower is increased by 253 MW to replace the coal power plant. Increasing hydropower capacity has been considered by the stakeholders during the consultation workshop. Although fossil fuel will still dominate electric supply at 70 per cent, the renewables share will increase to 30 per cent of the installed capacity, achieving the renewable capacity target by 2030. In the SDG scenario, electricity generation is expected to be 14.9 TWh in 2030, where renewable energy will account for 22.3 per cent.

Figure 14. **Power plant installed capacity by source 2023 - 2030**



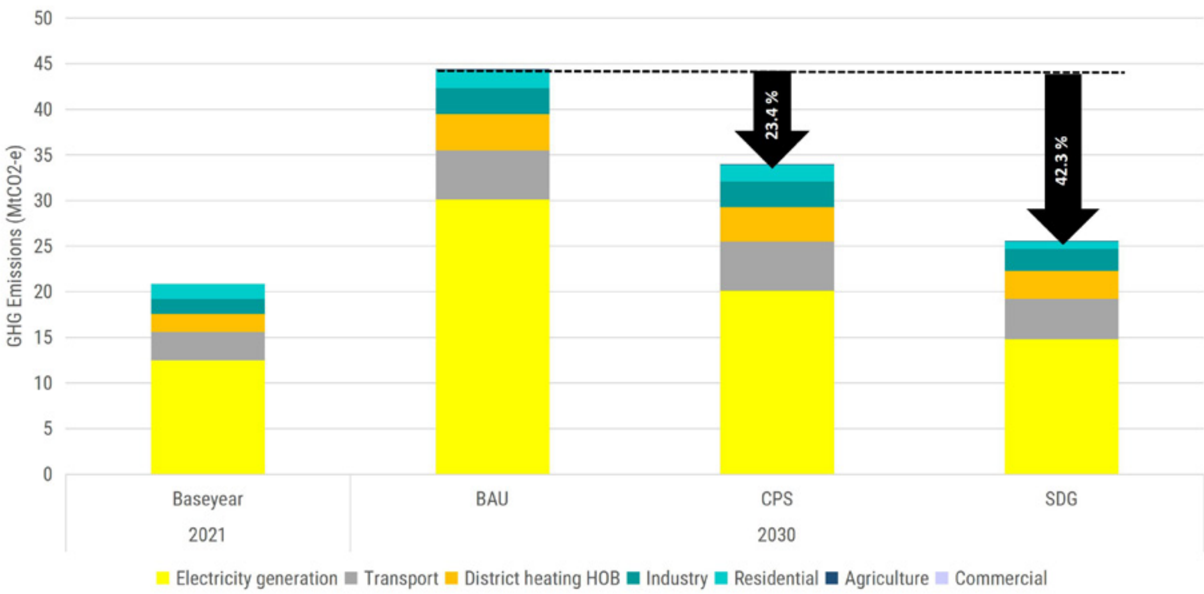
Source: ESCAP.

5.4. Nationally Determined Contribution Targets

Emissions from the combustion of fossil fuel are calculated based on IPCC Tier 1 emission factors. For the combustion of biomass and biomass products, the carbon emissions are not attributed to the energy sector, but are accounted for in the agriculture, forest and land-use change (AFOLU)[18] as per the accounting system suggested by IPCC. Nevertheless, the emissions of other GHGs, such as methane and nitrous oxide, are included in the total emissions in the energy sector.

Emissions analysis in this study suggests that the BAU emissions in 2030 will be 44.4 $MtCO_2$-e. Mongolia has committed to reducing GHG emissions in the energy sector by 22.7 per cent unconditionally (without international aid), and 44.9 per cent conditionally. Mongolia will be able to achieve unconditional NDC target by 2030 under the current policy settings. Although total emissions are expected to grow from 21 $MtCO_2$-e in 2021 to 34 $MtCO_2$-e in 2030 (Figure 15), there will be a 10.4 $MtCO_2$-e (23.4 per cent) reduction[19] compared to the BAU scenario. The decrease in GHG emissions, relative to the BAU scenario, is due to the increase of renewable share in electricity supply as per the capacity expansion plan.

Figure 15. Emissions trajectories for different main scenarios



Source: ESCAP.

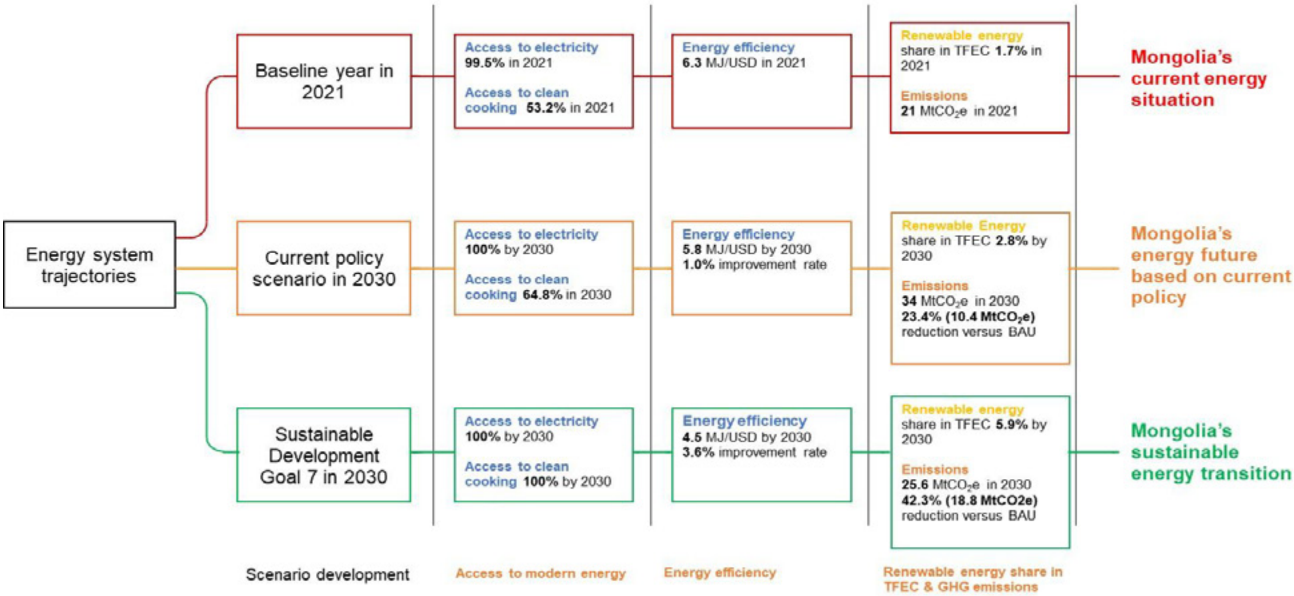
Note: BAU = Business-as-usual, CPS = Current policy scenario, SDG = Sustainable Development Goal

Mongolia can further enhance its efforts to achieve higher emissions reduction by accelerating the implementation of energy saving measures in order to align with the global improvement target of 3.4 per cent, as well as to increase renewable capacity to reach the renewable capacity target discussed in the previous chapter. In the SDG scenario, total emissions are expected to further decrease to 25.6 $MtCO_2$-e by 2030, corresponding to an 18.8 $MtCO_2$-e (or a 42.3 per cent) reduction compared to the BAU scenario.

Despite reaching its universal access to electricity and unconditional NDC targets, Mongolia must accelerate and strengthen its effort to achieve access to clean cooking, increase the renewables share, and improve energy efficiency. These can be considered for enforcement in the updated national energy policy. Figure 16 summarizes the SDG 7 indicators from three main scenarios.

18 The AFOLU sector is not within the scope of NEXSTEP.

Figure 16. Summary of SDG 7 indicators for three main scenarios



Source: ESCAP.

6. Going beyond SDG 7 with ambitious scenarios

The SDG scenario, as discussed in Chapter 5, sets out various strategies for facilitating an economy-wide strategy of 100 per cent access to modern energy, higher renewable energy penetration, and energy-efficiency improvement in alignment with the 2030 Agenda for Sustainable Development and the Paris Agreement. It also identifies appropriate technology options for advancing sustainable energy transition in Mongolia. The measures that have been discussed in Chapter 5, have allowed an energy demand reduction of 1.3 Mtoe and emissions reduction of 18.8 $MtCO_2$-e in the SDG scenario, relative to BAU by 2030.

Despite the fact that these measures might allow GHG emissions reduction which is sufficient enough to exceed the unconditional NDC target, stronger measures are required to achieve a conditional NDC target, and a significant increase in the renewable energy share in TFEC. Accordingly, two additional scenarios have been developed. The sustainable heating scenario (SHS) examines the possibility of Mongolia to transition towards more sustainable heating technology by 2030 in order to achieve the conditional NDC target. The Towards Net Zero Emissions by 2050 (TNZ) scenario aims to assess the potential to transitioning beyond 2030 by identifying technological interventions, defining a timeframe of implementation of different measures, and suggesting policy recommendations to help put Mongolia's energy sector on the right path on achieving net zero GHG emissions by 2050.

6.1. Sustainable heating scenario (SHS) by 2030

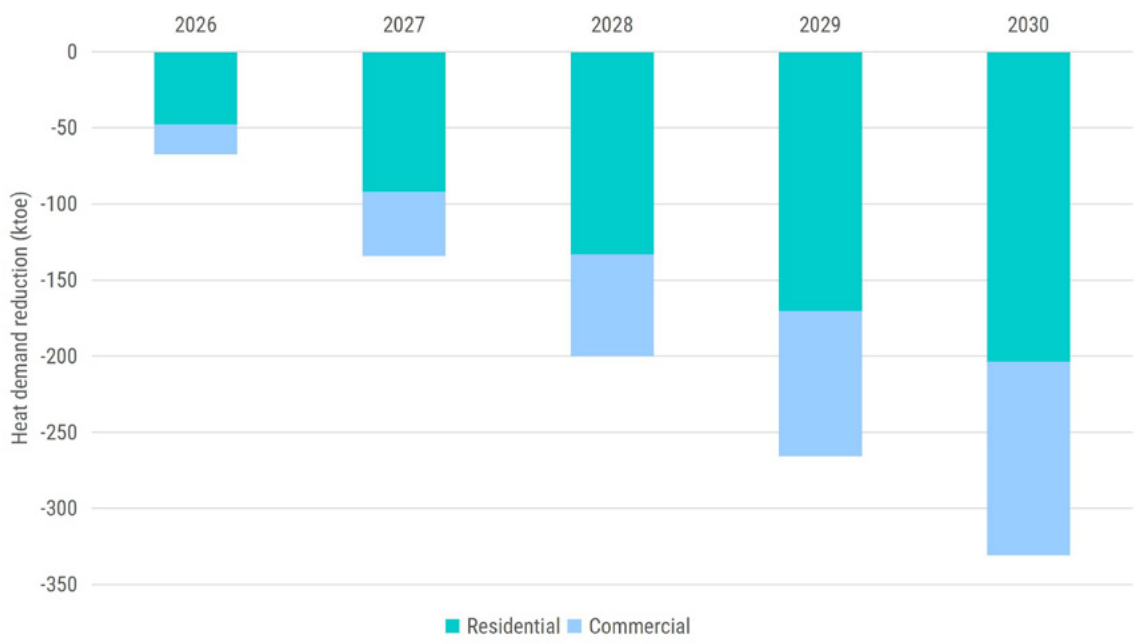
Due to its climatic condition, a significant amount of heat is consumed in Mongolia. Most of the demand, however, is fulfilled from polluting heating technology. Building on the SDG scenario, the SHS further explores how the country can transition its heating demand and supply side towards cleaner technologies.

