**Energy Transition Pathways for the 2030 Agenda**

**SDG 7 Roadmap for Nepal**

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*Developed using National Expert SDG 7 Tool for Energy Planning (NEXSTEP)*

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# Executive summary

Transitioning the energy sector to achieve 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 7 (SDG 7) and other SDGs. To address this challenge, 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 SDG 7 targets as well as 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.

The key objective of this SDG 7 roadmap is to assist the Government of Nepal in developing enabling policy measures to achieve the SDG 7 targets. This roadmap contains a matrix of technological options and enabling policy measures for the Government to consider. It presents several scenarios that have been developed using national data, and which consider existing energy policies and strategies as well as reflect on other development plans. These scenarios are expected to enable the Government to make an informed decision to develop and implement a set of policies to achieve SDG 7 by 2030, together with the NDC.

## Highlights of the roadmap

Nepal has made significant progress in increasing access to electricity in recent years. Based on this progress, it is estimated that Nepal will achieve universal access to electricity by 2024, earlier than the timeline mentioned in the Sustainable Development Goals Status and Roadmap 2016-2030. However, universal access to clean cooking technology and fuel has been, and remains, a challenge as more than half of the population is still relying on polluting cooking fuels and technology. Well-planned and concerted efforts will need to be made to achieve universal access to clean cooking by 2030. Energy efficiency improvement needs to be boosted across different sectors in order to achieve a 2.98 per cent annual improvement, reducing energy intensity to 3.5 megajoules per United States dollar by 2030.

Being a landlocked country with a mountainous topography and no proven fossil fuel reserve, Nepal is heavily reliant on imported energy resources (i.e., oil products); therefore, energy security is high on the national agenda. On the bright side, Nepal’s abundant hydro resources supply two-thirds of the country’s electricity demand. Small-scale renewable energy resources – mainly micro- and mini-hydro, and solar energy – are also used in meeting the electricity demand of remote and very remote areas. In addition, in its second NDC, Nepal has set out a plan for increasing its clean electricity exports to neighbouring countries. The NEXSTEP analysis has examined the usage of fossil fuel in the country e.g., in the transport sector and identified ways for Nepal to reduce its reliance on imported fuel to safeguard its energy sector from price and supply shocks.

## Achieving Nepal’s SDG 7 and NDC targets by 2030

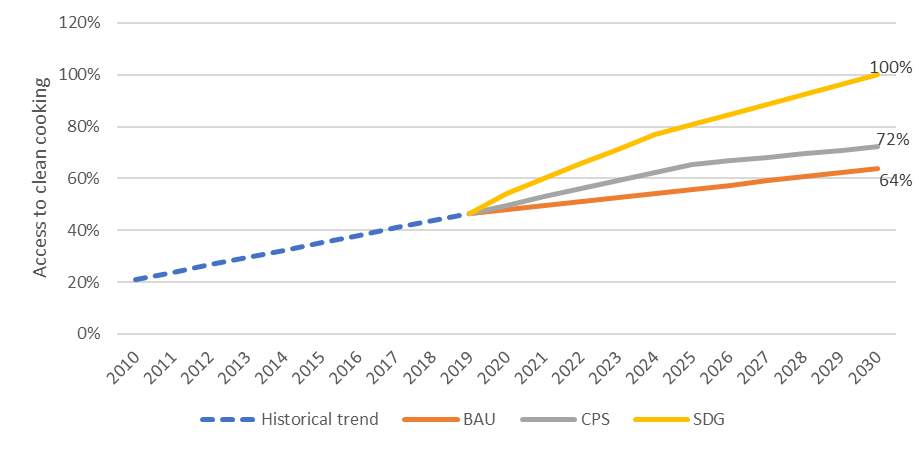
***Universal access to electricity***

As of 2019, Nepal’s electrification rate is estimated to be 86 per cent. Of the portion of Nepal’s population that lacks access to electricity, 90 per cent are in rural areas. Based on the historical improvement trend between 2000 and 2019, NEXSTEP analysis indicates that the remaining population will receive access by 2024, under the business-as-usual scenario.4 In light of Nepal’s complex terrain, providing last-mile connectivity may not be an easy feat, and achieving it will still require continued efforts from the Government, development partners and the private sector. NEXSTEP analysis indicates that providing off-grid/mini-grid electrification systems utilizing indigenous renewable resources may be the most appropriate solution, as micro- and mini-hydro systems provide the lowest cost per unit of electricity generated.

***Universal access to clean cooking***

As of 2019, more than half of the population in Nepal still relied on polluting cooking fuel and technology, thereby exposing themselves to negative health impacts. The Government of Nepal has disseminated more than 1 million clay and metallic improved cooking stoves; in 2019, the cooking stove distributions (estimated at 15) were made to 2.7 per cent of the total households in Nepal. It is expected that the clean cooking access rate will be raised to 72.3 per cent through the current policy settings, in accordance with the targets stipulated in the second NDC document. The targets include increasing the market penetration of electric cooking stoves to 25 per cent by 2030, and further dissemination of 500,000 Improved Cooking Stoves (ICS), 200,000 household biogas digesters and 500 large-scale biogas plants by 2025. Nevertheless, more needs to be done; NEXSTEP analysis suggests that electric cooking stoves may be the most suitable long-term solution in closing the remaining gap.

**Figure ES 1.** **Nepal’s access to clean cooking under the BAU, CPS and SDG scenarios[[1]](#footnote-2)**



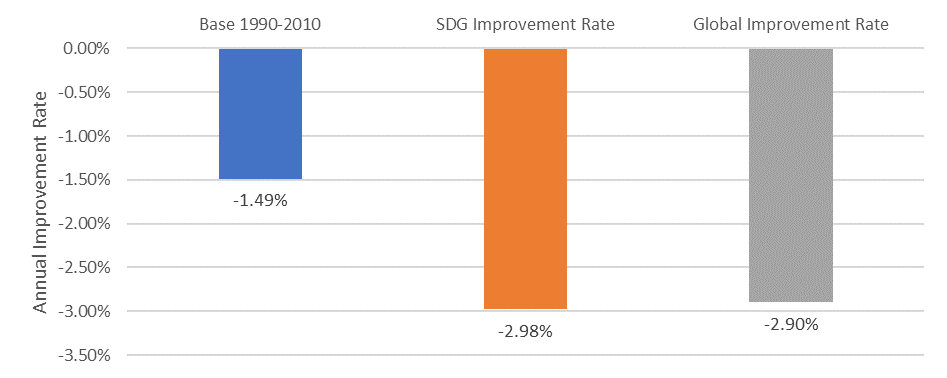
***Renewable energy***

The share of renewable energy in the total final energy consumption (TFEC) was 21.3 per cent in 2019. Based on current policies, the share of renewable energy is projected to increase to 35.9 per cent by 2030. The increase is due to the projected increase both in renewable electricity and other renewable energy (excluding traditional use of biomass) consumption, while the TFEC increases at a slower rate. In the SDG scenario, the share of renewable energy is further improved to 39 per cent of TFEC in 2030. This improvement is solely due to the adoption of electric stoves while phasing out of traditional biomass usage, which also decreases the total final energy consumption.

***Energy efficiency***

Nepal’s energy intensity in 2019 is estimated to have been 4.12 MJ/USD2011. Energy intensity in Nepal has declined at an average annual rate of 1.49 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 2.98 per cent between 2018 and 2030. Correspondingly, the energy intensity in 2030 should be 2.96 MJ/USD2011 to achieve the SDG 7 target.

**Figure ES 2. Nepal’s energy efficiency target**

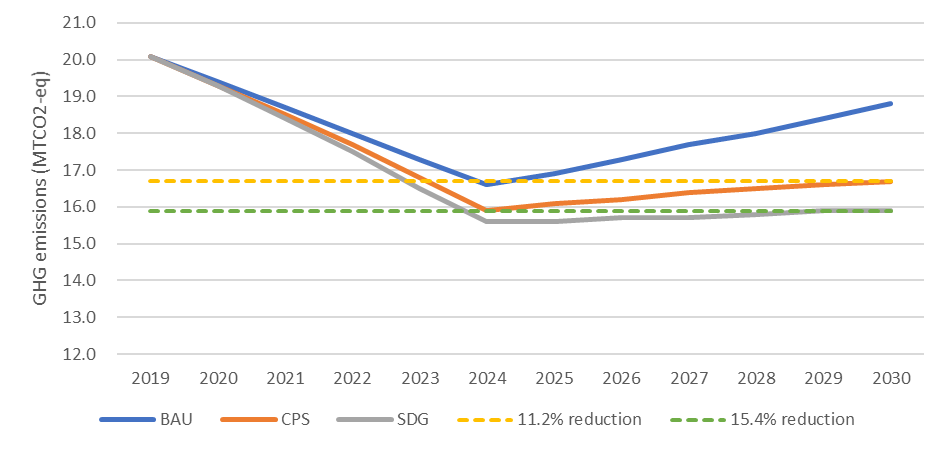


Under the current policy settings, the energy intensity is projected to drop to 2.96 MJ//USD2011. While the energy efficiency improvement target is achieved, more needs to be done to close the clean cooking gap. The energy efficiency target is exceeded in the SDG scenario with an energy intensity of 2.46 MJ//USD2011, compared with the target of 2.96 MJ//USD2011. This is achieved simultaneously with the clean cooking target through the phasing out of inefficient cooking technologies. There are ample energy savings opportunities for Nepal, as explored in the ambitious scenario. These opportunities are discussed in later sections of this report.

***Nationally Determined Contributions***

Nepal does not have an overarching GHG reduction target but has stipulated several sectoral strategies and measures in its second NDC document published at the end of 2020. As modelled, the stipulated measures may allow Nepal to reduce its GHG emissions by 11.2 per cent, with reference to the BAU scenario. In the SDG scenario, the GHG emission is projected to be 15.8 MTCO2-e in 2030, a 15.4 per cent reduction from the BAU scenario.

**Figure ES 3. Comparison of emissions by scenario, 2000-2030**



## C. Important policy directions

The roadmap sets out four key policy recommendations to help Nepal achieve the SDG 7 targets as well as reduce reliance on imported energy sources:

1. To ensure electricity access is on track to achieve the SDG 7 target by 2024, decentralised energy generation using indigenous resources such as wind and solar power should be utilized.Given Nepal’s complex mountainous terrain and last-mile connectivity challenges, these approaches are needed to complement grid extensions;
2. Electric cooking stoves should be the priority technology in improving clean cooking access. More effort is required from the Government to close the clean cooking gap. NEXSTEP analysis suggests that electric cooking stoves may be more appropriate technology, in terms of the health benefits, cost effectiveness, and little maintenance and follow-up requirements. However, comprehensive policies are required for promoting the uptake and long-term adoption of electric cooking stoves;
3. Transport electrification strategies provide multi-fold benefits. Vigorous adoption of electric vehicles reduces the demand for oil products, hence reducing Nepal’s reliance on imported energy resources. At the same time, it can contribute to climate mitigation by using Nepal’s zero-carbon hydropower-based electricity;
4. Energy efficiency measures should be encouraged with a whole-economy approach. Substantial energy savings can be achieved through sustainable heating technologies in the residential and commercial sectors, while utilization of efficient household appliances reduces electricity demand. Significant energy reduction can be similarly achieved through industry sector best practices.

# Introduction

## Background

Transitioning the energy sector to achieve 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, respond to increasing energy demand, reduce emissions, and consider and capitalise on the interlinkages between Sustainable Development Goal 7 (SDG7) and other SDGs. In this connection, 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 SDG7 targets as well as 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 the meeting’s outcome. NEXSTEP has 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. The ministerial declaration advises ESCAP to support its member States, upon request, in developing national SDG 7 roadmaps.

## 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 total final energy consumption (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 traditional use of biomass, NEXSTEP focuses entirely on modern renewables (excluding traditional use of biomass) for meeting 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 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 2011 PPP.

## Nationally Determined Contribution

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. For example, the global energy sector was responsible for 76 per cent of the global GHG emissions in 2018 (Climate Watch, 2021). For Nepal, the contribution from the energy sector is estimated to have been 46 per cent in 2011 (Government of Nepal, 2020). Key approaches to reducing emissions from the energy sector include increasing renewable energy in the generation mix and improving energy efficiency. In its second NDC document published at the end of 2020, Nepal stipulated several emissions reduction measures to be implemented and achieved by 2030. It is noted that some of the measures stipulated in the NDC document are conditional, unless international financial contribution is provided. Nonetheless, based on the consensus achieved during the stakeholder consultation workshop held in March 2021, all measures will be considered fulfilled by 2030, and the NDC commitments are included in the current policy scenario.