Under the SDG scenario, it is expected that at least 12.5 per cent of the urban population and 37 per cent of the rural population will be still using inefficient heating technology by 2030. In this sustainable heating scenario, NEXSTEP suggests phasing out of the remaining inefficient heating technology in the residential sector using electrical heaters and HELE to provide additional energy saving of 204 ktoe. In the commercial sector, savings may be maximized, up to an estimated 56 per cent, by further insulation measures on rooftops, basements and windows through what is called deep retrofitting (Yang, Lao, and Bayasgalan, 2022). Implementation of deep retrofitting in the commercial sector will provide additional savings of 127 ktoe, resulting in a total of 331 ktoe reduction across the economy (Figure 17).

In terms of the supply side, it is also critical to increase the share of renewable energy in heating. In 2021, the heating demand was supplied mainly by coal CHP and coal HOB. NEXSTEP analysis suggests reducing the capacity of coal HOB, from 370 MW in 2021 to 300 MW in 2030, and reducing the capacity of coal CHP, from 1,264 MW in 2021 to 1,100 MW, in 2030. This will need to be compensated for by the addition of 300 MW of waste-to-energy power plants and 400 MW of heat pump. As a result, this scenario will improve the following indicators:

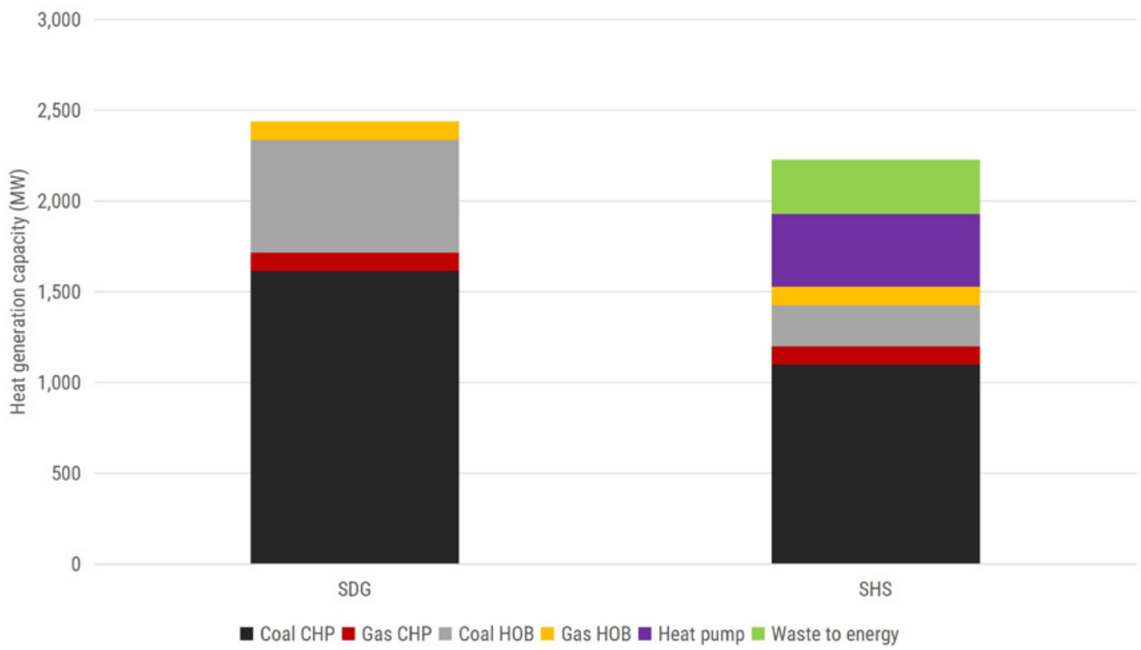
a) increase the share of renewable energy in heating generation to 30.5 per cent from 0 per cent in SDG scenario by 2030;
b) increase the share of renewable energy in power generation to 30.5 per cent from 22.3 per cent in SDG scenario by 2030;
c) increase the share of renewable energy in TFEC to 22.8 per cent from 5.9 per cent in SDG scenario by 2030;
d) reduce the energy intensity to 3.8 MJ/US$_{2017}$ from 4.5 MJ/US$_{2017}$ in SDG scenario by 2030; and
e) provide a GHG emissions reduction of 25 $MtCO_2$-e (56.3 per cent) compared to BAU exceeding the conditional NDC target.

Figure 17. Additional energy saving potential in SHS scenario compared to SDG scenario



Source: ESCAP.

Figure 18. Power and heating generation plan comparison



Source: ESCAP.

Note: SDG: Sustainable Development Goal, SHS: Sustainable Heating Solution

6.2. Towards Net Zero Emissions by 2050 scenario

Around three-quarters of current greenhouse gas emissions globally come from the energy sector. Limiting the temperature rise to 1.5°C requires climate mitigation efforts that are on an unprecedented scale and speed in order to reduce GHG emissions by about 45 per cent from 2010 levels by 2030, reaching net zero around 2050 (Rogelj and others, 2018). Failing to act on the most pressing issue of this generation may lead to a catastrophic impact on human livelihoods.

In addition, the COP 26 in Glasgow has created momentum and called for transitioning towards net zero. The TNZ scenario examines the potential for Mongolia to achieve net zero by 2050. The rationale for the choice of a longer timeframe for this scenario is to allow the non-electric energy consumers, e.g., direct fuel combustion in the transport sectors, to gradually transition to a fully electric system.

Achievement of the Net Zero Emissions target will require decarbonization of the Mongolian energy sector, which is best done in the following two steps: (a) decarbonizing the power and heat sectors; and (b) switching all energy sources to electricity. Fortunately, the energy system of Mongolia is well-positioned for an accelerated decarbonization effort as some required net zero technologies, such as electric cook stoves and electric vehicles, to decarbonize its energy system are readily available.

Building on the SDG scenario and extending the timeframe to 2050, this scenario suggests the following additional measures. On the demand side, the utilization of 100 per cent electric cook stoves will be needed to decarbonize the residential sector by 2050. The transport sector will require the adoption of 100 per cent e-mobility. In the commercial sector, the expansion of energy efficiency in building codes to all types of buildings will be required. In the industrial sector, fuel switching has a significant role, particularly the switching from fossil fuel to electricity. NEXSTEP identified that the replacement of oil products and coal by electricity in the industry sector will be a more appropriate strategy. NEXSTEP has not performed a quantitative analysis on hydrogen for implementation in Mongolia since hydrogen is not commercially available and the technology has several uncertainties. Further investigation is needed to identify the techno-economic potential of hydrogen in the long run (see Box 5).

Box 5. Hydrogen gains global interest, but application is still limited

Green hydrogen, created using renewable electricity, has garnered great interest globally. Various government policies have been introduced that directly or indirectly promote the adoption of renewable hydrogens as a means to achieve environmental and climate objectives. It is driven by an increasing interest to use renewable heat in large industry sectors. For example, five countries (Australia, Brazil, South Africa, Spain and Sweden) have road maps that include green hydrogen in the industry sector.[a]

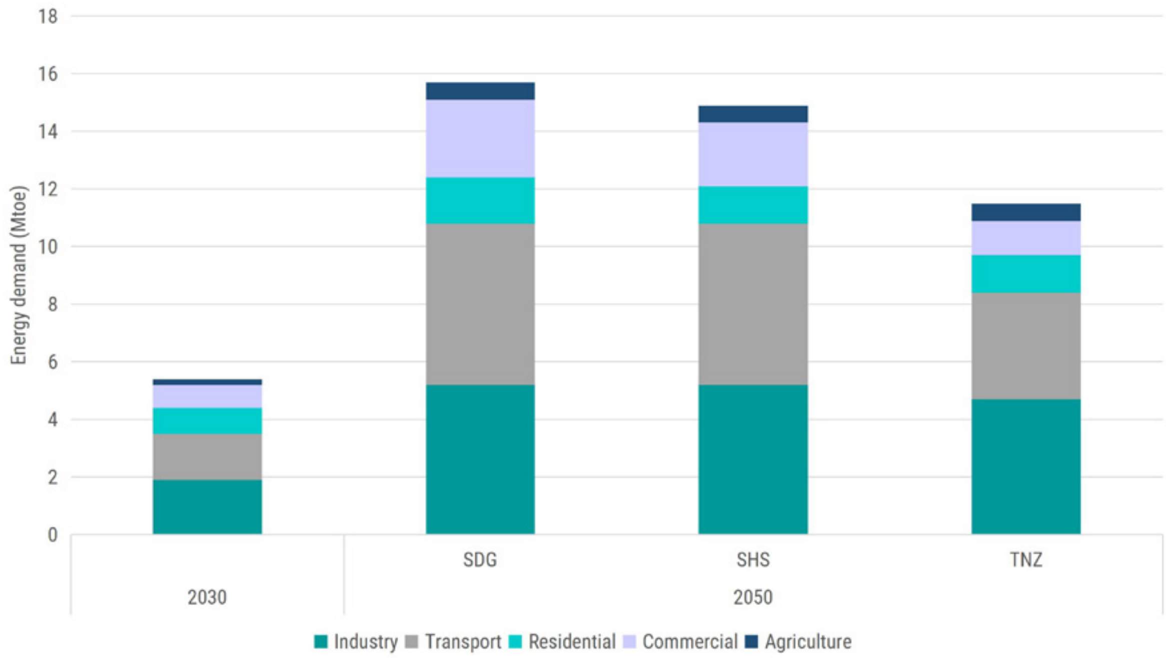
The implementation of green hydrogen, however, is still limited due to high production costs and the need for associated infrastructure. The IEA reported that producing hydrogen from low-carbon energy is still costly at the moment despite the declining costs of renewables.[b] IEA analysed that the cost of hydrogen production from solar PV and wind in the ASEAN region will be around $3/kg. The development of hydrogen through electrolysis may also require a significant amount of water and electricity. IEA estimated that if all current dedicated global hydrogen production were produced through water electrolysis, this would result in an annual electricity demand of 3,600 TWh, and water requirements would be 617 million cubic metres. The widespread adoption of hydrogen is also on hold due to the slow development of hydrogen infrastructure. Planning and coordination, between governments and industries, is required to address refuelling station problems in the future.

a REN21, "Renewables 2023 Global Status Report: Energy Demand", 2023. Available at https://www.ren21.net/wp-content/uploads/2019/05/GSR2023_Demand_Modules.pdf

b International Energy Agency (IEA), "The future of hydrogen: Seizing today's opportunities", June 2019. Available at https://iea.blob.core.windows.net/assets/9e3a3493-b9a6-4b7d-b499-7ca48e357561/The_Future_of_Hydrogen.pdf

With these measures, the total energy demand is expected to increase from 4.9 Mtoe in 2030 to 11.6 Mtoe in 2050, a reduction of about 4.1 Mtoe relative to the SDG scenario, and 3.3 Mtoe relative to the SDG scenario (Figure 19). The industrial sector consumption will remain the largest at 41 per cent, followed by the transport sector at 32.3 per cent. The residential sector will account for 11.1 per cent, the commercial sector at 10.6 per cent, and the agriculture sector at 5.1 per cent.

Figure 19. Comparison of total final energy demand in 2050 by sector



Source: ESCAP.

Note: SDG: Sustainable Development Goal, SHS: Sustainable heating solution, TNZ: Towards net zero

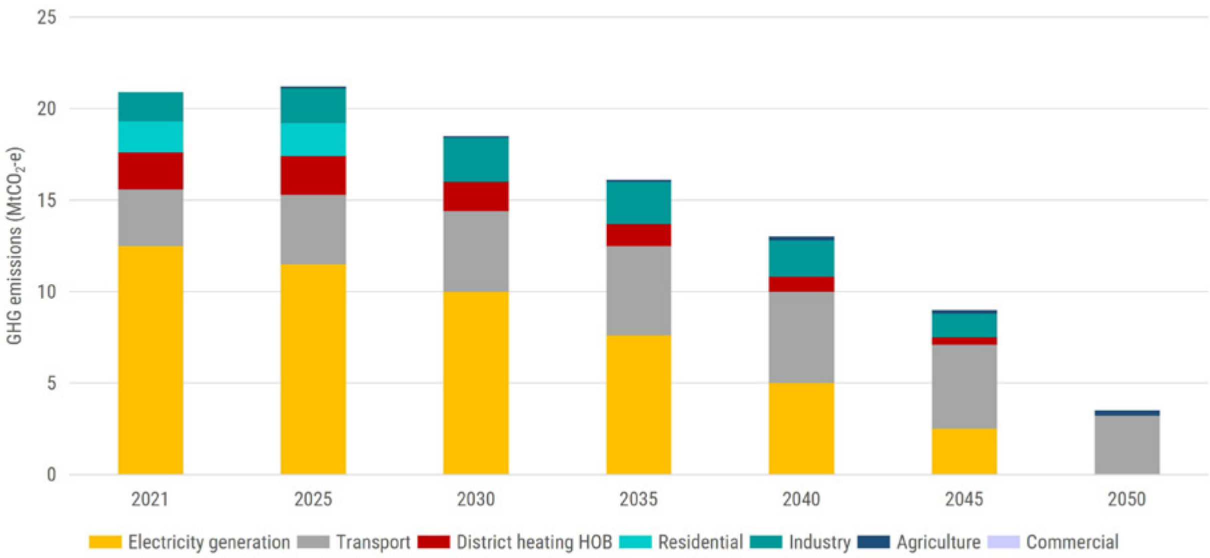
Despite requiring less amount of energy compared to the SDG scenario by 2050, the electrification of the energy system in this scenario will require an additional 49.8 TWh electricity compared to SDG scenario. A decarbonized electricity supply is also required to complement the hastened adoption of electricity-based technologies, such as electric vehicles and electric cook stoves, to realise the greatest potential of electrification. NEXSTEP estimated that the capacity of wind will be around 28.8 GW, solar will be around 1.5 GW, hydropower will be around 2 GW, and waste-to-energy will be 0.6 GW in 2050. Wind is considered the most since the country has a significant wind potential with a relatively high-capacity factor compared to solar PV. In addition to this, a 2.2 MW electric boiler and a 1.8 GW heat pump will be required to complement waste-to-energy in order to fulfil heat demand by 2050.

Box 6. Case study – Northeast Asia Power System Interconnection (NAPSI)

The Asian Development Bank is providing technical assistance to prepare a strategy for power system interconnection in the north-east Asia region. The project was approved in November 2015 and completed by November 2020. The technical assistance is provided to assess the powers system and market in the north-east Asia region, prioritize system interconnection projects including its investment plan, analyse the renewable energy capacity expansion plan in Mongolia, implement knowledge-sharing for the steering committee, and initiate a regional knowledge and investment platform. The project identifies that the economically viable resource potentials for wind and solar are around 192 GW and 1,116 GW, respectively. The project suggested that 5 GW of new wind and solar be developed in 2026 and an additional of 5 GW wind and solar be developed between 2026 and 2036. If implemented, the total new wind and solar capacity would be 10 GW by 2036 (5 GW each for wind and solar PV).

There will be a significant emissions reduction in the toward net zero by 2050 scenario. This is because of (1) full implementation of fuel switching, and (2) fully decarbonizing the electricity and heat supply. In this scenario, the emissions peak in 2025 and starts to decline gradually until 2050 due the implementation of several measures discussed above (Figure 20). Due to certain technological limitations in the transport and agriculture sectors, however, a small amount of emissions would still be produced in those sectors, which would be possible to offset by other means such as management of Land Use, Land Use Change and Forestry (LULUCF). In 2050, the transportation sector will still emit 3.2 $MtCO_2$-e from the rail transport and aviation system. Therefore, carbon sinks, such as reforestation or forest management, or other carbon capture technologies should be considered to absorb the remaining carbon emissions.

Figure 20. GHG emissions in the Towards Net Zero Emissions by 2050 scenario



Source: ESCAP.

7. Economic analysis and financing options

A sustainable energy transition offers financial benefits in the long-term, through which the switch to low carbon approaches generates positive economic returns. The transport, residential, commercial and industrial sectors have a high GHG mitigation potential, and most scenarios offer lower cost pathways compared to business-as-usual over the longer term. For instance, mode shifting in the transportation sector and energy management standard in industries would provide highest cost saving with high abatement potential.

Mongolia can consider the role of energy services companies (ESCOs) to promote energy efficiency. The key to supporting the growth of ESCOs is the availability of accessible financing. Mongolia might learn from other countries, such as Thailand, which have previously demonstrated leadership in this approach by establishing a "revolving fund" for energy conservation and efficiency. ESCOs can borrow funds from financial institutions at an interest rate lower than commercial rates, over an extended repayment period (see Box 7).

Box 7. Case study – Energy Efficiency Revolving Fund in Thailand

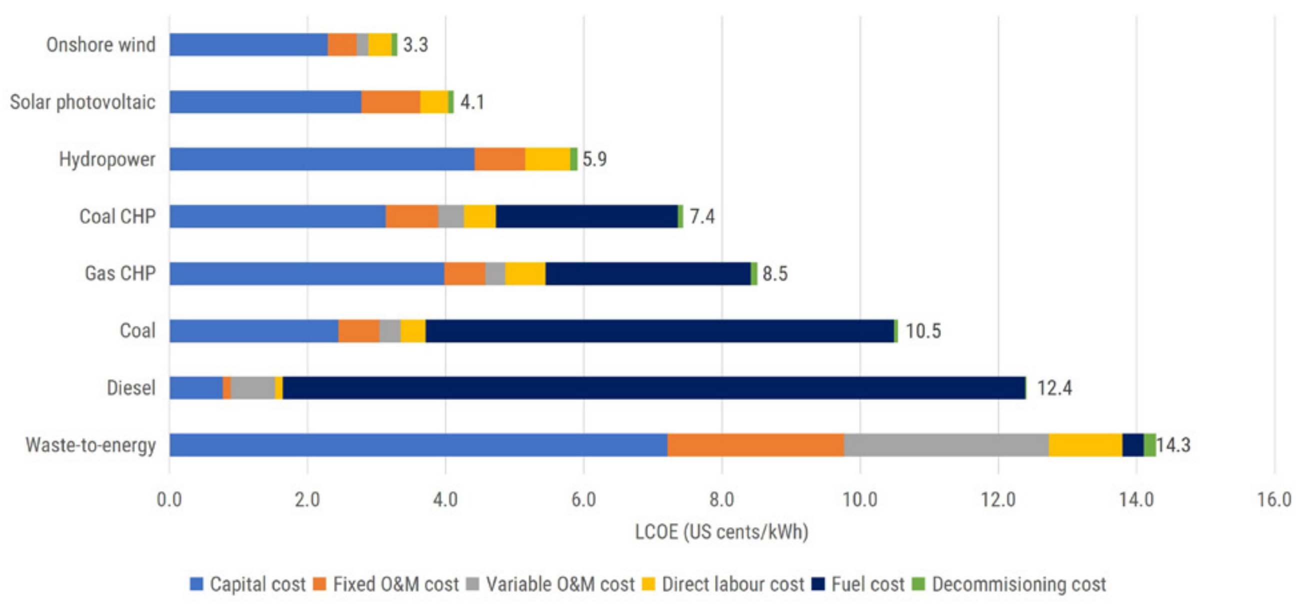
In 2003, the Government of Thailand launched the Thai Energy Efficiency Revolving Fund (EERF) as part of its Energy Conservation Programme. The EERF works to overcome barriers within the Thai financial sector to stimulate adequate financing for energy efficiency and reduce greenhouse gas emissions. It was aimed at strengthening the capacity of commercial banks to finance EE projects, developing the ESCO fund to enable smaller companies to access EE financing, and works with the Bureau of Investment to provide tax/duty exemptions for EE products. The establishment and implementation of the revolving fund has been successful in supporting initial investments in energy efficiency and creating a self-sustained market by encouraging the involvement of commercial banks in this area. This fund was initiated in 2003 to attract investments in energy efficiency, create confidence of entrepreneurs and promote ESCOs as a vehicle to improve energy efficiency. The fund was made available by the Department of Alternative Energy Development and Efficiency (DEDE) with the financial support from the Ministry of Energy. The total budget for five phases of the fund was $245.10 million. Phase 5 of the fund operated from June 2010 to May 2013. During the first phase (2003-2006), the fund was made available to commercial banks without an interest, however, an interest rate of 0.5 per cent was introduced from Phase 2, and was continued at the same rate through to Phase 5. Facility owners, ESCOs and project developers are eligible to borrow from this fund for a maximum of 7 years for EE and Renewable Energy (RE) projects. The size of single loans was capped to about $1.56 million and an interest rate of 4 per cent. Until 2013, 295 project proposals were received (60 per cent EE projects and 40 per cent RE projects) for a total investment of $498.7 million of which $226 million was contributed from this fund and the remaining supported by financial institutions.[a]

a A. Achavangkool, "Experiences on Energy Efficiency Financing Instruments in Thailand", presentation, Inter-regional Workshop on Energy Efficiency Investment Projects Pipeline, Thailand, 2014.