# NEXSTEP methodology

The main purpose of NEXSTEP is to help in designing the type and mix of policies that will enable achievement of the SDG 7 targets and the emission reduction targets (under NDCs) through policy analysis. However, policy analysis cannot be done without: (a) modelling energy systems to forecast/backcast energy and emissions; and (b) economic analysis to assess which policies or options would be economically suitable. Based on this, a three-step approach has been proposed. Each step is discussed in the following sections.

## Key methodological steps

### Energy and emissions modelling

NEXSTEP begins with energy systems modelling for developing different scenarios to achieve SDG 7 by identifying potential technical options for each scenario. Each scenario contains important information, including the final energy (electricity and heat) requirement by 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). LEAP is widely-used for energy sector modelling and for creating energy and emissions scenarios. Many countries have used LEAP to develop scenarios as a basis for their Intended Nationally Determined Contributions (INDCs). The Least Cost Optimization method is used to calculate the optimal expansion and dispatch of the electric power system. Figure 1 shows the different steps of the methodology.

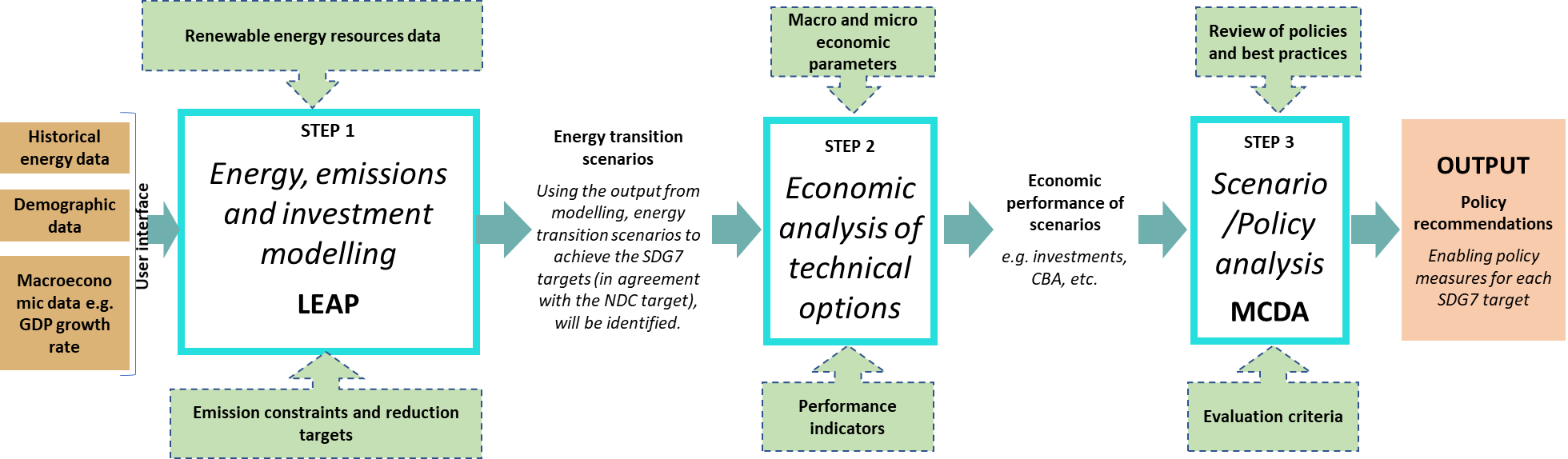
### Economic analysis module

The energy and emissions modelling section selects the appropriate technologies, and the economic analysis builds on this by selecting the least cost energy supply mix for the country. The economic analysis is used to examine economic performances of individual technical options identified and prioritize least-cost options. As such, it is important to estimate some of the key economic parameters such as net present value, internal rate of return and payback period. A ranking of selected technologies will help policymakers to identify and select economically effective projects for better allocation of resources. The economic analysis helps to present several economic parameters and indicators that would be useful for policymakers in making an informed policy decision.

### Scenario and policy analysis

Using the Multi-Criteria Decision Analysis (MCDA) tool, this prioritized list of scenarios is assessed in terms of their techno-economic for the energy sector, and environmental dimensions to convert to a policy measure. The top-ranked scenario from the MCDA process is essentially the output of NEXSTEP, which is then used to develop policy recommendations.

**Figure 1. The different components of the NEXSTEP methodology**

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*Note*: This tool is unique in the way that no other tools look at developing policy measures to achieve SDG 7. The key feature that makes it outstanding is the backcasting approach for energy and emissions modelling. This is important when it comes to planning for SDG 7, as the targets for the final year (2030) are already given; thus, the tool needs to be able to work its way backward to the current date and identify the best possible pathway.

## Scenario definitions

The LEAP modelling system is designed for scenario analysis, to enable energy specialists to model energy system evolution based on current energy policies. In the NEXSTEP model for Georgia, three main scenarios have been modelled: (a) a BAU scenario; (b) the current policy scenario (CPS); and (c) Sustainable Development Goal (SDG) scenario.

### The BAU scenario:

This scenario follows historical demand trends, based on growth projections, such as using GDP and population growth. It does not consider emission limits or renewable energy targets. For each sector, the final energy demand is met by a fuel mix reflecting the current shares in TFEC, with the trend extrapolated to 2030. Essentially, this scenario aims to indicate what will happen if no enabling policies are implemented or the existing policies fail to achieve their intended outcomes.

### Current policy scenario:

Inherited from the BAU scenario and modified, this scenario considers relevant policies and plans currently in place. These are, for example, the emission reduction measures and power capacity expansion plan stipulated in the second NDC document and the fifteenth National Plan.

### SDG 7 scenario:

This scenario aims to achieve the SDG 7 targets, including universal access to electricity and clean cooking fuel, substantially increasing renewable energy share and doubling the rate of energy efficiency improvement. For clean cooking, different technologies (electric cooking stove, LPG cooking stove and improved cooking stove) have been assessed, subsequently recommending the uptake of the most appropriate technology. Energy intensity has been modelled to help achieve the SDG 7 target.

### Ambitious SDG scenarios:

Like the SDG scenario, these ambitious scenarios are aimed at achieving the SDG 7 targets. In addition, these scenarios look to increasing the socio-economic and environmental benefits for the country from raising its ambition beyond just achieving the SDG 7 targets, such as: enhancing cost-effectiveness, by further improving its energy efficiency beyond SDG 7.3 target: or reducing GHG emissions beyond its NDC targets through decarbonising the power sector.

The baseline year, 2019, has been chosen, as it is the most recent year with sufficient data information for modelling. Updated data (i.e., data as of 2020 or 2021) may be available for some indicators. However, only 2019 data are referenced in this document and used in the modelling in order to maintain consistency.

## Economic analysis

The economic analysis considers the project’s contribution to the economic performance of the energy sector. The purpose of a cost-benefit analysis (CBA) is to enable better informed policy decisions to be made. It is a tool for weighing the benefits against costs and facilitating an efficient distribution of resources in public sector investment.

### Basics of economic analysis

An economic analysis of public sector investment differs from a financial analysis. A financial analysis considers the profitability of an investment in a project from the investor’s perspective. In an economic analysis the profitability of the investment also takes into consideration national welfare, including externalities. A project is financially viable only if all the monetary costs can be recovered in the project’s lifetime. Project financial viability is not enough for an economic analysis; the contribution to societal welfare should also be identified and quantified. For example, in the case of a coal power plant, the emissions from the combustion process emits particulate matter that is inhaled by the local population, causing health damage and acceleration of climate change. In an economic analysis a monetary value is assigned to the GHG emission to value its GHG emissions abatement.

### Cost parameters

The project cost is the fundamental input in an economic analysis. The overall project cost is calculated using the following information:

1. Capital cost – capital infrastructure costs for technologies, which are based on country-specific data to improve the analysis. They include land, building, machinery, equipment and civil works;
2. Operation and maintenance cost – comprising fuel, labour and maintenance costs. Power generation facilities classify operation and maintenance costs as fixed (US$/MW) and variable (US$/MWh) cost;
3. Decommissioning cost – the costs of the retirement of power plants related to environmental remediation, regulatory frameworks and demolition costs;
4. Sunk cost – existing infrastructure investments are not included in the economic analysis, since no additional investment is required for the project;
5. External cost – refers to any additional externalities that place costs on society.
6. GHG abatement – avoided cost of CO2 generation is calculated in monetary value terms, based on the carbon price. The 2016 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories is followed in calculating GHG emissions for the economic analysis. The sectoral analysis is based on the Tier 1 approach, which uses fuel combustion from national statistics and default emission factors.

## Scenario analysis

The scenario analysis evaluates and ranks the scenarios, using the Multi Criteria Decision Analysis (MCDA) tool, with a set of criteria and weights assigned to each criterion. Ideally, the weights assigned to each criterion should be decided in a 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 weights of each criterion, where the total weight needs to be 100 per cent. The criteria considered in the MCDA tool can include those listed below; however, stakeholders may wish to add/remove criteria to suit the local context.

* Access to clean cooking fuel
* Energy efficiency
* Share of renewable energy
* Emissions in 2030
* Alignment with Paris Agreement
* Fossil fuel subsidy phased out
* Price on 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 generally applied to all countries utilizing NEXSTEP in developing the national SDG 7 Roadmap, as a means to suggest the best way forward for the countries by prioritizing the several scenarios. Nevertheless, it has not been applied to Nepal as a limited number of scenarios have been developed.

# Overview of Nepal’s Energy Sector

## Current situation

Geography and climate: Located in the South Asia region, Nepal is a landlocked country bordering India and China. The country occupies a land area of 147,181 km2, with an average stretch of 885 km in the East-West direction and 193 km in the North-South direction (Government of Nepal, 2014). Nepal has a diverse geography, including the fertile plain in the southern border area and some of the most challenging terrain in the world, i.e., the Himalayan mountain range. The country can be divided into five physio-graphic regions, characterized by an elevation ranging from 60 metres to 8,845 metres above sea level. While Nepal sits within the subtropical climatic zone, it exhibits a wide range of climatic conditions that vary from tropical in the south to alpine/arctic in the north due to topographic extremes. Its capital city, Kathmandu, sits in the Kathmandu Valley in central Nepal.

Population: The total population of Nepal was estimated at 29.6 million in 2019. The total population recorded in 2011 was 26.5 million (Government of Nepal, 2014), which translates into an annual growth rate of 1.4 per cent between 2011 and 2019. The recorded annual growth rate has slowed, compared to the growth rate between 1961 and 2001 (Government of Nepal, 2014). Nonetheless, the population has increased by more than threefold during the past 60 years, from just 9.6 million in 1961. The percentage of urban population ways estimated to be 23 per cent in 2019, a rapid increase from just 4 per cent in 1971 (Government of Nepal, 2014)

Economy: Nepal’s GDP in 2019 was estimated as US$30.6 billion. Correspondingly, the GDP per capita stood at US$1,039. The growth in GDP per capita is remarkable, increasing at an average annual growth rate of 6.4 per cent during the past decade, from just US$592 in 2010 (World Bank, 2021a). According to the World Bank’s country classification, Nepal is classified as a lower-middle income economy as of the 2021 fiscal year (World Bank, 2021b). The agricultural sector has been consistently the main contributing economic sector, accounting for about 27 per cent of the national GDP (Ministry of Finance, 2019). The Government of Nepal (2014) noted that the agricultural sector was the base of livelihood for around 80 per cent of its population and accounted for 60 per cent of the total employment.

Climate change risks: Nepal is highly vulnerable to climate change impacts as it is ranked fourth in terms of vulnerability towards climate change (UNDP, 2021b). As a nation that is highly dependent on its agricultural sector, probable changes in climatic conditions may cause adverse effect on Nepal’s economy and its population’s livelihood. Additionally, as the planet warms, the increased rate of glacier melting in the mountainous region towards the North will alter the dynamics of river flows in Nepal and across the region as well as increase the risk of glacier lake outburst flooding.