Raising ambition towards net zero emissions in 2050 might seem a challenging target since the country must (1) increase renewable share significantly, and (2) phase out its coal power plant by 2050. However, it will be feasible in the future. In the past, investment in coal-fired generation was a cheap and reliable, albeit polluting, method of generating electricity. This is no longer the case as renewables have matured and costs have dropped significantly. It is cheaper today to generate electricity from renewables, such as solar, hydropower, wind and biomass, as compared to coal-fired technologies. The Levelized Cost of Electricity (LCOE) is a widely used metric in the energy industry for comparing the economic value of different electricity generation technologies. It calculates the unit cost of electricity (US$/MWh or cents/kWh) over the lifetime of the project, including capital, operating and financing costs. LCOE is measured using the lifecycle cost of a system, and therefore balances out the disparity where some technologies have a high capital cost but low operating cost, whereas the other technologies have low capital cost and high operating cost.

NEXSTEP has calculated LCOE for Mongolia (Figure 21) using cost figures presented in Annex 3. This makes LCOEs entirely reflective of the national context of Mongolia. The LCOE component analysis highlights renewable electricity generation technologies e.g., onshore wind (3.3 cents/kWh), solar photovoltaic (4.1 cents/kWh), and hydro (5.9 cents/kWh) are cheaper than coal-fired generation technologies today in Mongolia. The given LCOE for renewable energy is without energy storage addition. Box 8 shows the impact of battery energy storage systems (BESS) on the LCOE. Nevertheless, it must be noted that the landlocked condition of Mongolia might make the materials cost to be more expensive. Additionally, the RE market in Mongolia is yet to get its maturity and the supply chain is still evolving which makes everything expensive. A detailed cost assessment of renewable energy systems will need to be undertaken as part of any RE project planning.

Figure 21. Comparison of Levelized Cost of Electricity



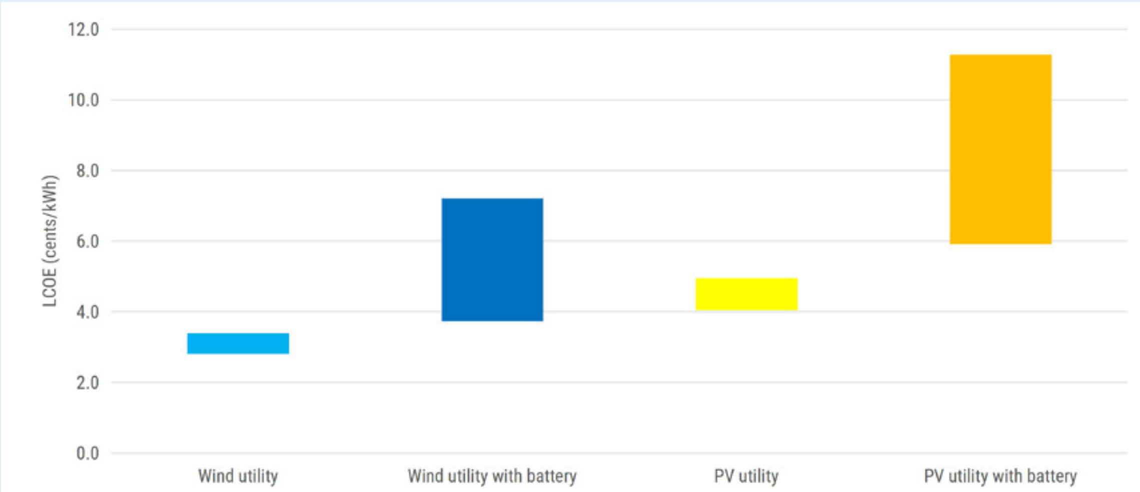
Source: ESCAP.

Box 8. LCOE of electricity generation with battery energy storage system

Battery energy storage system will play a critical role in a fully decarbonized energy system. However, calculating battery capacity requirement for national level is impractical since the ratio between battery capacity and solar PV capacity varies depending on the size and location of the project. For instance, the Port Blair project in India has a battery capacity to renewable capacity ratio of 1.25 (8 MW/10 MWh Lithium-Ion (Li-ion)). However, the Maktoum project in the United Arab Emirates has a ratio of 6 (1.25 MW/ 7.5 MWh). In France, the Diamant and the Barzhour projects have different factors despite being installed in the same country. Therefore, storage capacity is better estimated at the project level. Because of its inherent difficulties, NEXSTEP analysis has avoided estimating specific storage capacity at the national level. Instead, an indicative ratio between battery and solar PV capacity has been considered, which is expected to be around 2.5.[a]

Using this factor, NEXSTEP has estimated the LCOE of utility-scale renewable project with and without storage. Without storage, the LCOE of utility-scale solar photovoltaic will range from 4 to 4.9 cents/kWh while the LCOE of utility-scale onshore wind will range from 5.9 to 11.3 cents/kWh. With storage, the LCOE of utility-scale solar photovoltaic will range from 2.8 to 3.4 cents/kWh, while the LCOE of utility-scale onshore wind range from 3.7 to 7.2 cents/kWh depending on the capacity of storage (the given LCOE range is based on a battery versus capacity ratio between 1 and 4). The higher the battery size, the higher the LCOE. Therefore, finding the optimum battery sizing will be critical for the development of renewable with BESS projects.

LCOE comparison with and without batteries for Mongolia



a H. Beltran, and others, "Battery size determination for photovoltaic capacity firming using deep learning irradiance forecasts", *Journal of Energy Storage*, vol. 33 (January 2021).

NEXSTEP estimated that the capacity of wind will be around 28.8 GW, solar will be around 1.5 GW, hydropower will be around 2 GW, and waste-to-energy will be 0.6 GW in 2050. The investment costs required in power generation will be $48.4 billion until 2050 with net benefits of around $10.9 billion.

There are several pathways that the country may explore, in collaboration with citizens and/or private investors, in order to achieve a net-zero carbon power supply objective. One workable solution and a recent policy instrument that can be considered is the renewable energy auction. This approach is likely to substantially decrease the cost of electricity supply through a competitive price bidding and therefore, return a greater net benefit. The recent auctions e.g., the 60 MW solar PV auction in Cambodia has achieved $0.0387 per kWh. A renewable energy auction, also known as a "demand auction" or "procurement auction", is essentially a call for tenders to procure a certain capacity or generation of renewables-based electricity. The auction participants submit a bid with a price per unit of electricity at which they are able to realize the project. The winner is selected on the basis of the price and other criteria, and a power purchase agreement is signed. The auctions have the ability to achieve deployment of renewable electricity in a well-planned, cost-efficient and transparent manner. Most importantly, it makes the achievement of targets more precise than would be possible by other means, such as a Feed-in-Tariff (FiT).

Auctions are flexible and they allow governments to combine and tailor different design elements to meet deployment and development objectives. Unlike FiTs, where the government decides on a price, auctions are an effective means of discovering the price appropriate to the industry, which is the key to attracting private sector investment. In addition, an auction provides greater certainty about future projects and is a fair and transparent procurement process. However, the administrative and logistic costs associated with auctions are very high unless multiple auctions are undertaken at regular intervals. Further details of designing renewable auction can be found in Box 9.

Box 9. Key design principles of a renewable auction

It is imperative that an auction be appropriately designed to (a) avoid the risk of underbuilding and project delays, and (b) allow sufficient competition among different levels of bidders in order to drive down the cost. IRENA suggests the following key design elements:

- Auction demand: Governments need to clearly indicate the scale or size of each auction, the preferred technology (technology neutral of a specific technology), auction frequency, and the upper and lower limits of projects size and price.
- Pre-qualification: A strict or high pre-qualification for bidders will leave out the smaller entities, while a relaxed pre-qualification may undermine the quality of the project and increase the administrative costs. Governments need to make a trade-off, depending on the project size and other development objectives.
- Selection criteria: Commonly two selection criteria are used: (a) the lowest bid where only the lowest bidder will win; and (b) lowest bids plus other objectives where in addition to the price, other objectives, such as local content and jobs, are taken into consideration.
- Payment modalities: The pay-as-bid model is good to minimize the cost; however, the marginal cost payment model, where the same price (selected based on the highest cost winner) is paid to all winners is also practiced.
- Penalties for non-compliance: There could be cases where the developer either delays the project or fails to complete. To avoid such cases, penalties should be in place. There are two modes of penalty. In the monetary penalty, money will be deducted from bidder's "bond", or the price of energy will be reduced for a delayed completion. A form of non-monetary penalty can be the exclusion of the bidder from future auctions.

Another consideration for the long term is internalizing externalities. The challenges associated with accurately estimating the externalities of fossil fuel energy technologies have continued to result in unfair comparisons with renewables. If the external costs of fossil fuel systems are considered, energy generation from renewables would have been equal, if not lower, to that of conventional energy systems. The external costs arise from pollution and environmental degradation caused by the extraction of fossil fuel resources, indoor and outdoor air pollution, and the negative economic impacts of extreme weather events caused by global warming, such as its impact on agricultural yields.

Carbon pricing is recognized around the world as an effective policy tool to facilitate sustainable energy transition. The external cost of carbon emissions paid by society should be shifted towards the producers and consumers responsible for producing pollution-causing goods by directly setting a price on carbon emissions. There are two main mechanisms for carbon pricing: emissions trading schemes (cap and trade) and carbon taxation. Emissions trading systems place a cap on CO_2-e emissions and allow participants to trade an allowance of CO_2-e emissions under the cap. The mechanism results in a wealth transfer from high emissions to low-emissions technology proponents, increasing the attractiveness of low-emissions technology investments. Carbon taxes simply put a price on the GHG emissions or on the carbon content of fuels. Governments may choose to treat this as a revenue stream or hypothecate these funds to use it as a wealth transfer mechanism.

In today's market, there is no consistency in carbon price, and it is therefore very difficult to choose a carbon price that will suit the national context. The *State and Trend of Carbon Pricing 2022* report published by the World Bank (World Bank, 2022a) suggests that a minimum carbon price of $50-100 per ton of tCO_2-e is needed by 2030 to cost-effectively reduce emissions in line with the temperature goal of the Paris Agreement. In Singapore, the carbon tax rate will be increased to $18/$tCO_2$-e in 2024 and 2025, and $33/$tCO_2$-e in 2026 and 2027, with a view to reaching $37-59/$tCO_2$-e by 2030. In the absence of any carbon price in the East Asia region, an indicative price of $18/$tCO_2$-e could be considered. This is an indicative price to demonstrate how a price on carbon would support the proposed transformation of the energy sector. Further in-depth investigation should be performed, involving subject matter experts and stakeholders, to identify the price suitable for Mongolia.