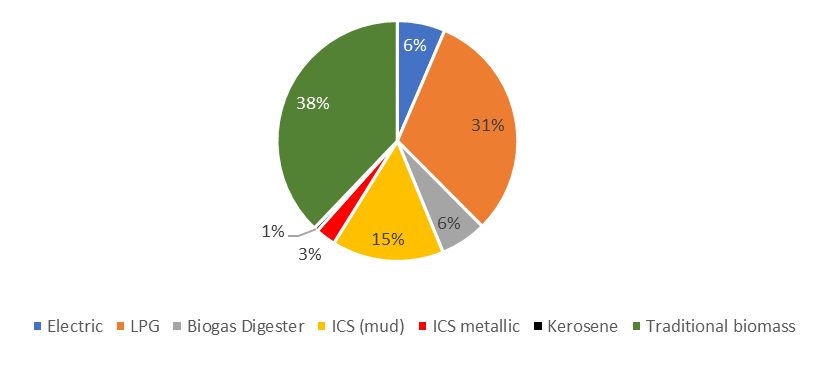
Energy: The Government’s ambition towards a more sustainable energy transition is depicted in its second NDC, (Government of Nepal, 2020). For the energy sector, Nepal envisions increasing its clean power capacity by ten-fold, not only to meet the increasing electricity demand sufficiently but also to allow cross-border power trade. In addition, it plans to increase the market penetration of electric vehicles during the coming decade. Increased ambitions are also stipulated for the cooking sector to expand the share of clean cooking technologies (i.e., electric cooking stoves). Nepal is currently formulating a long-term low greenhouse gas emission development strategy, which aims to achieve carbon net-zero by 2050.

## National energy profile

The electrification rate in Nepal was 86 per cent in 2019. That has left around 887,000 households yet to be connected to any form of electricity supply. Nevertheless, Nepal’s progress in electricity access improvement has been remarkable, rising by about 60 percentage points from 2001 to 2019 (ESCAP, 2021a). Among the unelectrified households, around 8 per cent are in urban areas, while the remaining are in rural areas.7 The majority (approximately 89 per cent) of the current electrified population is connected to the main grid. A small percentage of households rely on off-grid systems, such as micro-hydro power and solar PV systems. The provision of off-grid systems not only provides essential electricity needs, but also brings in other indirect positive impacts, such as increasing local employment and women’s empowerment.

In 2019, only 46.5 per cent of the population had access to clean cooking fuel and technologies.7 Liquefied petroleum gas (LPG) stoves are the dominant cooking technology used by the majority of Nepalese urban households, accounting for around a 31 per cent share of total stove usage distribution. This is followed by the traditional biomass stove, which has a share of 38 per cent and includes the use of wood, agricultural residue and animal dung as fuel mostly in rural areas. The Alternative Energy Promotion Centre (AEPC) of Nepal has disseminated more than 1 million improved cooking stoves, mostly mud stoves, since 2005. The cooking stove distribution of clay ICS and metallic ICS in 2019 was estimated at 15 per cent and 2.7 per cent, respectively. This analysis considers metallic ICS as a clean cooking technology (Tier 3+ Multi-Tier Framework – MTF) for cooking exposure attribute), while clay ICS is regarded as a non-clean cooking technology. Other stove usage includes electric cooking stoves (6.4 per cent), biogas digesters (6.3 per cent) and kerosene (0.5 per cent).

**Figure 2. Cooking stove distribution in 2019**



Modern renewable energy delivered approximately 21.3 per cent of TFEC in 2019. This excludes traditional biomass usage in residential cooking and heating, which corresponds to an estimated 2,970 ktoe. On average in 2019, 37 per cent of Nepal’s electricity demand was met by imported electricity from India, which is assumed non-renewable for the NEXSTEP analysis as electricity from India is mostly produced from fossil fuels. Most of the remainder (61.9 per cent) was locally produced in 2019 with large hydropower. Strategies to raise the renewable energy share are set out in the second NDC (Government of Nepal, 2020). These include increasing the renewable energy capacity to meet both local and external demand, and increasing the market penetration of electric vehicles that utilize renewable electricity.

While endowed with an abundance of hydropower potential, Nepal has a high reliance on imported fuels (i.e., coal and oil products) to meet its heating and transport fuel demands. Several strategies have been put forward to reduce its imported oil dependency in order to safeguard the energy sector from supply and prices shocks. For example, transport electrification ambitions set out in its second NDC does not only reduce GHG emissions, but also makes Nepal less susceptible to future supply and price shocks. In addition, the Government has set a maximum threshold for LPG stove penetration of 30 per cent.

The energy intensity in 2019 was calculated as 4.12 MJ/US$2011.[[2]](#footnote-3)

## National energy policies and targets

Nepal’s energy sector development is guided by several national policies and frameworks. These policies have been used as guiding references for the NEXSTEP modelling, to better understand the country context and to provide 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.[[3]](#footnote-4) The policies or strategic documents consulted are detailed below.

* **Nepal’s Second NDC (**Government of Nepal, 2020) stipulates ambitions to:
  1. Raise the renewable capacity by another 15,000 MW by 2030,[[4]](#footnote-5) of which 5-10 per cent of the capacity will be from renewable technologies exclusive of large hydropower;
  2. To produce15 per cent of the total electricity demand from renewable sources (not including large hydropower);
  3. Raise the market sales of electric vehicles for private 2- and 4-wheelers and public 4-wheelers;
  4. Increase the share of electric stoves to 25 per cent and disseminate an additional of 500,000 ICS and 200,000 household-scale biogas plants.
* **Biomass Energy Strategy 2017** (Ministry of Population and Environment, 2017)aims to increase the access to biomass energy and hence contribute to environment conservation by transforming biomass energy use into modern, sustainable and clean energy.
* **National Energy Efficiency Strategy 2018** (MOEWRI, 2019) is to promote energy efficiency by effectively implementing energy efficiency programmes through establishing policy, legal and institutional frameworks. It also stipulates a goal of doubling the average improvement rate of energy efficiency from 0.84 per cent per year (between 2000-2015) to 1.68 per cent per year in 2030.
* **National Renewable Energy Framework** (AEPC, 2017) was formulated in 2017 as an umbrella mechanism for AEPC to coalesce and coordinate policies and programmes in the renewable sector, covering four objectives (i.e., governance, demand, supply and financing) with activities in capacity-building, knowledge management, gender and social inclusion, and monitoring in a cross-cutting manner.
* **Renewable Energy Subsidy Policy 2016** (Ministry of Population and Environment, 2016)details the subsidy mechanism for various renewable energy technologies with a long-term goal of achieving universal access to clean, reliable and affordable renewable energy solutions by 2030.
* **Rural Energy Policy 2006** aims to contribute to rural poverty reduction and environmental conservation by ensuring access to clean, reliable and appropriate energy in the rural areas.
* **National Climate Change Policy 2019** (Ministry of Forests and Environment, 2020) provides policy guidance to various sectors and thematic areas (i.e., agriculture and food security, water resources and energy), in order to contribute to socio-economic prosperity of the nation by building a climate resilient society.

**The Fifteenth Plan** (National Planning Commission, 2020)was formulated with the aim of raising Nepal from a least developed country to a developing country by 2022, and achieving the SDGs by 2030. At the same time, it is aimed lifting Nepal to the level of a middle-income country through an increase in income level, development of quality human capital and the reduction of economic risks. Several energy sector targets and strategies are also outlined in the national development plan.

## National energy resources

Nepal depends on both indigenous renewable resources (i.e., hydro and solar) and imported electricity to meet its electricity demand. Other resources used in its energy system include petroleum products, coal and biomass. Nepal does not have its own petroleum reserve; the demand is met through importation via India. Coal deposits exist in Nepal; however, they are of low quality. The majority of its coal is imported from India and other countries (WECS, 2010). Nepal’s theoretical hydropower potential has been estimated at about 83,000 MW, of which 45,000 and 42,000 MW is technically and economically feasible, respectively (WECS, 2010). Nepal has an abundant solar power potential; the average solar insolation intensity is about 4.7 kWh/m2/day.

A study carried out by AEPC and UNEP in 2008 shows that potential of solar energy in grid connected areas was estimated as 2,100 MW based on free land availability (WECS, 2010). Wind potential is largely untapped in Nepal; the commercial potential of wind power is suggested at 3,000 MW (AEPC, 2021), a comparatively low level which is in part due to the lack of road and grid access to the regions with high wind speeds. Biomass is widely used in Nepal for cooking and heating purposes. Khatiwada, Purohit and Ackom (2019) estimated that the economic potential of biomass power using surplus agricultural residue is approximately 0.6 GW in 2030.

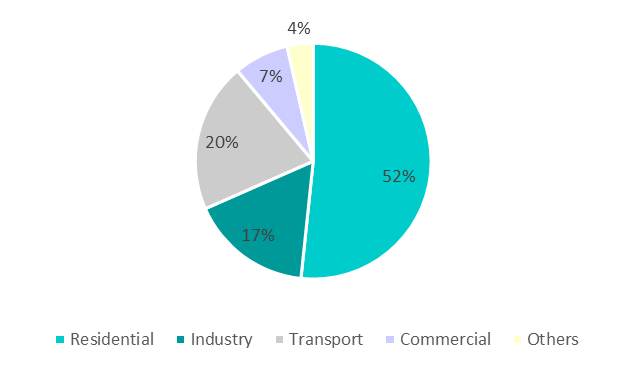
## National energy balance

The official national energy balance is unfortunately not available for 2019. The following describes the estimated national energy consumption, built up using data collected with a bottom-up approach, based on data such as activity level and energy intensity.

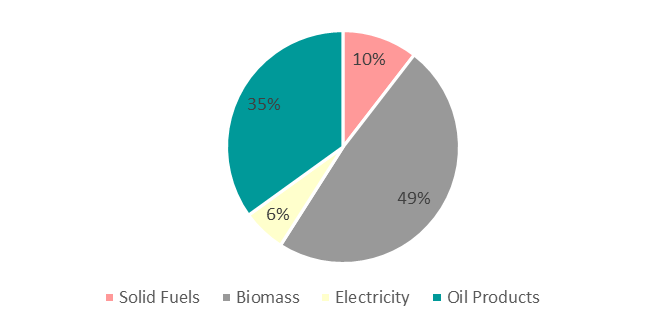
In 2019, the total final energy consumption (TFEC) was 9,179 ktoe. Most of the demand came from the residential sector (51.7 per cent). Within the residential sector, 85.7 per cent of energy is consumed for cooking purposes. Such a high share is attributable to the widespread use of inefficient traditional biomass stoves. This is followed by the transport sector (20.5 per cent), industry sector (16.7 per cent), commercial (7.5 per cent) and others (3.6 per cent).

In terms of fuel usage in the TFEC, biomass is the dominant fuel, accounting for 47.3 per cent. Oil products, including LPG, diesel, kerosene and petroleum account for around 35 per cent of the TFEC. The transport sector, which operates predominantly with internal combustion engine vehicles, is the main consuming sector for oil products (58 per cent). Other uses of oil products include residential cooking and space heating (21.4 per cent), process heating in the industry sector (5.12 per cent) and space heating in the commercial sector (4.83 per cent). Other fuel use includes coal (10.5 per cent) and electricity (6 per cent). Coal is mainly used in the industrial sector, with a small percentage (15 per cent) used in the commercial sector as a heating fuel. Figures 3 and 4 illustrate the total final energy consumption by consuming sector and fuel type.

**Figure 3 Total final energy consumption by sector, 2019**

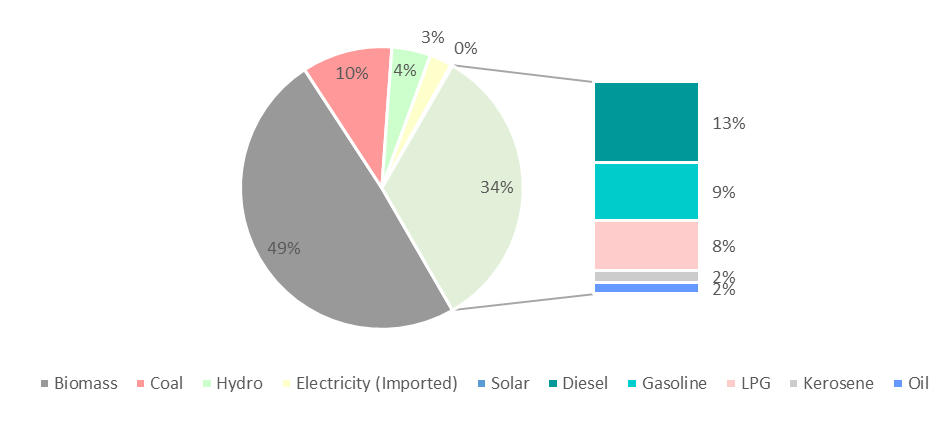


**Figure 4. Total final energy consumption by fuel type, 2019**



The total primary energy supply (TPES)in 2019 was 9,279 ktoe. It generally shows a fuel usage distribution similar to the TFEC. Hydro and solar power contribute a total of 4.6 per cent and are used in power generation. Around 3 per cent of the primary energy is supplied in the form of electricity, imported from India. Imported electricity accounts for about 37 per cent of the electricity demand of Nepal.