8. Policy recommendations

8.1. Scenario evaluation

The current policy, SDG and the ambitious scenarios have been evaluated and ranked, using the Multi-Criteria Decision Analysis (MCDA) tool, with a set of 12 criteria and weighting assigned to each criterion (Table 10). While the criteria and weights have been selected based on expert judgement, ideally the process should use stakeholder consultation. If deemed necessary, this step can be repeated using the NEXSTEP tool in consultation with stakeholders where the participants may want to change the weighting of each criterion. The following factors have been considered to assume comparative weighting across the set of criteria, where the total weight needs to be 100 per cent:

(a) Universal access to electricity to be achieved;

(b) Universal access to clean cooking fuel to be achieved;

(c) Renewable energy share in the total final energy consumption to increase;

(d) Energy efficiency improvement should be doubled, and where there is an economic benefit, it should be further enhanced;

(e) The unconditional NDC target should be achieved. Where possible, the conditional target should be achieved if it is economically viable;

(f) Total investment should be kept low, but the net benefit should be high. This was done by assigning both indicators the same weight to ensure that a scenario is chosen on the value-for-money basis; and

(g) Carbon pricing should be introduced to encourage investments in clean energy.

Table 10. Criteria with assigned weighting for MCDA

Criterion	Weighting
Access to clean cooking fuel	10%
Energy efficiency	10%
Share of renewable energy	11%
Emissions targets in 2030	10%
Alignment with Paris Agreement	10%
Fossil fuel subsidy phased out	5%
Price on carbon	5%
Fossil fuel phase-out	5%
Cost of access to electricity	7%
Cost of access to clean cooking fuel	7%
Investment cost	10%
Net benefit from the power sector	10%
Total	**100%**

Table 11 shows the summary of results obtained through this evaluation process. The scenario evaluation suggests that the Towards Net Zero Emissions by 2050 scenario is the highest-ranked energy transition pathway for Mongolia since there will be a significant energy efficiency improvement, renewable share increase, and emissions reduction. Most importantly, it would set the course for the energy sector to achieve the goal of net zero emissions. Therefore, Mongolia should begin developing and aligning strategies and plans in line this scenario, which will also ensure the achievement of all SDG 7 targets as well as the NDC conditional target since the scenario is developed based on the SDG scenario.

Table 11. **Scenario ranking based on MCDA**

Scenarios	Weighted scores	Rank
Towards Net Zero Emissions by 2050 scenario	59.9	1
Sustainable Heating by 2030 scenario	55.3	2
SDG scenario	52.3	3
Current policy scenario	31.6	4
Business-as-usual scenario	14.3	5

8.2. Revisiting existing policies

Mongolia's current energy policies have been evaluated based on the outputs from the LEAP model, in order to highlight any revisions required to achieve the SDG 7 and NDC targets by 2030. These are summarized in Table 12.

Table 12. **Assessment of SDG 7 and NDC targets**

Category	Existing policy	Policy evaluation	NEXSTEP analysis
Access to electricity	Not available.	Mongolia is on track to achieve 100 per cent universal access to electricity by 2024.	There may be some unregistered households and gers that still have no access to electricity. In such minor cases, solar mini-grids and solar home systems, could be considered.
Access to clean cooking	Not available.	The NEXSTEP analysis projects that Mongolia may only reach a 64.8 per cent clean cooking access rate as per the historical improvement trend.	In consideration of comments from stakeholders, NEXSTEP analysis suggests bridging the remaining gap with electric cook stoves and ICS as the most appropriate clean cooking solution.

Category	Existing policy	Policy evaluation	NEXSTEP analysis
Renewable energy in TFEC	Not available.	The share of renewables in TFEC is projected to be 2.8 per cent in the CP scenario due to the increase of planned renewable power capacities under the existing capacity expansion plan.	The renewable energy share in TFEC will further increase to 5.9 per cent in the SDG scenario. This increase is attributable to phasing out of inefficient traditional biomass and charcoal stoves with electric cook stoves and ICS. This increase has also resulted from the additional measures in the energy efficiency.
Renewable energy in power sector	The State Policy on Energy 2015-2030 (IEA, 2018) aims to build the energy security of the country, assure sustainability of the energy sector development and create the basis for enhanced deployment of renewables in the future. Between 2024 and 2030, the share of RE in electricity generation capacity will reach 30 per cent.	The NEXSTEP analysis projects that Mongolia may only reach a 23.3 per cent renewable capacity, falling short from the target. This is because a significant amount of coal-fired generation will still be in operation in Mongolia.	The renewable energy share in installed capacity will further increase to 30 per cent in the SDG scenario. This increase is attributable to the replacement of 253 MW coal power plant with 253 MW hydropower.
Energy efficiency	The State Policy on Energy 2015-2030 (IEA, 2018) aims to build the energy security of the country, and assure sustainability of the energy sector development. An integrated smart energy system will be created by connecting regions with high-capacity transmission lines. Transmission losses should be reduced from 13.7 per cent in 2014 to 10.8 per cent by 2020, and to 7.8 per cent by 2030. In addition, heat loss in buildings should be reduced by 20 per cent in 2020 and by 40 per cent in 2030, compared to 2014 levels.	The CP scenario will not achieve the suggested global energy efficiency improvement target of 3.4 per cent or 4.6 MJ/US$_{2017}$ in 2030. It is projected that the energy intensity will be 5.8 MJ/US$_{2017}$ in 2030.	The energy intensity is further reduced to 4.5 MJ/US$_{2017}$ in 2030 under the SDG scenario, which meets the global energy efficiency target. Achievement of this target requires phasing out inefficient cooking technologies, reducing the share of unclean heating technology, accelerating the implementation of energy management standards and building codes in designated factories/buildings, accelerating mode shifting in transport sector, and promoting equipment performance benchmarks and labelling.
Emissions reduction	In its Updated Nationally Determined Contribution (Government of Mongolia, 2022), Mongolia intends to reduce its GHG emissions unconditionally by 22.7 per cent from the BAU baseline by 2030, and by 44.9 per cent subject to adequate and enhanced access to technology development and transfer, financial resources and capacity-building support.	Mongolia is on track to achieve the unconditional target of 22.7 per cent emissions reduction by 2030.	Mongolia will further achieve more than 40 per cent emissions reduction by 2030 because of the additional measures in the demand sector to improve its energy efficiency.

8.3. Policy recommendations

8.3.1. Promote electric cook stoves to provide a sustainable solution to achieving universal access with multifold benefits

Universal access to clean cooking solutions should be a key priority in Mongolia and it needs to be included in the energy policy. The NEXSTEP analysis suggests the remaining clean cooking gap in Mongolia should be closed with the promotion of electric cook stoves. Electric cook stoves are a key solution to achieving universal access to clean cooking by 2030, and will support the achievement of net zero emissions scenario with no added burden on fuel imports.

Electric cook stoves are more efficient than other cook stoves, including gas stoves. Electric cook stoves have cheaper annualized costs compared to LPG stoves, making them more affordable for households. The annualized cost of an electric cook stove will be $74, while the LPG cookstove will be $113. In the area where reliable electricity supply is not available, ICS can be considered. It is estimated that a total investment of $30.9 million will be required to distribute electric cook stoves to 0.14 million households ($10.5 million), and ICS stoves to 0.23 million households ($20.4 million).

8.3.2. Adopt a multi-sectoral approach to raise energy efficiency strategies by 2030 to align with the global improvement target

Energy efficiency policies across sectors can help achieve substantial energy savings by reducing the need for investment in energy infrastructure, fuel costs and vulnerability to fossil fuel prices. Policymakers should improve the energy efficiency strategy by including well-defined best practice policies, implementation timelines and enforcement.

Achievement of the SDG 7 target of 4.5 MJ/US$ by 2030 (3.6 per cent annual improvement rate), will require a reduction of TFEC by 1.3 Mtoe compared to the BAU scenario. To achieve this target, the Government should consider accelerating the implementation of energy management standards, energy codes, equipment performance benchmarks and labelling, and transport mode shifting by 2030. Phasing out inefficient individual heating technologies is also critical in the long run.

8.3.3. Fuel switching strategies, including electrification, accelerate SDG 7 progress and provide multi-fold benefits in the long run.

This Road Map suggests that policymakers should raise the ambition further to align with net zero emissions scenarios. NEXSTEP identified that electricity will be an important strategy for Mongolia to replace the demand for oil products, rather than hydrogen, due to current uncertainties in the hydrogen market. Further in-depth investigation should be performed, involving subject matter experts and stakeholders, to identify the techno-economic potential of hydrogen in Mongolia.

Electrification of the transport system will also be critical for Mongolia. A vigorous adoption of electric vehicles, for example, would reduce the demand for oil products. Another advantage of EVs is their ability to absorb excess renewable energy. With specialized networks and large numbers of EVs plugged into the grid at any one time, there is the possibility to use the combined stationary battery capacity as an element of load levelling to enable higher renewable penetrations in future. To promote the investments, Mongolia can set financial and tax incentives, and safety standards.

8.3.4. Decarbonize the power and heating sector by investing in renewable energy to help achieve the net zero emissions target

Mongolia will fall short of achieving 30 per cent renewable share target in the installed capacity by 2030. Stopping new investment in coal-fired power generation is essential to meet the renewable targets. Policymakers should cancel any coal-fired capacity addition and plan the retirement of existing coal-fired power plants. The importance of early action cannot be overstated. A schedule for the planned retirement of existing coal-fired power plants should be defined and forced-retired as quickly as possible to reach zero coal power plant by 2050.

In the past, investment in coal-fired generation was a cheap and reliable, albeit polluting, method of generating electricity. This is no longer the case as renewables have matured and costs have dropped significantly. It is cheaper today to generate electricity from renewables, such as solar, hydropower, and wind, as compared to coal-fired technologies. Strategies, such as renewable auction and carbon pricing, can be considered to provide revenue streams for investing renewable energy generation in a fully decarbonized energy system. The same measure must be implemented simultaneously in the heating generation as well.

8.3.5. Develop green financing policies

Accelerating green financing is critical to achieving the proposed sustainable energy transition. Policymakers need to work with central banks, regulatory authorities and investors to examine the possibility of developing a green finance policy or fund to help close the investment gap. Another option is green bonds to mobilize resources from domestic and international capital markets to finance climate solutions. Renewable energy technologies have relatively high financing costs in developing countries, which reflects their unattractive risk/return profile. This is because of their long-term horizon, high initial capital costs (including high infrastructure cost), unfavourable policy for grid access, illiquid equipment and project risks. Policymakers can reduce high financing costs by using two methods: de-risking and direct incentives. De-risking has two basic forms: policy de-risking instruments that reduce risk, and financial de-risking instruments that transfer risk. Direct incentives are direct finance transfers or subsidies to low carbon investments. The United Nations Development Programme's *De-risking Renewable Energy Investment* is an important guide for policymakers in developing strategies to reduce risks in renewable energy investment (United Nations Development Programme, 2021).

8.4. Building back better in the recovery from the COVID-19 pandemic

Energy plays a key role in the process of building better from the COVID-19 pandemic. There are two important dimensions of energy that must be considered.

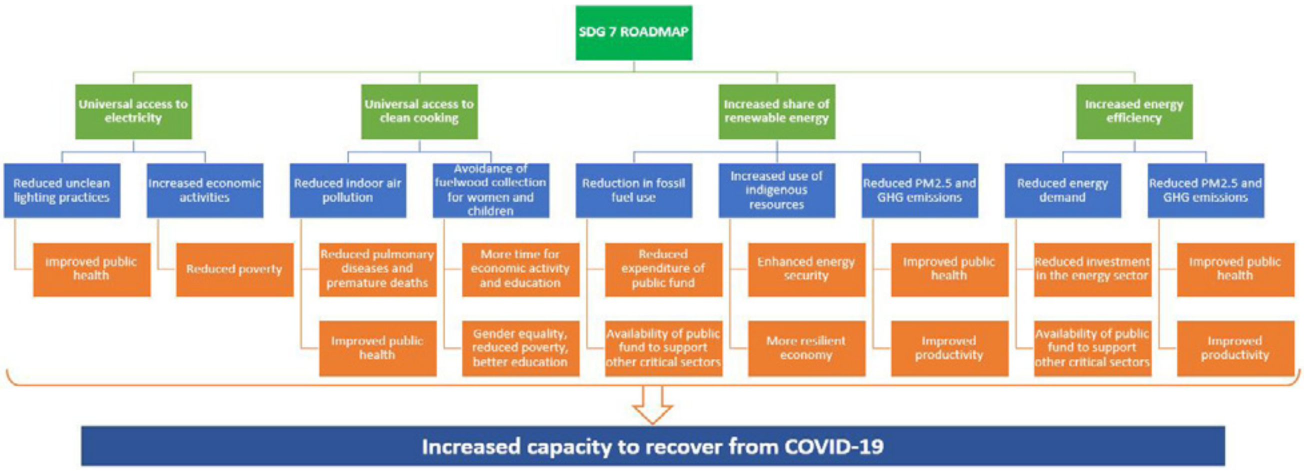
First, energy enables a range of essential services to be delivered: supporting health-care facilities, supplying clean water for essential hygiene, enabling communication and IT, and off-grid renewables refrigeration for vaccine storage. These services are only possible with reliable, affordable supplies of energy and are essential in boosting the resilience of the country.

Second, where countries are seeking to revive their economies after the downturn triggered by the COVID-19 pandemic, investing in sustainable energy offers opportunities to generate economic activity and create jobs. Unfortunately, many developing countries suffer from a limited fiscal space to be able to make these investments. However, it is important that countries in the Asia-Pacific region avoid investing in high carbon sectors to revive GDP growth, as this will undermine long-term sustainable development. In the energy sector, there are many opportunities for investment in both renewable energy and energy efficiency, even on small scales. These investments on balance have higher economic and job multipliers than investing in fossil fuels. Moreover, energy efficiency investments can benefit the economic recovery by reducing energy costs for households and businesses.

The COVID-19 pandemic has caused social and economic disruption globally, and Mongolia was no exception. With the Government of Mongolia's effective COVID-19 health strategies, according to WHO (2023), there have been 1,010,975 confirmed cases of COVID-19 with 2,284 deaths (as of 21 September 2023). A total of 5,668,144 vaccine doses have been administered (as of 16 March 2023). Notwithstanding, the country's GDP contracted by 4.6 per cent in 2020 (World Bank, 2023). While grappling with the devastation caused by the pandemic, Mongolia should not lose sight of its progress and ambitions towards achieving the SDG targets. Mongolia should take the opportunity to build back better from this crisis, in order to become more resilient to face future challenges, such as climate change.

Thus, it has never been more important to design a well-planned energy transition pathway that enables the country's energy sector to shield itself from the likely impacts of the COVID-19 pandemic and helps to build back better as part of COVID-19 recovery. The SDG 7 Road Map has identified several key areas that will assist policymakers in strengthening policy measures to help recover from the COVID-19 impact while maintaining the momentum to achieving the 2030 Agenda for Sustainable Development and the Paris Agreement. Figure 22 presents how the SDG 7 Road Map will help to increase the capacity of Mongolia to recover from the COVID-19 pandemic.

Figure 22. **SDG7 Road Map will increase the capacity of Mongolia to recover from the COVID-19 pandemic**



Source: ESCAP.

8.4.1. Accelerating access to clean and modern energy services

Access to clean and modern energy services is essential in helping rural populations combat challenges related to the COVID-19 pandemic. Relying on traditional and hazardous technologies for cooking increases their susceptibility to the effects of the virus. Ongoing research is finding relationships between air pollution and the incidence of illness and death due to COVID-19. Recent research suggests that PM2.5[20] air pollution plays an important role in increased COVID-19 incidence and death rates. One such study reported that PM2.5 is a highly significant predictor of the number of confirmed cases of COVID-19 and related hospital admissions (Andree, 2020). It is important to consider how the lack of access to clean cooking combines with COVID-19 to affect the most vulnerable people.

Mongolia had around 46.8 per cent of the population, or around 0.43 million households, that lacked access to clean cooking fuel in 2021. Women and children disproportionately bear the greatest health burden from polluting fuels and technologies in homes as they typically labour over household chores such as cooking and collecting firewood, and spend more time exposed to harmful smoke from polluting stoves.

One potential medium-term impact of COVID-19 could be decreased investment in energy access, as national budgets come under strain and priorities shift. In addition, access to clean cooking technologies is a major development challenge that is often forgotten. WHO has warned about the severity of health impacts arising from the exposure to traditional use of biomass for cooking and space heating, and is encouraging policymakers to adopt measures to address this challenge. By 2019, there were around 1,009 fatalities per year due to household air pollution-related diseases in Mongolia.[21]

The SDG 7 Road Map has identified technical options for connecting the remaining population to cleaner fuel for cooking and heating. The benefits resulting from this measure, in the form of reduced mortality and health impact outweigh the needed investment to advance the clean cooking rate and clean heating rate to reach 100 per cent. According to the World Bank (World Bank, 2022b), the cost of health damage from PM2.5 exposure due to household air pollution in Mongolia is around $395 million per year, which is significantly higher compared to the cumulative cost of providing clean cooking technologies of $30.9 million.

20 Particulate matter (PM2.5) particles are produced during fossil fuel combustion and able to travel deeply into the respiratory tract, reaching the lungs. Exposure to fine particles can cause short-term health effects such as eye, nose, throat and lung irritation, coughing, and shortness of breath.

21 See World Bank, "The Global Health Cost of PM2.5 Air Pollution: A Case for Action Beyond 2021", International Developmed in Focus, Washington, D.C., 2022b.

8.4.2. Savings from the energy sector will help to build other sectors

The NEXSTEP analysis identifies that there are ample opportunities for Mongolia to save energy by improving energy efficiency beyond the current practices. Several of these measures also provide cost savings and strengthen the country's energy security, making it less susceptible to fuel supply and price shocks. For example, the total energy saving potential in the transport sector through the introduction of electric vehicles and the improvement of fuel efficiency in the SDG scenario will be around 224 ktoe in 2030. Savings from this improvement can help investment in other sectors, such as health, social protection and stimulus, which are critical in responding to and recovering from the COVID-19 pandemic.

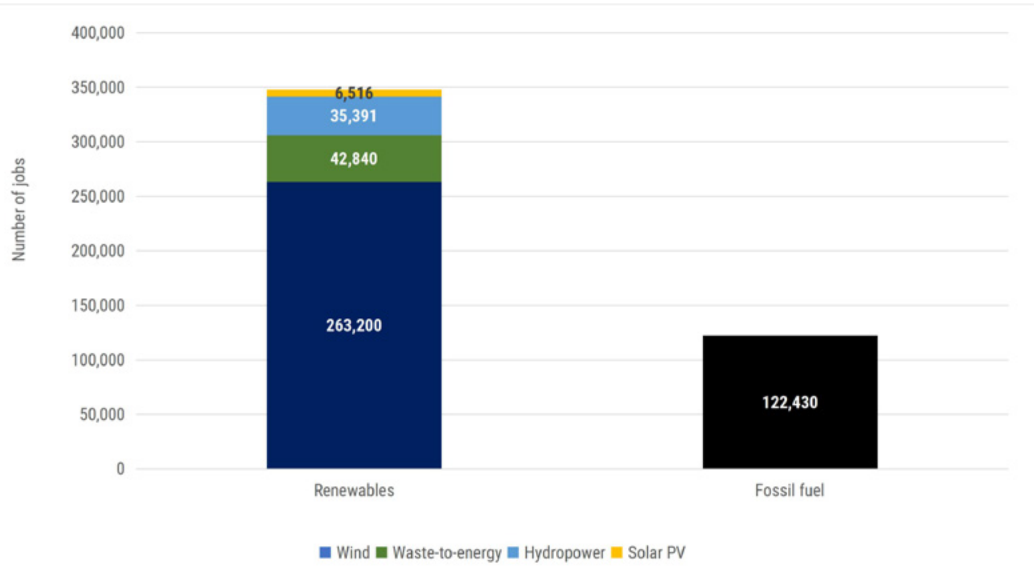
The electrification of the transport sector provides multiple additional benefits (in addition to energy saving), including the reduction of expenditure on importing petroleum products and reducing local air pollution. Such measures are very important to solidifying the pathway to recovery from COVID-19 and building back better.

8.4.3. Long-term recovery planning to build back better while ensuring sustainable growth

The COVID-19 pandemic has caused unprecedented socioeconomic impacts around the world. On the brighter side, many countries have taken this opportunity to "reset" their economies. For example, the World Economic Forum has launched the Great Reset initiative to encourage economic transformation and build a better society as the world recovers from the global health-care crisis (World Economic Forum, 2020), and the European Commission has placed the European Green Deal at the heart of their programme for long-term sustainable recovery from the pandemic (European Commission, 2020).