**Figure 5. Total primary energy supply by fuel type, 2019**



* 1. **Energy modelling projections**

The energy demand is estimated 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 1 provides a summary of the key modelling assumptions for the three main scenarios (i.e., BAU, CPS and SDG scenarios).

**Table 1. Important factors, targets and assumptions used in NEXSTEP modelling**

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameters** | **Business as usual scenario** | **Current policy scenario** | **Sustainable Development Goal (SDG) scenario** |
| Economic growth | 3.11% per annum | | |
| Population growth | 1.36% per annum | | |
| Urbanization rate | 23 per cent in 2019, gradually increasing to 28.6 per cent in 2030 | | |
| Commercial floor space | 127.2 million m2in 2019, annual growth rate of 3.11 per cent | | |
| Transport activity | Transport activities in 2019 were 125.6 billion passenger-kilometres and 23.1 billion tonne-kilometres, with assumed growth of 1.35 per cent annually | | |
| Access to electricity | 2024: 100% | 2024: 100% | 2024: 100% |
| Access to clean cooking fuels | Based on the historical penetration rate assumed for LPG and electric cookstove. Number of households utilizing biogas digester and ICS are assumed constant. | As per the ambitions stated in the NDC document:   * 1. increase share of electric stoves to 25% by 2025   2. disseminate an additional of 500,000 ICS and 200,000 household-scale biogas plants by 2030   In addition, a maximum limit of 30 per cent LPG stove penetration by 2030 is applied | Building on the current policy scenario, NEXSTEP further recommends the use of electric stoves in reaching a 100% access rate. |
| Energy efficiency | Additional energy efficiency measures not applied | Improvement based on current policies (explained further in section 3.7) | 2.98 per cent annual improvement in TPES target achieved |
| Power plant | Based on 2018 capacity share | New renewable energy capacity of 15,000 MW[[5]](#footnote-6), and 15 per cent of total electricity demand will come from renewable energy (excluding large hydro), as stated in the second NDC | New renewable energy capacity of 15,000 MW13, and 15 per cent of total electricity demand will come from renewable energy (excluding large hydro), as stipulated in the second NDC |

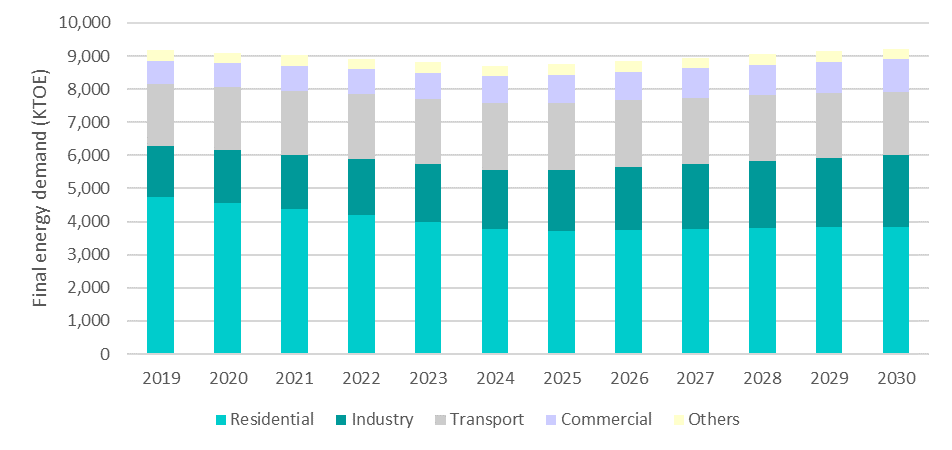
* 1. **Energy demand outlook**

Several measures have been outlined in the recently published NDC document in a bid to reduce GHG emissions. These include clean cooking strategies involving the dissemination of ICS and biogas digesters as well as increasing the market penetration of electric cooking stoves, as described in table 1. In addition, the Government is aiming to raise the usage of electric vehicles – an effective emission reduction strategy by phasing out the use of oil products with replacement by carbon-free electricity in the transport sector. The market sales of electric vehicles for private passenger 2- and 4-wheelers is expected to reach 25 per cent in 2025, and gradually rise to 90 per cent in 2030.The market sales of electric vehicles for public passenger 4-wheelers will be 20 per cent in 2025 and gradually increase to 60 per cent in 2030. These policy measures and targets, as included in the CP scenario, have substantial implications for the energy demand outlook in 2020-2030, relative to the BAU scenario.

In the current policy settings, TFEC is projected to increase from 9,179 ktoe in 2019 to 9,223 ktoe in 2030. This corresponds to an average annual growth rate of 0.04 per cent, a number that is much lower than the projected growth in GDP (3.11 per cent) and population (1.34 per cent). As mentioned above, such low growth in energy demand is attributable to the Government’s GHG emission reduction strategies in the residential sector (mainly by replacing biomass cooking stoves) and the transport sector.

In 2030, the residential sector will remain the main consuming sector, with an estimated TFEC of 3,847 ktoe (41.7 per cent), followed by the industrial sector at 2,153 ktoe (23.3 per cent), transport sector at 1,928 ktoe (20.9 per cent), commercial sector at 968 ktoe (10.5 per cent) and others at 327 ktoe (3.5 per cent). The sectoral overview of energy demand in the current policy scenario is discussed below and shown in figure 6.

**Figure 6. Nepal's energy demand outlook, 2019-2030**



1. Residential

The residential sector will continue to dominate Nepal’s TFEC, with a 41.7 per cent share in 2030. Nevertheless, demand is projected to decrease to 3,847 ktoe by 2030, compared with 4,471 ktoe in 2019. The notable decrease in energy demand is attributable to the phasing out of unclean and inefficient cooking technologies, specifically traditional biomass stoves. The share of traditional biomass in the cooking stove distribution is projected to decrease to 14.7 per cent, as the uptake of electric cooking stoves, ICS and biogas digesters increases in accordance with the Government’s plans stipulated in the second NDC and Fifteenth Plan. As projected in NEXSTEP, the energy demand for cooking decreases from 4,061 ktoe in 2019 to 3,191 ktoe in 2030 through the adoption of more efficient cooking stoves, and fuel switching from traditional biomass to electricity.

(b) Transport

Nepal’s transport sector comprises passenger and freight road transport. The total energy demand is projected to be 1,928 ktoe in 2030, increasing from 1,882 ktoe in 2019. Such a slow average annual growth rate of 0.21 per cent is due to the increased market penetration of electric vehicles as envisaged in the NDC document, specifically in the passenger road transport sector. A decreasing trend in energy demand growth is also projected from 2026 onwards, as the share of electric vehicles grows exponentially, replacing the less efficient internal combustion engine vehicles.

(c) Commercial

The commercial sector energy demand is projected to increase from 691 ktoe in 2019 to 968 ktoe in 2030. The sector is divided into seven subcategories, with each one projected to grow at an annual rate similar to the GDP growth rate (i.e., 3.11 per cent). The energy demand distribution is dominated by hotels at 467.2 ktoe (67.6 per cent), followed by government buildings at 97.2 ktoe (14.1 per cent). Other subcategories are shopping malls at 48 ktoe (6.9 per cent), universities at 31.4 ktoe (4.6 per cent), private offices at 20.8 ktoe (3 per cent), hospitals at 17.7 ktoe (2.6 per cent) and religious buildings at 9.2 ktoe (1.3 per cent).

(d) Industry sector

Energy demand by the industry sector is expected to grow from 1,537 ktoe in 2019 to 2,153 ktoe in 2030. The share of energy demand from the 10 different industrial sectors are detailed in Annex II. The energy intensity of the industrial sector is assumed to be constant, while the industrial sector GDP is projected to grow by 3.11 per cent annually.

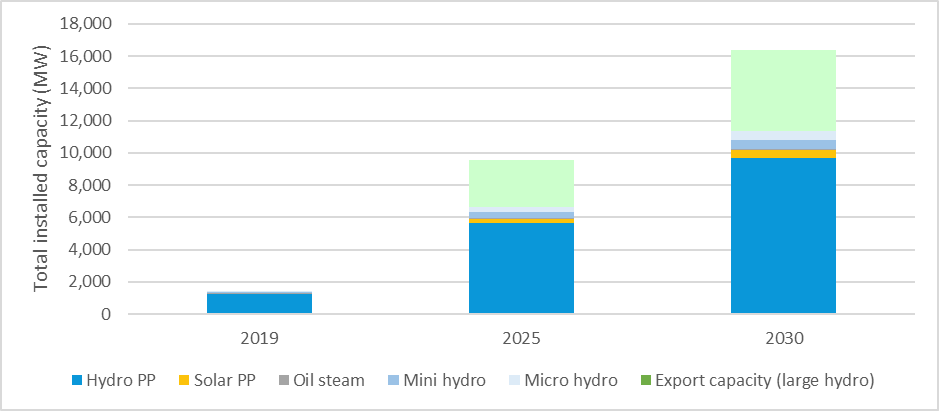
## Electricity generation outlook

The 2030 demand for electricity in the current policy scenario will be 12 Terawatt-hours (TWh), increasing from 6.4 TWh in 2019. The demand will be the highest in the residential sector at 6.8 TWh (56.8 per cent), followed by the industry sector (3.7 TWh, 30.6 per cent), the commercial sector (1.1 TWh, 9.6 per cent) and the transport sector (0.4 TWh, 3 per cent).

Nepal’s installed electric power generation capacity in 2019 was 1,379 MW, of which 91.3 per cent was renewable generation capacity including large hydropower. As of 2019, the installed capacity available in Nepal was not sufficient to meet its local demand, particularly in the dry season, and 37 per cent of its electricity requirement was fulfilled by imported electricity from India. Nevertheless, it is expected that a total of 15,000 MW of new capacity will be installed by 2030, raising the total installed capacity to 16,378 MW. This includes 5,000 MW that will be designated for cross-border trade.

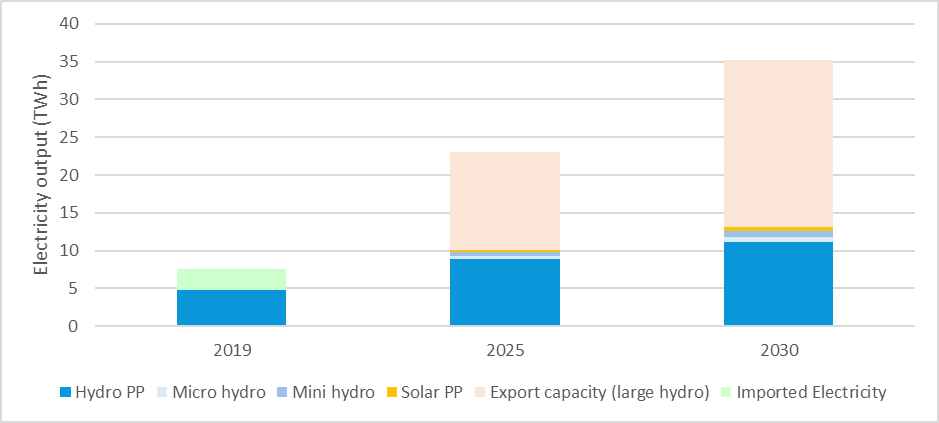
While the exact capacity shares of different power technologies are not available, the NEXSTEP analysis assumes that the export capacity will be fulfilled by large hydropower plants. Including the generation capacity for fulfilling local demand, the total installed capacity is assumed to be made up of large hydropower 90 per cent, mini-hydropower 3.5 per cent, micro-hydropower 3.5 per cent and solar PV 3 per cent. This conforms to the target set out in the NDC document, of which 5-10 per cent capacity will be mini- and micro-hydro power, solar, wind and bio-energy technologies. Figure 7 shows the expected installed capacity during the analysis period.