Deployment of clean energy systems requires much less lead time than fossil fuel counterparts. Moreover, clean energy can create three times more jobs for the same amount spent on fossil fuel. Under the Towards Net Zero Emissions by 2050 scenario discussed in chapter 6, an additional 2 GW solar power plant, 28.8 GW wind, 2 GW hydropower, and 0.6 GW waste-to-energy plant are required. This will require an investment cost of around $0.9 billion for solar power plants, $35 billion for wind, $4.7 billion for hydropower, and $5.6 billion for waste-to-energy plants by 2050. The average job creation for solar PV, wind, hydropower and waste-to-energy generation are around 7.24, 7.52, 7.53, and 7.65 per million US dollars respectively (Garrett-Peletier, 2017). In contrast, Garrett-Peletier (2017) found that only 2.65 full-time equivalent jobs are created per million US dollars of spending in fossil fuels. Therefore, these renewable investments will provide employment opportunities for around 2.54 million people as compared with employment opportunities for around 0.93 million people that have been generated from the same amount of investment in fossil fuel (Figure 23).

Figure 23. Comparison of number of jobs created by renewable energy and fossil fuels



Source: ESCAP.

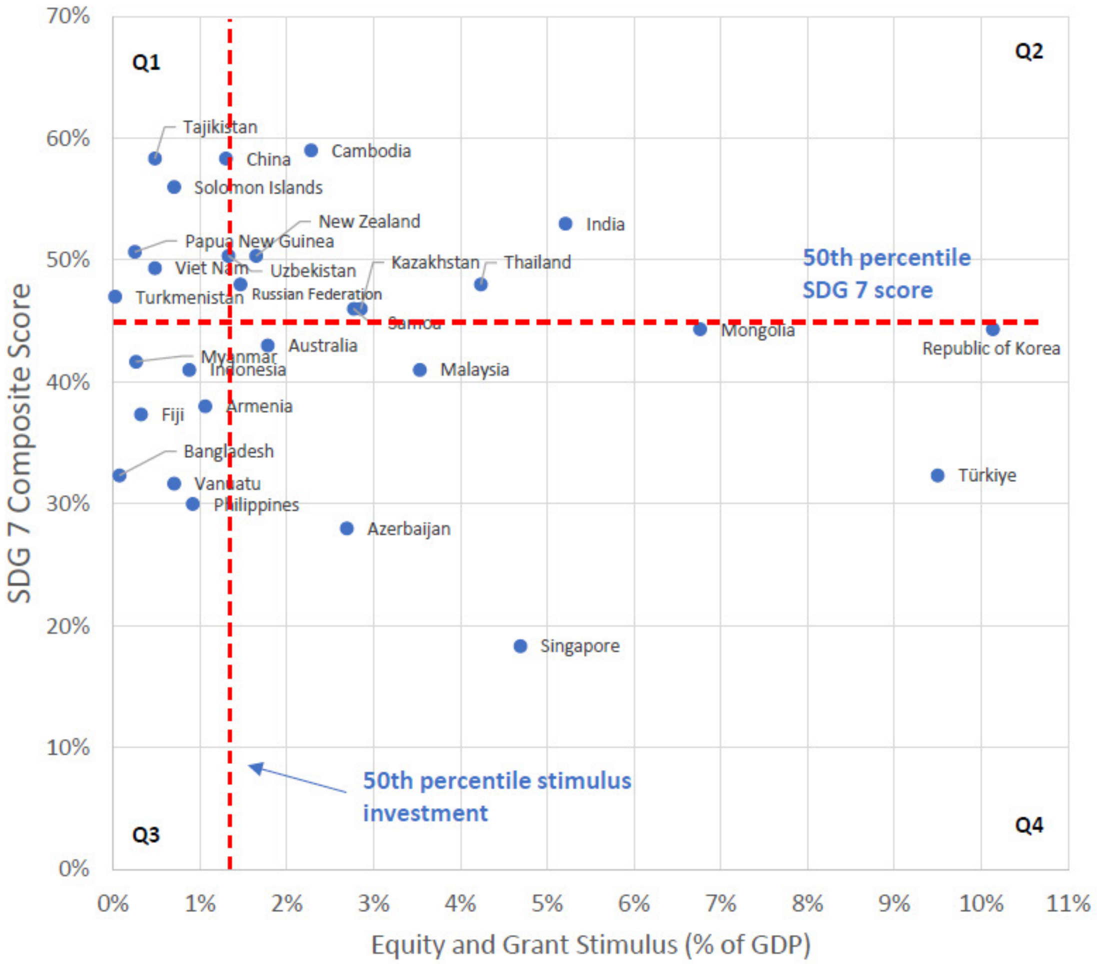
8.4.4. COVID-19 recovery options for Mongolia

ESCAP dedicated the 2022 edition of its *Economic and Social Survey of Asia and the Pacific* to the issue of sustaining early recovery from COVID-19, with a focus on the challenges faced by developing countries (ESCAP, 2022). The report advocates “spending smart and taxing fairly” to combat the fiscal shortfall. Investments in health care, social protection and education are critical for long-term sustainable development and future resilience but consume considerable resources. This should be offset by more efficient tax collection and a wider tax base. Even if these reforms were wholeheartedly accepted, they would take years to implement, and would not immediately provide the financial space needed for energy and/or other investments to recover from the current crisis.

Other forms of support are increasingly needed, such as debt service suspension, issuance of public bonds, debt swaps, the increased use of risk transfer instruments, and the relaxation of investment restrictions for sovereign wealth funds and pension funds (ESCAP, 2021).

Williamson (2022) mapped the Asia-Pacific countries by their SDG 7 composite values against the COVID-19 stimulus-response (as a percentage of GDP) to propose different fiscal options for a sustainable energy-led recovery (Figure 24). Mongolia has shown the capacity to launch stimulus measures, but at the same time it needs to accelerate progress on SDG 7 (quadrant 4). The SDG 7 deficits vary across different targets. Much more needs to be done by Mongolia to address direct stimulus towards its SDG 7 related investments.

Figure 24. Asia-Pacific countries mapped by equity and grant stimulus against SDG 7 composite score



Source: M. Williamson, “A Sustainable Energy-Led Recovery from COVID-19 in the Asia-Pacific Region”, Working Paper Series, United Nations Economic and Social Commission for Asia and the PACIFIC. ESCAP/ 9-WP/71.

Note: Countries with zero stimulus omitted.

9. Conclusion and the way forward

The 2030 Agenda for Sustainable Development and Paris Agreement provide a common goal for all countries to achieve their sustainability and climate objectives. Achieving the SDG 7 and NDC targets is not an easy feat, but it will help to create a more sustainable and resilient society. This Road Map has presented a number of different scenarios together with their technical feasibility, investments, benefits, challenges and opportunities to inform policymakers on different pathways to energy transition. NEXSTEP has also looked beyond just achieving SDG 7 targets and explored the full potential of the country in relation to decarbonizing its power sector and assessing the potential to advance towards net zero by 2050.

Mongolia is projected to achieve universal access to electricity by 2024. On the other hand, much needs to be done to achieve universal access to clean cooking by 2030. A coordinated approach is therefore much desired from the private and public sectors in advancing the clean cooking gaps in order to provide clean technologies to the remaining population. For example, electric cook stoves, which build on commonly used practices, should be promoted to reduce fuel consumption and household indoor pollution. ICS can be promoted in areas where reliable electricity supply is not available.

Opportunities exist in the residential, industrial, transport, and commercial sectors to save more energy through the implementation of energy efficiency measures particularly via mode shifting, fuel switching, energy management standards, and energy codes. Increased efforts can help achieve the global energy efficiency improvement target of 3.4 per cent annually. Although the country is on track to achieve the unconditional energy target, increasing the energy efficiency measures will help Mongolia achieve more emissions reduction. In the Sustainable Heating by 2030 scenario, eliminating unclean heating technology will further help Mongolia to achieve its conditional NDC targets.

Mongolia will fall short of achieving its renewable energy capacity target by 2030. The renewable energy share in TFEC will just improve slightly since Mongolia's energy system is heavily dependent on coal. Improving energy efficiency and increasing modern renewable energy will further increase the renewable energy share. The promotion of electric cook stoves and electric vehicles in the long run will require substantial amount of electricity in the future. Diversification of generation sources using solar PV, wind, hydropower, waste-to-energy, heat pumps, and electric boilers would help the country to meet the increasing demand for electricity and heat, diversify generation sources and improve energy security. The scenario analysis using the MCDA tool suggests that the Towards Net Zero Emissions by 2050 scenario is the highest ranked scenario for navigating the energy sector towards 2050. In addition to achieving the SDG 7 targets, this scenario will also enable Mongolia to exploit its full potential for emissions reduction in the long term as well as fulfil the commitment made in COP 26.

Annexes

I. National Expert SDG 7 tool for energy planning methodology

The analysis presented in this national Road Map is based on the results from the National Expert SDG 7 Tool for Energy Planning (NEXSTEP) project. NEXSTEP is an integrated tool for assisting policymakers in making informed policy decisions that will help in achieving SDG 7 and NDC targets by 2030. The SDG 7 and NDC targets are integrated in the LEAP energy model and back casted from 2030, since the targets for 2030 are already defined.

Annex Table 1. Targets and indicators for SDG 7

Target	Indicators	2021	2030
7.1. By 2030, ensure universal access to affordable, reliable, and modern energy services.	7.1.1. Proportion of population with access to electricity.	99.5%	100%
	7.1.2. Proportion of population with primary reliance on clean fuels and technology for cooking.	53.2%	100%
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.	1.8% (excluding traditional biomass)	5.9%
7.3. By 2030, double the global rate of improvement in energy efficiency.	7.3.1. Energy intensity measured as a ratio of primary energy supply to gross domestic product.	6.3 MJ/US$ (2017) PPP	4.5 MJ/US$ (2017) PPP

SDG 7.2. Renewable Energy

Methodology: Share of renewable energy in total final energy consumption, where TFEC is total final energy consumption, ELEC is gross electricity production and HEAT is gross heat production.

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

SDG 7.3. Energy Efficiency. "By 2030, double the global rate of improvement in energy efficiency", as measured by the energy intensity of the economy. This is the ratio of the total primary energy supply (TPES) and GDP. Energy intensity is an indication of how much energy is used to produce one unit of economic output. As defined by the IEA, TPES is made up of production, plus net imports minus international marine and aviation bunkers plus stock changes. For comparison purposes, GDP is measured in constant terms at 2017 PPP.

where EI_{t1} is energy intensity in year t1 and EI_{t2} is energy intensity in year t2.

The SDG 7.3. improvement rate for Ormoc (suggested global improvement rate): 3.2 per cent.

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

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

where EI_{t1} is energy intensity in year t1 and EI_{t2} is energy intensity in year t2.

Base period improvement rate for Mongolia (1990-2010): 2.4 per cent.

Doubling the improvement rate requirement for Mongolia (2010-2030): 4.8 per cent.

Historical improvement rate for Mongolia (2010-2021): 2.2 per cent.