**Figure 7. Installed power capacity, CPS scenario**



In terms of power output, it is expected that the export capacity of the 5,000 MW of large hydropower will allow an estimated export of 22 TWh, assuming running at a capacity factor of 51 per cent. In fulfilling the domestic electricity demand, the NDC document stipulates a generation target of 15 per cent from small-scale renewables by 2030, not including large hydropower. The projected generation by technology type is as illustrated in figure 8, whereby the total percentage of renewable energy share in electricity generation is 100 per cent.

**Figure 8. Electricity output by technology type, CPS scenario**

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## Energy supply outlook

In the current policy scenario, TPES is forecast to increase from 9,279 ktoe in 2019 to 9,318 ktoe in 2030. The fuel shares in 2030 are projected to be oil products 3,303 ktoe, biomass 3,527 ktoe, hydro 2,987 ktoe, coal 1,345 ktoe and solar 62 ktoe. The substantial decrease in the biomass usage is due to the reduced consumption in the residential cooking sector. The primary supply of hydropower has ramped up steeply from just 412 ktoe. The steep increase is due to the projected electricity export of 1,907 ktoe. The share of imported fuels, such as oil products and coal, will still make up about 50 per cent of the TPES in 2030, posing a threat to Nepal’s energy security and exposing it to future price and supply shocks.

## Energy sector emissions outlook

The energy sector emissions, from the combustion of fossil fuel, is 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. For the combustion of biomass and biomass products, the carbon emissions are not attributed to the energy sector but are accounted in the agriculture, forest and land use change (AFOLU) 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.

In the second NDC document submitted to the United Nations Framework Convention on Climate Change (UNFCCC) in 2020, Nepal did not stipulate an overarching quantitative GHG emissions target for 2030. It has instead specified several quantified targets for several key sectors. These include ambitions in increasing access to clean and efficient cooking technologies, renewable power capacity and generation as well as transport electrification, as already described in the previous sections.

In the current policy scenario, the total GHG emissions from the energy sector decrease from 20.1 MTCO2-e to 16.7 MTCO2-e. The substantial decrease is again due to the reduced combustion of traditional biomass. The transformation sector is emission-free, as all electricity is generated from hydro and solar only. In the demand sector, the largest contributor of GHG emissions in 2030 will be the transport sector (34.2 per cent), followed by the industry sector (31.3 per cent), residential sector (17.9 per cent), commercial sector (9.7 per cent) and others (6.9 per cent).\

**Figure 9. Nepal energy sector emissions outlook in the current policy scenario**

# SDG scenario: Achieving SDG 7 by 2030

Access to affordable, reliable, sustainable and modern energy is essential to achieving the 2030 Agenda for Sustainable Development and the Paris Agreement on climate change. SDG 7 offers a holistic approach to achieving these essential targets. The NEXSTEP analysis considers Georgia’s current policies and plans of the energy sector, looks at the national context, assesses opportunities and challenges, and develops an SDG scenario for the energy sector, with a focus on achieving the SDG 7 targets by 2030. This scenario is discussed below where gaps in achieving different targets have been identified, and policy measures to bridge those gaps have been recommended.

## SDG energy demand outlook

In the SDG scenario, TFEC increases from 4,394 ktoe in 2018 to 5,295 ktoe in 2030. The reduction in TFEC in this scenario, compared to the current policy scenario, is due to the improvement in energy efficiency as per the SDG 7 targets. In 2030, the transport sector will have the largest share of TFEC at 1,966 ktoe (62 per cent), followed by the residential sector at 1,070 ktoe (20 per cent), the industrial sector at 1,052 ktoe (20 per cent), the commercial sector at 665 ktoe (12 per cent), non-energy use at 340 ktoe (6 per cent), non-specified at 165 ktoe (3 per cent) and the agricultural sector at 37 ktoe (1 per cent). Figure 7 shows the TFEC by scenario in 2030.

**Figure 7. Projection of TFEC by sector, 2020, 2025 and 2030**

## SDG 7 Targets

### SDG 7.1.1 Access to electricity

Georgia achieved universal access to electricity in 2010. In the SDG scenario, electricity demand will increase from 13 TWh in 2020 to 18 TWh in 2030. This includes the additional demand in the residential sector to achieve universal access to clean cooking fuel (discussed below).

### SDG 7.1.2. Access to clean fuels and technologies for cooking

Access to clean cooking fuels and technologies will not be achieved in the current policy scenarios (97 per cent), leaving 109,000 people (32,000 households) relying on inefficient and hazardous cooking fuels and technologies. Based on a detailed cost analysis and suitability of implementation (discussed further in section 4.4.1), NEXSTEP shows that electric cooking stoves can be used for the remaining 32,000 households to achieve universal access to clean cooking fuels and technologies. Implementation of this programme will cost the Government of Georgia US$1,280,000 by 2030. (Refer to section 4.4.1 for an overview of suitable clean cooking technologies for Georgia). Figure *8* shows the technology mix needed to achieve universal access to clean cooking for different scenarios.

**Figure 8. Georgia’s access to clean cooking by scenario, 2030**

### SDG 7.2. Renewable energy

SDG 7.2 does not have a quantitative target; however, an increase in renewable energy is required to meet the NDC target under the Paris Agreement. The NEXSTEP methodology first estimates the net increase in energy demand in response to universal energy access (both electricity and clean cooking) as well as energy efficiency improvement. It then uses the NDC target for the energy sector to estimate the renewable energy share in TFEC.

The share of renewable energy in TFEC in 2030 will be 22.7 per cent in the current policy scenario (figure 9). Renewable energy share in TFEC will need to increase to 25.4 per cent to reduce emissions and meet the NDC unconditional target. These figures also account for the reduction of TFEC due to the improvement in energy efficiency, and for switching from a biomass-based cooking stove to an electric cooking stove.

**Figure 9. Renewable energy in TFEC, 2030**

### SDG 7.3. Energy efficiency

The primary energy intensity, a proxy for the measurement of energy efficiency, was 5.33 MJ/$ in 2018. In the current policy scenario, primary energy intensity is projected to improve to 4.07 MJ/$ in 2030, a rate of improvement of 2.2 per cent per annum. The SDG scenario requires improvement of 2.9 per cent per annum, in line with global targets.

|  |
| --- |
| **Box 1. Georgia energy efficiency target**  The energy efficiency target for Georgia is explained as follows: The base period rate for calculating energy efficiency improvements is 1990-2010. ESCAP energy portal data for primary energy intensity is used to analyse improvements in the base period. In 1990, the primary energy intensity for Georgia was 13.6 MJ/$ and had improved to 5 MJ/$ by 2010. Between 1990and 2010 the compounded annual growth rate (CAGR) for primary energy intensity improvements in the base period was 4.9 per cent. The SDG target for energy efficiency requires the doubling of improvement in primary energy intensity, which is 9.8 per cent per year.  This sets an unrealistically ambitious target for Georgia. A revised target of 2.9 per cent annual improvement, in line with global targets, was recommended and agreed for the NEXSTEP analysis. In the current policy scenario, energy efficiency measures, if implemented, indicate that Georgia will only achieve 2.2 per cent annual improvement in primary energy intensity by 2030. |

There are ample opportunities for Georgia to achieve this target as well as implement a higher rate of improvement. These include, for example, minimum energy efficiency standards (MEPS), rapid deployment of electric vehicles and improvement of energy efficiency in new commercial buildings. Energy efficiency measures in the residential, transport, industrial and commercial sectors will reduce TFEC by more than 462,000 TOE in 2030, compared with the current policy scenario (figure 10), with the highest coming from the residential sector (184 ktoe), followed by the industrial sector (122 ktoe), transport sector (93 ktoe) and commercial sector (63 ktoe).

**Figure 10. Energy efficiency savings in SDG scenarios**

### NDC unconditional target

Georgia has pledged to reduce GHG emission by 15 per cent (unconditional) compared with BAU and 25 per cent (conditional) with international support compared with BAU by 2030. Emissions in the BAU scenario emission is projected to be 15,966,000 tonnes of CO2-e (ktCO2-e) by 2030. This sets the unconditional and conditional NDC targets of Georgia as 13,571 ktCO2-e and 11,974 ktCO2-e, respectively. Emissions in the current policy scenario are projected as 13,579 ktCO2-e by 2030, missing the NDC unconditional target of 15 per cent reduction in GHG emissions by a slight margin. Emissions in the SDG scenario will be 12,013 ktCO2-e in 2030 which is set to achieve the NDC unconditional targets for the energy sector. Figure 11 shows the emissions in different scenarios.

**Figure 11. Emissions by scenario, 2030**

## Power generation in the context of SDG 7

The demand for electricity is expected to increase to 18 TWh in the SDG scenario, largely due to the electrification of passenger buses (figure 12). The demand in the industry sector will be 5.2 TWh, followed by the commercial sector (5.4 TWh), residential sector (3.6 TWh) (47 per cent), transport sector (1.8 TWh), agricultural sector (0.1) TWh and non-specified (1.9 TWh).

In terms of fuel mix in power generation, a high penetration of renewable energy will be needed to achieve the NDC target and to substantially increase the share of renewable energy in TFEC. Figure 13 shows theshares of different renewable energy sources in different scenarios in 2030. Hydropower will be the dominant source of power generation at 50.3 per cent, followed by wind at 25.4 per cent and natural gas at 19.3 per cent.

**Figure 12. Electricity demand by sector, 2030, all scenarios**

**Figure 13. Renewable power generation, 2030**

## Policy actions for achieving SDG 7

### 4.4.1. Promote electric cooking stoves to achieve universal access to clean cooking fuel

**Universal access to clean cooking solutions should be a top priority for Georgia, and this target should be achieved by promoting electric cooking stoves. Policymakers can achieve additional benefits to reduce the impact of deforestation in rural communities.**

**Evaluation of clean cooking technologies**

1. *Improved cooking stove*

Studies suggest that improved cooking stove (ICS) programmes often have low adoption rates due to the inconvenience of use, the preference for traditional cooking stoves and the need for frequent maintenance and repairs. ICS programmes initially require strong advocacy to promote adoption, after which they require ongoing follow-up, monitoring, training, maintenance, and repairs in order to ensure continuing usage.

Based on World Health Organization (WHO) guidelines for emission rates for clean cooking, only certain types of ICS technology comply with these requirements, particularly when considering the fact that cooking stove emissions in the field are often higher than they are in laboratory testing. Based on the need for ongoing follow-up, ICS serve better as a bridging option, but are not well-suited as a long-term solution.

1. *Biogas digester*

Biogas digesters have high upfront capital costs – about US$1,000 for a standard size unit suitable for a four-person family – and require a substantial subsidy due to their longer payback period. The technology is not favoured in rural areas due to the cultural aspects of using animal or human waste for cooking. Additionally, a standard size biogas digester requires 2-4 cows, depending on the size of the cow, to produce enough feedstock for daily gas demand for a household.

1. *LPG cooking stove*

The LPG cooking stove causes lower indoor air pollution compared to ICS and is classified as Level 4 in the World Bank Multi-Tier Framework (MTF)[[6]](#footnote-7) for cooking exposure. It also reduces indoor air pollution by 90 per cent compared to traditional cooking stoves. However, as LPG is imported, promoting its utilization will increase import dependency on petroleum fuel in Georgia.

1. *Electric cooking stove*

Georgia has surplus electricity generation potential and it makes sense to use this surplus to promote electric cooking stoves. The technology is classed as Level 5 in the World Bank MTF for Indoor Air Quality Measurement. Electric cooking stoves are more efficient than other types of cooking stoves, including gas stoves. Electric cooking stoves can be generally divided into two types – solid plate and induction plate. While a solid plate cooking stove uses a heating element to pass radiant energy onto the food and reaches about 70 per cent efficiency, an induction plate cooking stove uses electromagnetic energy to directly heat pots and pans, and can be up to 90 per cent efficient. Promotion of electric cooking stoves will not only be cost-effective they will also improve the country’s energy security by reducing its dependence on imported petroleum products.

*(e) Natural gas stove*

Clean cooking with natural gas is not a viable solution for rural households as it would require building gas distribution infrastructure, which is extremely difficult for remote locations. Table 2 summarizes the annualized cost of different cooking technologies.

**Table 2. Annualized cost of cooking technologies**

|  |  |
| --- | --- |
| **Technology** | **Annualized Cost** |
| ICS | US$35 |
| Electric stove | US$87 |
| LPG stove | US$189 |
| Biogas digester | US$133 |

### 4.4.2. Energy efficiency improvement offers significant cost saving

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

Achieving the recommended SDG 7 target of 3.8 MJ/$ by 2030 will require a 2.9 per cent reduction in energy intensity per year, up to 2030. This equates to reducing TFEC of 455 ktoe by 2030, compared to the current policy scenario. The NEXSTEP analysis identified the following measures for supporting this reduction cost-effectively, with the annual savings in energy by 2030 stated for each measure.

**Residential sector – total savings: 184 ktoe**

1. Replace natural gas boilers in 40 per cent of households in Georgia with heat pumps - 109 ktoe.
2. Introduce MEPS for all new lights from 2022 onwards to replace existing incandescent bulbs (75W) and CFL bulbs (20W) with LED bulbs (12W - 47 ktoe).
3. Introduce MEPS for all new televisions from 2022 onwards (14 ktoe).
4. Introduce MEPS for all new refrigerators from 2022 onwards (9 ktoe).
5. Introduce MEPS for all new washing machines from 2022 onwards (2 ktoe).
6. Switch from traditional cooking to clean cooking (electric cooking stove) (3 ktoe).

In the NESTEP analysis, the implementation of MEPS has been modelled from 2022 onwards to provide time for policymakers to ready market participants for these measures.

**Transport sector – total savings: 93 ktoe**

Convert 100 per cent[[7]](#footnote-8) of passenger buses to electric buses by 2030 (3 ktoe).

**Industrial sector – total savings: 114 ktoe**

1. Change the wet process of clinker production in the cement industry to a pre-heated process using pre-calciner kilns (34 ktoe).
2. Install LED lighting across all industrial sectors (25 ktoe).
3. Improve boilers and steam/hot water distribution systems in the pulp and paper, food and beverage, and chemical industries (31 ktoe).
4. Install energy-efficient motors, pumps, fans and compressors across all industries (24 ktoe).

**Commercial sector – total savings: 64 ktoe**

1. Install roof insulation and polymer secondary glazing across all government buildings in Georgia to reduce thermal energy consumption by 39 per cent (Timilsina et al., 2016) (39 ktoe).
2. Install polymer secondary glazing in windows of private buildings to reduce thermal energy consumption by 15 per cent (25 ktoe).

Energy efficiency measures in the NEXSTEP model are applied at the end-use level to estimate savings from measures such as MEPS, efficient cooking stove adoption, electrification of transport, improved fuel economy standards and industrial energy efficiency measures.

### 4.4.3. Increase the share of renewables further in the power sector

The SDG 7 target for renewable energy does not specify any quantitative target – it suggests substantially increasing the share of renewable energy in TFEC by 2030. The NEXSTEP methodology employs an integrated and logical approach to estimating a target that would not only help in achieving the SDG 7 targets, but would also support the achievement of NDC. Based on this approach NEXSTEP estimates that the share of renewable energy in TFEC would need to be 25.4 per cent in 2030.

The current trend suggests that Georgia will fall short of this target and will reach only 22.7 per cent in TFEC under the current policy scenario. Therefore, a step up is necessary to bridge the gap. The proposed increase will mainly be in the power sector, which will reach a renewable energy share of 75.7 per cent in the fuel mix for power generation. As a comparison, the renewable energy share in the power sector is 73.1 per cent in the current policy scenario. In terms of technology mix for renewable energy, the share of generation will come from hydro (50.3 per cent) followed by wind (25.4 per cent), solar (0.8 per cent), combined cycle gas turbine (19.3 per cent) and single cycle gas turbine (4.3 per cent).

Total investment in the power sector under the CP scenario will be US$9.5 billion. On the other hand, the SDG scenario requires an investment of US$4 billion. The reduction in investment is mainly due to a reduction in capacity arising from lower energy demand in 2030.

### Leverage the declining cost of renewables

The Levelized Cost of Electricity (LCOE) is a widely used metric in the energy industry to compare the economic value of different electricity generation technologies. It calculates the unit cost of electricity (US$/MWh) over the lifetime of the project, including capital, operating and financing costs. The LCOE method sums up the lifetime costs of an energy system divided by the lifetime energy generation. It is a measure of the cost-competitiveness of different electricity generation technologies. LCOE is measured using the lifecycle cost of a system and therefore balances out the disparity where some technologies have high capital cost but low operating cost, whereas the other technologies have low capital cost and high operating cost.

NEXSTEP has calculated LCOE for Georgia (figure 14) using cost figures available in literature for the region. LCOE component analysis in figure 14 highlights the fact that today renewable electricity generation technologies, e.g., solar photovoltaic (45 $/MWh) and hydro (46 $/MWh), are cheaper than gas-based generation technologies in Georgia.

The results from the LCOE analysis are comparable with analysis done by others. For example, LAZARD LCOE analysis 13.0 gives a range of 32-42 $/MWh for utility-scale solar photovoltaic, while IRENA Renewable Power Generation 2019 LCOE for onshore wind is 53 $/MWh.

**Figure 14. LCOE of different power plant technologies in Georgia**

# Energy transition pathways with increased ambition

**Several ambitious scenarios have been further analysed to identify the best way forward for Georgia to transition its energy sector to 2030. This analysis identifies a range of socio-economic and environmental benefits for Georgia to raise its ambition beyond just achieving the SDG 7 targets, such as the cost-effectiveness of furthering energy efficiency improvements as well as the economic benefits, to enhancing NDC targets beyond the existing unconditional and conditional NDCs.**

The SDG scenario is further expanded with four different ambitious scenarios to analyse and compare costs and benefits, and to identify a scenario that is most suited to Georgia. Like the SDG scenario, these ambitious scenarios, at a minimum, aim to achieve the SDG 7 targets. In addition, these scenarios are also modelled to achieve the NDC conditional target of a 25 per cent reduction of emissions in 2030, compared to the BAU scenario. To do so, a Next Energy Modelling system for Optimization (NEMO), based on least cost optimization, has been applied to electricity generation by considering the emission constraints. The scenarios are:

1. **Clean electricity export scenario.** Georgia has the potential to substantially increase clean electricity exports to neighbouring countries. In this scenario, a target of 10 TWh in electricity exports by 2030 is modelled.
2. **Sustainable heating scenario.** Decarbonisation of heat is a major challenge. Inherited from scenario (a), this scenario further analyses the deployment possibilities of heat pumps to replace natural gas boilers as well as the use of solar water heaters in replacing natural gas water heater consumption in households. Thisscenario also analyses the impact of a US$40/tCO2-e carbon price on electricity generation.
3. **Sustainable transport scenario.** Thisscenario is same as scenario (b), with an additional focus on the transport sector. Policies such as electrification of 50 per cent of passenger vehicles in Georgia by 2030 is modelled. Thisscenario also analyses the impact of a US$40/tCO2-e carbon price on electricity generation.
4. **Decarbonising the power sector to enhance NDC scenario.** Thisscenario is the most ambitious one, in which the power sector is completely decarbonized by phasing out all fossil fuel-based power generation by 2030. Thisscenario also analyses the impact of a US$40/tCO2-e carbon price on electricity generation.

The following section presents details of the key results of the ambitious scenarios. In addition, further descriptions with reference to the SDG targets and NDC target achievement can be found in Annex IV.

|  |
| --- |
| **Box 2.** **Carbon pricing**  A carbon price of US$40/tCO2-e has been included in scenarios (b) to (d) above to assess the impact of this externality on Georgia’s power sector. The carbon price selection is based on World Bank guidance on a minimal price range of US$40/tCO2-e – US$ 80/ tCO2-e needed to be consistent with Paris Agreement targets (World Bank, 2020c).  Carbon pricing, whether through a carbon tax or a cap-and-trade emissions trading system, improves the competitiveness of carbon-free technologies and provides additional revenue. Hypothecation allows the mechanism to act as a transfer of funds into clean technology investment. However, today’s market shows little consistency in carbon pricing, and it is therefore very difficult to choose a carbon price that is appropriate to the national context. For example, the carbon price for the European Union Emission Trading Scheme (EU-ETS) may reach a price of €59 by 2030 (Abnett, 2020). An additional carbon tax has also been implemented in several countries (e.g., Finland, Switzerland and France) with a price up to US$119 tCO2-e (World Bank, 2020c) .  The *State and Trend of Carbon Pricing 2020* report published by the World Bank (2020c) suggests that a minimum carbon price of US$40-US$80 per ton was needed by 2020 to cost-effectively reduce emissions in line with the temperature goal of the Paris Agreement. In this study, a lower limit of the proposed carbon price of US$40 has been chosen. This is provided as an indicative demonstration of how a price on carbon would support the proposed transformation of the energy sector. Further in-depth investigation should be performed by engaging subject matter experts and stakeholders to identify the price and mechanism best suited to Georgia. |

## Clean electricity export scenario

This scenario explores Georgia’s potential in increasing its clean electricity exports to neighbouring countries, specifically with an annual target of 10 TWh. The rationale is based on the “Ten-Year Network Development Plan” of Georgia that was developed for 2018-2029, which projects electricity production will exceed 30 TWh by 2029 and consumption will reach 22 TWh to make about a 10 TWh export target possible for Georgia (Chomakhidze et al., 2018).

The energy demand profile of the end-use sectors during the analysis of the clean electricity export strategy remains similar to the SDG scenario, as no changes in demand technologies have been assumed. Nevertheless, increasing the electricity export ambition as well as the utilization of the NDC conditional target as the emission constraints have resulted in changes in several aspects, particularly related to the power generation structure, as explained further below.

### Power generation

The power capacity built in this scenario increased from 4,153 MW in 2018 to 12,365 MW in 2030, an increase of 5,262 MW compared with the SDG scenario. The power technology capacity mix is predominantly hydropower at 8,715 MW (70.5 per cent), followed by wind at 1,500 MW (12.1 percent). A major decrease in natural gas-based power technologies, CCGT and SCGT, is projected, with a combined total of 1,637 MW (13.2 per cent) of installed capacity. In comparison, the combined capacity of CCGT and SCGT in the SDG scenario is 2,059 MW (29 per cent).

**Figure 15. Total installed power capacity in 2018 and 2030**

**Figure 16. Electricity generation by power technologies, 2018-2030**

### Decreased natural gas import

The reliance on natural gas for electricity generation decreased in this scenario. The total import of natural gas is 2,197 ktoe in 2030, of which 435 ktoe is used in electricity generation. This is a decrease of 375 ktoe compared with the SDG scenario.

### Investment cost and net benefits

The total investment cost during the analysis period for the power sector is US$13.5 billion, an increase of US$9.5 billion compared to the SDG scenario. In comparison, a slight reduction of US$0.7 billion in investment is projected for the natural gas-based power technologies. The total investment in renewable technologies is projected to be US$12.8 billion, of which US$9.9 billion is invested in newly-built hydropower capacity.

The net benefit from the power sector is US$3.0 billion. This corresponds to a US$1.9 billion decrease compared with the SDG scenario, due to the high investment in a hydropower plant. Nevertheless, the net benefits do not include the possible revenue generated through electricity sales to neighbouring countries over the lifetime of the power plant, which is expected to be significant. On the other hand, the net benefit is US$2.3 billion higher compared to the current policy scenario. This is because of the higher fuel and operational and maintenance costs of fossil fuel-based power plant lifetime costs.

### GHG emissions

The total GHG emissions in 2030 increase to 11,132 kTCO2-e. This is a substantial decrease from the current policy and SDG scenarios of 2,447 kTCO2-e and 881 kTCO2-e, respectively. The total emissions from this scenario allow the meeting of the NDC unconditional target by a margin of 842.5 kTCO2-e.

## Sustainable heating scenario

Due to Georgia’s continental climate, the residential demand for space heating and water heating is substantial. Space heating demand constitutes around 57 per cent of the total residential energy demand, while water heating demand is around 8 per cent of the total residential demand. To put this into perspective, the total residential demand is around 51 PJ, which is 28 per cent of Georgia’s total energy demand. The adoption of energy efficiency measures in the residential heating sector would provide substantial improvement in Georgia’s overall energy use.

Energy efficiency measures to replace natural gas boilers in 40 per cent of households in Georgia with heat pumps has been considered in the SDG scenario as well as in the ambitious scenarios discussed above, saving 109 ktoe annually in 2030. This scenario explores the following additional efficiency improvement opportunities:

1. increasing the use of heat pumps in households to 60 per cent share (replacing natural gas heating);
2. increasing the use of solar water heaters (replacing natural gas water heaters) to 30 per cent share.

The key results are explained further in the following sections.