Required improvement rate for Mongolia in the remaining period to achieve the doubling improvement rate (1990-2010): 7.7 per cent.

SDG 7.3. Improvement rate for Mongolia (suggested global improvement rate): 3.4 per cent.

II. Key assumptions for NEXSTEP energy modelling

(a) General parameters

Annex Table 2. GDP, PPP and growth rate

Parameter	Value
GDP (2021, constant 2015 US dollar)	US$ 13.75 billion
PPP (2021, constant 2017 US dollar)	US$ 39.06 billion
Growth rate	2021 to 2022 (4.8%); 2022 to 2023 (5.4%); 2023 to 2024 (6.1%); 2024 forward (6.6%)

Annex Table 3. Population, population growth rate and household size

Parameter	Value
Population (2021)	3,312,275
Population growth rate	2% per annum
Number of households (2021)	920,076
Household size (constant throughout the analysis period)	3.6

(b) Demand-side assumptions

(i) Transportation

- Land transport consumption is estimated using the vehicle statistics, load factor, annual travel mileage and estimated fuel economy as shown in Annex Table 4. The factors are based on vehicle statistics compiled by the local consultant.
- Land transport activities, in 2021, were estimated to have been 28.6 billion passenger-kilometres and 28.1 billion tonne-kilometres. The growth in both passenger transport and freight transport activities is assumed to be growing at the same rate as the GDP per capita, i.e., 4.5 per cent per annum.

Annex Table 4. Passenger-km and ton-km distribution

Passenger Transport	Percentage share of vehicles by fuel type	Annual travelled mileage (km)	Fuel consumption	Percentage share of passenger-km
Passenger Car	Gasoline – 78.9%	6,550	8.3 km/l	25.3%
	Diesel – 21%		10.0 km/l	
	Electric – 0.1%		2.5 km/kWh	
Motorbike	Gasoline – 100%	2,500	33.3 km/l	0.7%
Taxi	CNG – 100%	12,500	9.1 km/l	1.5%
Bus	Diesel – 99.7%		2.5 km/l	72.5%
	Electric – 0.3%		0.5 km/kWh	
Freight Transport	**No. of vehicles**	**Annual travelled mileage (km)**	**Fuel consumption**	**% share of ton-km**
Freight Truck	Diesel – 100%	6,000	2.5 km/l	92.5%
Van	Diesel – 100%	7,500	3.3 km/l	7.5%

(ii) Residential

- The residential sector is further divided into urban and rural households. Both urban and rural households have achieved a 99.5 per cent electricity access rate and the overall clean cooking rate was 53.2 per cent in 2021. The breakdown is shown in Annex Table 5.

Annex Table 5. Cooking distribution in urban and rural households[22]

Stove type	Energy intensity (GJ/household)	Urban	Energy intensity (GJ/household)	Rural
LPG stove	4.5	2.5%	4.5	0.4%
Natural gas stove	4.5	0.5%	4.5	-
Electric stove	3.8	68.7%	3.0	16.3%
Biomass stove*	4.5	12.3%	4.5	75.5%
Charcoal stove*	4.5	16.0%	4.5	7.8%

* This is assumed as unclean fuel/technology.

- The residential appliance ownership data and energy use intensity in the baseline year were provided by the local consultant. The appliance ownership is projected to grow a rate similar to the growth in GDP. The average electrical demand per owning household for the different appliances are assumed to be constant throughout the analysis period, unless further energy efficiency measures are implemented.

22 The clean cooking access rate is indicated as 53.2 per cent (World Health Organization, 2022). The energy intensity is based on assumptions provided by the local consultant.

Annex Table 6. **Residential appliance baseline assumptions**

Appliance	Electricity intensity (kWh/HH/year)	Ownership – urban	Electricity intensity (kWh/HH/year)	Ownership – rural
Lighting	351.0	100%	720.0	100%
Refrigerator	280.8	90%	327.6	50%
Television	302.4	100%	504.0	100%
Oven	432.0	100%	288.0	60%
Washing machine	115.2	60%	40.8	15%
Iron	48.0	95%	48.0	80%
Other	163.2	50%	516.0	50%

- The residential heating technology data and energy use intensity in the baseline year were provided by the local consultant. The average heat demand per owning household for the different technology are assumed to be constant throughout the analysis period, unless further energy efficiency measures are implemented.

Annex Table 7. **Heating distribution in urban and rural households**

Heating technology	Energy intensity (GJ/household)	Urban	Energy intensity (GJ/household)	Rural
District heating	36.5	80%	36.5	-
Coal furnace	63.4	15%	63.4	54%
Wood furnace	34.2	5%	34.2	20%
Electric heater	290.6 (kWh/HH)	-	290.6 (kWh/HH)	16%
Animal waste	2	-	2	10%

(iii) Industry

- The industry sector is differentiated into 11 subcategories. The fuel consumption by industry subcategories is detailed in Annex Table 8.
- The industrial GDP is assumed to grow at a rate similar to the national GDP growth rate. The energy intensity is assumed constant throughout the analysis period in the absence of energy efficiency interventions.

Annex Table 8. Fuel consumption by industry subcategories in 2021

Industry	Fuel consumption (ktoe)				
	Coal	Oil products	Electricity	Heating	Total
Cement and non-metals	55.8	1.2	186.2	3.7	**246.9**
Pulp and paper	0.3	1.6	1.2	4.4	**7.4**
Textile, leather, and leather products	-	9.0	3.0	27.1	**39.1**
Iron and steel	8.0	4.7	98.2	13.0	**123.9**
Fertilizer, chemical and rubber products	0.2	0.8	0.3	3.7	**4.9**
Food and beverages	14.5	78.2	85.6	218.0	**396.3**
Machinery and transport equipment	0.4	1.6	0.9	4.4	**7.2**
Wood and other products	0.4	2.0	0.7	5.4	**8.4**
Other processing industry	-	22.0	-	-	**22.0**
Mining	12.3	269.2	35.5	61.4	**378.4**
Communication	12.0	-	28.0	40.0	**80.0**
Total	**104**	**390**	**439**	**381**	**1314.0**

(iv) Commercial sector

- The total annual energy consumption in the commercial sector was 532 ktoe in 2021. It is projected to grow at an annual rate similar to the national GDP growth rate.
- The commercial sector is further differentiated into seven categories and the energy consumption by categories are as shown in Annex Table 9.

Annex Table 9. Commercial sector fuel consumption in 2021

Category	Floor space (million m^2)	Fuel consumption (ktoe)				
		Electricity	LPG	Diesel	Heating	Total
Private offices	3.75	8.3	-	0.8	157.0	166.1
Government buildings	1.41	3.2	-	0.3	61.3	64.9
Shopping malls	1.70	16.2	-	2.1	77.0	95.3
Hotels	0.04	0.3	-	-	2.6	2.9
Health facilities	1.14	6.7	-	2.0	58.2	66.8

Category	Floor space (million m²)	Fuel consumption (ktoe)				
		Electricity	LPG	Diesel	Heating	Total
Educational institution	2.43	6.8	-	0.7	128.6	136.1
Worship centres	0.01	-	-	-	-	-
Total	**356.84**	**41.5**	**-**	**6.0**	**484.6**	**532.1**

(v) Other sectors

- The remaining demand is used for agriculture. The consumption growth is projected to grow at the same as the national GDP growth rate.

Annex Table 10. Consumption by other sectors in 2021

Category	Fuel consumption (ktoe)					
	Coal	Natural gas	Oil products	Electricity	Heating	Total
Agriculture	2	-	-	7	6	15

III. Power technologies cost and key assumptions

The cost parameters considered for the power technologies are as follows:

Annex Table 11. Power technologies key assumptions

Technology	Efficiency	Investment cost (US$/MW)	Fixed O&M (US$/MW-year)	Variable O&M (US$/MWh)
Coal CHP	55%	2.60	42,424	3.7
Gas CHP	69%	3.30	33,400	2.9
Coal	35%	2.03	33,079	3.1
Diesel	46%	0.80	8,000	6.4
Solar	-	0.61	12,726	-
Wind	-	1.22	15,209	1.6
Hydro	-	2.35	26,570	-
Waste	95%	9.32	223,788	29.6
Coal HOB	95%	0.77	35,524	2.1
Gas HOB	95%	0.06	2,080	1.2

Technology	Efficiency	Investment cost (US$/MW)	Fixed O&M (US$/MW-year)	Variable O&M (US$/MWh)
Heat pump	310%	0.93	2,173	1.8
Electric boiler	99%	0.08	1,162	1.0

Source: International Renewable Energy Agency (IRENA), "Renewable Energy Solutions for Heating Systems in Mongolia: Developing a strategic heating plan", Abu Dhabi, 2023. Available at https://www.irena.org/Publications/2023/Aug/Renewable-Energy-Solutions-for-Heating-Systems-in-Mongolia

IV. Economic analysis data for clean cooking technologies

The NEXSTEP economic model utilizes the technological and cost parameters to estimate the annualized cost of clean cooking technologies (Annex Table 12). The calculation assumes an annual cooking thermal energy requirement of 3,840 MJ per household. In addition, a discount rate of 5.37 per cent is assumed.

Annex Table 12. Technology and cost data for clean cooking technologies

Technologies	Efficiency[23] (%)	Lifetime[24] (years)	Stove cost (US$)	Variable O&M[25] (US$/year)	Fuel cost (US$)
LPG stove	47	7	30	10	0.52 per kg
Electric stove	84	15	37	10	0.045 per kWh
ICS stove	30	4	35	10	0.1 per kg

V. Summary results for the scenarios

	BAU scenario	CPS scenario	SDG scenario
Universal access to electricity in 2030	100%	100%	100%
Universal access to clean cooking in 2030	64.8%	64.8%	100%, via electric stoves
Energy efficiency in 2030	6.9 MJ/US$	5.8 MJ/US$	4.5 MJ/US$
Renewable energy share in TFEC in 2030	1.8%	2.8%	5.9%
GHG emissions in 2030	44.4 $MtCO_2$-e	34 $MtCO_2$-e	25.6 $MtCO_2$-e
Renewable energy share in installed capacity in 2030	18.3%	23.3%	30%
Net benefits from the power sector	US$ 1.6 billion	US$ 2 billion	US$ 218.4 billion
Total investment for the power sector up to 2030	US$ 4.9 billion	US$ 4.3 billion	US$ 4.3 billion

23 Source for: ICS – ESCAP estimation; LPG stove efficiency ranges from S. Malla and G.R. Timilsina, 2014; electric cookstove (induction stove) from IEA and ESTAP, 2012.

24 Source for: ICS – ESCAP estimation; LPG stove from Clean Cooking Alliance, 2021; electric stove from IEA and ESTAP, 2012.

25 Variable O&M is based on own assumptions. ESCAP assumptions or author's assumptions?

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