### Energy demand and import dependency

The adoption of additional energy efficiency measures would further reduce the residential energy demand by an additional 55 ktoe, totalling up to 164 ktoe in 2030 compared to the current policies scenario. The decrease in energy demand is due to the replacement of natural gas boilers with heat pump technologies. The demand for electricity to run the heat pump technologies is only around 40 per cent of the energy demand of natural gas boilers. The total additional electricity need that is due to these additional measures is around 2.8 TJ, compared to the SDG and ambitious scenarios discussed above. Considering the overall energy efficiency improvement analysed for residential heating, the additional electricity demand is 5.3 TJ, compared with the current policy scenario.

Consequently, the reduced use of natural gas in residential heating (both space and water heating) would help to relieve the reliance on natural gas imports. The additional measures considered in this scenario reduce natural gas imports by 111 ktoe, compared with the SDG scenario.

**Figure 17. Energy savings in residential heating, 2018-2030, compared to the SDG scenario**

## Sustainable transport scenario

In addition to the measures modelled in the sustainable heating scenario, this scenario looks at increasing the percentage share of electric passenger cars from 0.2 per cent in 2018 to 50 per cent by 2030. This results in a reduced share of petroleum- and diesel-fuelled passenger cars by 25.6 per cent and 9.4 per cent, respectively, by 2030. This transport energy efficiency measure is in addition to the measure already applied across the SDG scenario and the ambitious scenarios, which replaces 100 per cent of passenger buses with electric buses by 2030, saving 93 ktoe annually in 2030. The key results are discussed below.

### Energy demand and import dependency

Increased electrification in the transport sector reduces the transport energy demand by 298 ktoe, compared to the SDG scenario, in 2030. Such a decrease in energy demand is due to the lower energy intensity of electric cars compared to petroleum- and diesel-fuelled cars. The additional electricity demand incurred by the electrification measure would be around 6.2 PJ in 2030, compared with the SDG and ambitious scenarios discussed above. Figure 19 shows the energy savings compared with the current policies measures, including energy savings through the electrification both of passenger bus and passenger cars.

The reduced use of oil products (i.e., petroleum and diesel) in the transport sector due to the 50 percent electrification of passenger cars will help to relieve the reliance on oil and gas imports by 448 ktoe.

**Figure 18. Energy savings in the transport sector, 2018-2030, compared to the current policy scenario**

## Decarbonising the power sector to enhance the NDC scenario

This scenario is the most ambitious one, as it not only considers all measures discussed in the SDG and ambitious scenarios described above, but also raises the ambition to decarbonise the power sector completely by 2030. The key results, mainly in the power generation and GHG emissions aspects, are described further below.

### Power capacity and generation

The total installed power plant capacity increases from 4,153 MW to 14,209 MW in 2030, with gradual phasing out of fossil fuel-based power generation units by 2030. Installed power plants are dominated by hydropower plant at 12,209 MW (86 per cent), with the remaining being wind at 1,500 MW (11.5 per cent) and solar at 500 MW (3.5 percent). Due to lower availability of renewable power plants, the phasing out of fossil fuel-based power plant results in an increased required capacity of 2.4 GW, compared to the sustainable transport scenario. Figure 20 compares the installed capacities in this scenario, the SDG scenario and the current policy scenario.

**Figure 19. Installed power capacity in 2030**

In terms of electricity generation, hydropower makes up around 78.5 per cent (115 PJ) of the total electricity produced in 2030, followed by wind (19 per cent) and solar (2.5 per cent).

### Investment cost and net benefits

The total investment cost during the analysis period for the power sector is US$19 billion, an increase of US$15 billion compared with the SDG scenario. The substantial difference is due to the high amount of hydropower installed, incurring around US$15 billion cumulatively throughout the analysis period.

However, the net benefits gathered from a fully decarbonised power sector during the analysis period are not optimistic, with a negative benefit of US$0.4 billion. Phasing out of fossil fuel-based power plants reduces the feedstock cost to zero, yet the benefit is negated by the investment costs and fixed O&M costs incurred due to the newly-built hydropower capacities. However, a higher return can be expected over the lifetime of renewable power plants due to zero feedstock cost.

# Policy recommendations

## Scenario ranking

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 weights assigned to each criterion (table 3). While the criteria and weights have been selected based on expert judgement, ideally the process should use a 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 weights of each criterion. The following factors have been considered to assume comparative weights across the set of criteria, where the total weight needs to be 100 per cent:

1. Universal access to electricity to be achieved;
2. Universal access to clean cooking fuel to be achieved;
3. Renewable energy share in the total final energy consumption to increase;
4. Energy efficiency improvement should be doubled, and where there is an economic benefit it should be further enhanced;
5. The unconditional NDC target should be achieved. Where possible, the conditional target should be achieved if it is economically viable.
6. 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;
7. Carbon pricing should be introduced to encourage investments in clean energy.

**Table 3. Criteria with assigned weights for MCDA**

|  |  |
| --- | --- |
| Criterion | Weight (%) |
| Access to clean cooking fuel | 10 |
| Energy efficiency | 10 |
| Share of renewable energy | 10 |
| Emissions in 2030 | 10 |
| Alignment with PA | 9 |
| Fossil fuel subsidy phased out | 3 |
| Price on carbon | 3 |
| Fossil fuel phase-out | 5 |
| Cost of access to electricity | 5 |
| Cost of access to clean cooking fuel | 5 |
| Investment cost | 15 |
| Net benefit from the power sector | 15 |

Table 4 shows the summary of results obtained through this evaluation process. The scenario recommendation suggests that the ambitious scenario, i.e., the “sustainable transport” scenario, is the highest-ranked energy transition pathway for Georgia.

**Table 4. Scenario ranking based on MCDA**

| Scenarios | Weighted scores | Rank |
| --- | --- | --- |
| Sustainable transport | 60.2 | 1 |
| SDG scenario | 57.3 | 2 |
| Decarbonising power sector to enhance NDC | 55.0 | 3 |
| Sustainable heating | 54.1 | 4 |
| Clean electricity export | 47.1 | 5 |
| Current policy scenario | 31.3 | 6 |

The following section presents several policy recommendations to aid Georgia in raising its ambitions beyond the SDG and NDC targets. The policy recommendations are not only valid for the conditional NDC and sustainable transport scenarios, but also offer cross-cutting suggestions for the other ambitious scenarios.

## Improving energy efficiency beyond the SDG 7 target

Georgia has the technical potential to further accelerate energy efficiency beyond the SDG 7.3 target. This can be achieved through demand-side energy efficiency measures in the residential and transport sectors. Additional demand-side energy efficiency measures, complementary to the previous set of measures listed in subsection 4.4.2, further reduces the TFEC by 353 ktoe.

**Residential sector energy savings: 55 ktoe**

1. Replacing natural gas boilers in 60 per cent of households in Georgia with heat pumps to save an additional 55 ktoe annually in 2030.
2. Replacing natural gas water heaters with solar water heaters in 30 per cent of Georgia households.

**Transport sector energy savings: 298 ktoe**

Fleet conversion of 50 per cent[[8]](#footnote-9) of passenger vehicles to electric vehicles by 2030, saving an additional 298 ktoe annually in 2030.

In order to reach even further, such as in the “enhancing NDC by decarbonising power sector scenario*”*, the increased share of renewable energy in the power sector further reduces the energy intensity due to the higher conversion efficiency of renewables compared to fossil-fuel-based technologies. For example, phasing out fossil fuel-based power technologies reduces the total primary supply by 553 ktoe, or in energy intensity terms, a reduction of 0.54 MJ/US$.

## Reducing natural gas dependency via electrification of residential and transport sectors and decarbonising the power sector

Natural gas currently constitutes around 42 per cent of Georgia’s total primary energy supply, with the needs being met through importation. Such reliance on imported natural gas brings risks to Georgia, making it susceptible to future supply problems and price shocks. Nevertheless, energy efficiency measures involving electrification of residential heating and transport sectors, not only reduce the country’s energy intensity, but relieve Georgia’s reliance on natural gas.

Additionally, decarbonising Georgia’s power sector by phasing out natural gas-based power technologies further reduces the use of natural gas in the energy system. Decarbonisation of the power sector can be met by ramping up the installed capacity for hydropower, solar and wind power generation. The LCOE analysis (figure 15) shows that hydropower, solar and wind have a lower LCOE than most, if not all, other fossil fuel-based technologies – even for existing generators where the only expenses are operating costs. The use of locally available renewable resources, instead of natural gas, increases Georgia’s energy security and prevents future price shocks, making natural gas-based electricity generation more expensive.

## Exporting clean electricity is feasible

Based on the “Ten-Year Network Development Plan” of Georgia developed for 2018-2029, it is projected that by 2029 electricity production will exceed 30 TWh and consumption will reach 22 TWh, allowing 8 TWh to be exported to neighbouring countries. Georgia’s high renewable energy potential, particularly in hydropower, allows such a target to be met with clean energy, while reducing GHG emissions. Furthermore, adoption of energy efficiency measures reduces the electricity needs in Georgia, requiring less electricity production capacity to be built to fulfil such targets. The comparatively low LCOE of renewable electricity creates a lucrative economic opportunity when the surplus electricity is sold to countries with higher generation costs (i.e., Turkey).

Nonetheless, the integration of renewable electricity in a power system connected with other countries yields a positive contribution towards climate change mitigation. This allows the utilisation of renewable electricity in countries lacking renewables resources, reducing the need for fossil fuel-generated electricity.

## Putting a price on carbon to help reduce the investment gap and encourage low-carbon transition

Carbon pricing is recognized around the world as an effective policy tool to facilitate sustainable energy transition. The external cost of carbon emissions such as health damage, climate impact and social costs paid by society should be shifted to the producers and consumers responsible for producing pollution. There are two main mechanisms for carbon pricing – emission trading schemes (cap and trade) and carbon taxation.

Emission trading schemes place a cap on CO2-e emissions and allow participants to trade an allowance of CO2-e emissions under the cap. The mechanism results in a wealth transfer from high-emission to low-emission technology proponents, increasing the attractiveness of low-emission technology investments. An exemplary emission trading system is EU-ETS, which covers 45 per cent of the European Union’s GHG emissions. Carbon taxes simply mean putting a price on the GHG emissions or on the carbon content of fuels. In the NEXSTEP analysis, a carbon price of US$40 per ton has been used for ambitious scenarios. Governments may choose to treat this as a revenue stream or use these funds as a wealth transfer mechanism.

As of 2019, 55 per cent of countries that submitted the NDC document have stated plans for, or are considering, the implementation of carbon pricing. Sweden is an example of successful implementation of the carbon pricing mechanism. Introduced in 1991, Sweden’s carbon tax is currently US$127/tCO2-e. Funds raised from this mechanism are used to develop energy efficient technologies such as biomass-based district heating.

In this analysis, a price on carbon has been considered as a mechanism for limiting emissions and levelling the playing field for low-carbon technologies, currently limited to the power sector. Carbon pricing mechanisms can be similarly applied to other sectors such as the industry sector. The fuel consumption of Georgia’s industry sector is still currently dominated by fossil fuels, such as natural gas and solid fuels (i.e., coal). The resultant emissions are at around 2,086 ktCO2-e in 2030, across the SDG and the ambitious scenarios. Consideration of a carbon price is likely to lead to process innovation or uptake of cleaner technologies.

## Green financing

Accelerating green financing is critical to achieving sustainable energy transition. Large capital investments in renewables will be required; however, at the same time, it will lead to even greater savings compared to fossil fuel-based generation. Policymakers need to work with central banks, regulatory authorities and investors to examine the possibility of developing a green finance policy and establishing a green finance bank or fund to help close the investment gap.

Green bonds mobilize resources from domestic and international capital markets to finance climate solutions. For example, in July 2020, Georgia issued its first green bond offering worth US$250 million (*Alliance News*, 2020). Such an initiative is welcomed by financial investors and has received financial support from the Asian Development Bank (ADB) through investment up to US$20 million (ADB, 2020b.

Renewable energy technologies involve relatively high financing costs in developing countries, which reflects their unattractive risk/return profile. This is because of their long-time horizon, high initial capital costs, illiquid equipment and project risks. Policymakers can reduce high financing costs 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 (UNDP) “De-risking Renewable Energy Investment”[[9]](#footnote-10) is an important guide for policymakers in developing strategies to reduce risks of renewable energy investment.

# Rebuilding better with the SDG 7 roadmap in the recovery from COVID-19

Energy plays a key role in rebuilding better in the recovery from the COVID-19 pandemic. Energy services are essential to supporting health-care facilities, supplying clean water for essential hygiene, enabling communication and IT, and off-grid renewables refrigeration for vaccine storage. Economic challenges resulting from the pandemic have the potential to force countries in the Asia-Pacific region to focus on short-term fixes to revive GDP growth, potentially undermining long-term sustainable development. In the energy sector. This can result in the decline of investment in clean energy development – slowing progress in renewable energy and energy efficiency, and eventually, impeding national economic growth.

The lockdown measures to contain COVID-19 have led to economic contraction in Georgia. The ADB suggests that the impacts of COVID-19 could cause Georgia’s economic growth to retract by 5 per cent in 2020 before it recovers to 4.5 per cent in 2021 (ADM, 2020a). A significant drop in energy consumption has also been observed. The reduction of business activities during the pandemic has caused electricity demand to fall. Experts and policymakers are still taking stock of the impacts of COVID-19 on the energy landscape resulting from the contraction of the economy as well as what it will mean for the ongoing transition to sustainable energy.

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 which helps in the recovery to build back better. The SDG 7 roadmap has identified several key areas that will assist policymakers in strengthening policy measures to help recover from the COVID-19 impacts, while maintaining the momentum to achieving the 2030 Agenda for Sustainable Development and the Paris Agreement.

## Accelerating access to clean and modern energy services

Access to clean and modern energy services is essential for helping rural populations to combat challenges related to COVID-19. Relying on traditional and hazardous technologies for cooking increases their susceptibility to the effects of the virus. It is important to consider how these seismic shifts in the energy sector resulting from COVID-19 affect the most vulnerable people.

In 2017, Georgia had about 900,000 people without access to clean cooking fuel. Access to clean cooking technologies is a development challenge that is often forgotten. One medium-term impact of COVID-19 could be a decrease in investment in energy access, as national budgets come under strain and priorities shift. The World Health Organization has warned about the severity of health impacts arising from the exposure to traditional use of biofuel for cooking, and is encouraging policymakers to adopt measures to address this challenge. Moreover, scientists are already investigating links between air pollution and higher levels of coronavirus mortality, with preliminary results showing a probable correlation between the two.

The SDG 7 roadmap has analysed and identified technical options for connecting the remaining population to cleaner fuel for cooking and has estimated the cost of the measure. The benefits resulting from this measure, in the form of reduced mortality and positive health impact, will exceed the needed investment of US$1.3 million.

## Savings from the energy sector will help build other sectors

The NEXSTEP analysis shows that there are ample opportunities in Georgia to save energy by improving energy efficiency beyond the current practices as well as further strengthening efforts to reach the national target of energy-intensity reduction. As highlighted in the previous chapters of this report, several cost-effective energy efficiency measures can be implemented in the residential, transport and industrial sectors, which will result in net financial gain – with annual energy savings of up to 808 ktoe. 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.

An example of low- to no-cost measures is the introduction of minimum energy efficiency standards (MEPS) in producing appliances, e.g., air conditioners, televisions and lights, all of which have zero or negative costs. There is also potential for implementing energy efficiency in the transport sector, for example by promoting electric vehicles. This has multiple related benefits (in addition to energy saving), including the reduction of expenditure on importing petroleum products and reducing local air pollution. At the same time, other options for sustainable transport also need to be explored. These include: (a) avoiding the need for integrated land-use planning and transport demand management; (b) shifting travel to the most efficient or clean mode, e.g., non-motorised or public transport; and (c) improving the environmental performance of transport through technological improvements to make vehicles more energy-efficient and less carbon-intensive. Such measures are very important to solidifying the pathway to recovery from COVID-19 and rebuilding better.

## Revenue from carbon pricing to invest in where it is needed the most

Fossil fuel combustion is not only the main driver of global warming, but is also the major source of air pollution, causing severe health impacts that are likely to increase the vulnerability of people to pandemics like COVID-19. Renewable energy technologies have multiple benefits – including improved health, increased energy security by utilizing indigenous energy sources, reduced import costs of feedstocks and technologies, and enhanced natural capital. While the cost of renewables has decreased significantly and LCOEs are already cheaper than their fossil fuel counterparts, the importance of putting a price on carbon should not be ruled out. The additional funds generated with such a fiscal instrument can be used to level the playing field for renewables as well as support economic recovery in cases like the COVID-19 pandemic.

# Revisiting existing policies

Georgia’s current energy policies have been evaluated based on the outputs from the LEAP model, in order to highlight any inconsistencies or revisions required to achieve the SDG 7 and NDC targets by 2030. These are summarised by topic below.

## Universal access to clean cooking

|  |  |
| --- | --- |
| Existing policy | NEXSTEP Analysis – Gaps and recommendations |
| **Nationally Appropriate Mitigation Action (NAMAs)**  NAMA aims to provide 15,000 rural households with fuel-efficient wood stoves. | **Gaps:**  Georgia will fall short of achieving the SDG target, reaching only 97 per cent of the population with clean cooking fuel by 2030.  **Achieving SDG and ambitious scenarios:**  NEXSTEP analysis shows that promoting the electric cooking stove will be the most appropriate approach, leveraging Georgia’s low electricity tariff. In addition, it can provide additional benefits by reducing the impact of deforestation in rural communities. |

## Renewable energy

|  |  |
| --- | --- |
| Existing policy | NEXSTEP Analysis – Gaps and recommendations |
| **National Renewable Energy Action Plan (NREAP) Georgia, 2019**  The NREAP proposes a number of measures and investments in achieving the target of 30 per cent of energy consumed coming from renewable energy by 2020. | **Gaps:**  The document summarises several measures and the investment planned between 2018 and 2020, to achieve the renewable energy target set forth by the Government of Georgia. However, no concrete direction/strategy planning towards 2030 has been observed.  **Achieving the SDG scenario:**  Increasing the renewable energy share in the energy sector will require long-term planning, involving multi-sectors. In addition, the interlinkages between achieving the other SDG targets and NDCs must be taken into account in setting a target for renewable energy implementation.  The NEXSTEP analysis proposes that a 25.4 per cent renewable energy target in TFEC is optimum when considering all other SDG and NDC targets.  **Achieving ambitious scenarios:**  The renewable energy share (in TFEC) can be further increased to 39.3 per cent, as proposed by the decarbonising power sector to enhance the NDC scenario. This, however, requires the uptake of additional energy efficiency measures in the residential and transport sectors as well as phasing out fossil-fuel power technologies. |

## Energy efficiency

|  |  |
| --- | --- |
| Existing policy | NEXSTEP Analysis – Gaps and recommendations |
| **National Energy Efficiency Action Plan (NEEAP) Georgia, 2019-2020**  NEEAP has identified several energy efficiency measures across different sectors to be implemented during 2019-2020.  It is estimated that a 14 per cent reduction can achieved, compared with the BAU scenario, in 2030. The estimated primary energy use in the BAU scenario is 366.5PJ, while final primary energy use, with energy efficiency measures adopted, is an estimated reduction of 314PJ. | **Gaps:**  To achieve the SDG energy efficiency target of 3.9 MJ/US$, the primary energy use needs to be reduced to 259 PJ in 2030. The estimated energy saving achieved by the measures stipulated in NEEAP misses the target by 55 PJ.  **Achieving SDG scenario:**  The NEXSTEP analysis proposes several energy efficiency measures across different sectors. Altogether, the proposed measures allow the achievement of SDG target 7.3.  The increased use of renewable electricity will further reduce the energy intensity as it replaces the less efficient fossil fuel-based power plants. The reduced use of primary energy, specifically natural gas, will further strengthen Georgia’s energy security, and avoid supply and price shocks.  **Achieving ambitious scenarios:**  Georgia has the potential to further reduce its energy intensity through the residential heating and passenger transport sectors. Energy intensity of 3.25 MJ/US$ can be achieved by decarbonising the power sector, if the proposed efficiency measures are adopted. |

# Conclusion

Georgia is steadily progressing towards SDG 7, but more effort is needed to achieve all the SDG 7 targets. The SDG 7 roadmap offers an integrated multi-sectoral plan to build on the existing plans and policies of Georgia in achieving the SDG 7 and NDC targets. The policy gap analysis suggests several areas where concerted efforts are needed to achieve these targets as well as Georgia’s emissions reduction target under the Paris Agreement.

Without well-designed and targeted policy measures, Georgia will still have a substantial population that uses harmful fuels and technologies for cooking in 2030 and beyond. While the national energy intensity has been declining at a rapid rate for the past decade, Georgia will need to further strengthen its efforts to achieve the target. Georgia’s emission trajectories in the current policy scenario appear promising, although they fail to achieve the unconditional NDC target by a small margin. Nevertheless, adoption of energy efficiency measures and increasing the renewable power share will not only increase the renewable energy share in TFEC, but also reduce emissions close to the level needed to achieve the conditional NDC target. Indirectly, Georgia would strengthen its energy security by reducing natural gas imports.

Going beyond the stipulated targets, Georgia may leverage its huge renewable energy resources for clean electricity exports. Georgia may also increase its ambition to reduce its energy intensity further by adopting additional demand-side measures, as well as through phasing out the low efficiency fossil-fuel-based power technologies. Further reduction of Georgia’s emissions is not only feasible, it will also benefit from the reduction of its energy intensity beyond the SDG target. For example, the most ambitious scenario proposed by NEXSTEP shows that close to a 38 per cent reduction, compared to the CP scenario, can be achieved. Putting a price on carbon will level the playing field for renewables and help to reduce the investment gap as well as attract private investment and spur innovation.

Finally, the energy transition pathway presented in this SDG 7 roadmap will support rebuilding better after the COVID-19 pandemic. The proposed energy transition presents opportunities for reducing economic risks, both for public and private investment, and identifies areas for financial savings in the energy sector that can support the recovery of other critical sectors, such as the health sector.

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**Annexes**

**Annex I. National Expert SDG 7 tool for energy planning methodology**

The analysis presented in the national roadmap 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 to make 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 backcasted from 2030, since the targets for 2030 are already defined.

**Annex table 1. Targets and indicators for SDG 7**

|  |  |  |  |
| --- | --- | --- | --- |
| **Target** | **Indicators** | **2018** | **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. | 100% | 100% |
| 7.1.2. Proportion of population with primary reliance on clean fuels and technology for cooking. | 75.2% | 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. | 25.9% (including traditional biomass) | 25.4% |
| 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. | 5.3 MJ/US$ (2011) PPP | 3.8 MJ/US$ (2011) PPP |
| 7. A. By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency, and advanced and cleaner fossil fuel technology, and promote investment in energy infrastructure and clean energy technology. | 7.A.1. International financial flows to developing countries in support of clean energy research, and development and renewable energy production, including in hybrid systems. | US$ 29.2 million, 2017 PPP (2017 data) | N.A. |

**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 2011 PPP.

where is Energy intensity in year t1 and is energy intensity in year t2.

Base period improvement rate for Georgia (1990-2010): 4.9 per cent.

SDG 7.3 improvement rate for Georgia (doubling of base period improvement rate): 9.8 per cent.

Revised SDG 7.3 improvement rate for Georgia: 2.9 per cent (based on global improvement rate).

**SDG 7.2. Renewable energy**

Renewable energy share in total final energy consumption is increased to meet NDC emission requirements by 2030.

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

**Annex II. Key assumptions for NEXSTEP energy modelling**

1. **General parameters**

**Annex table 2. GDP and GDP growth rate**

|  |  |
| --- | --- |
| Parameter | Value |
| GDP (2018, current US$)[[10]](#footnote-11) | 17.6 billion |
| GDP growth rate[[11]](#footnote-12) | 4.8% |

**Annex table 3. Population, population growth rate and household size**

|  |  |
| --- | --- |
| Parameter | Value |
| Population (2018)8 | 3.72 million |
| Population growth rate | -0.2% |
| Household size (remains constant during 2018-2030) | 3.3818 |

1. **Demand-side assumptions**

**Industry:**

**Annex table 4. Productivity by industry type**

|  |  |
| --- | --- |
| Industry type | Productivity in 2018 |
| Iron and steel | 188.7 kton |
| Chemical | 45.4 kton |
| Non-metallic minerals) | 6,161.0 kton |
| Food, beverages and tobacco | 1,518.6 kton |
| Pulp paper and printing | 22.0 kton |
| Machinery and transport tool | 55.9 kton |
| Textile and leather | 8.3 kton |
| Wood and other products | 59.2 kton |
| Construction | US$1,267.8 million |
| Mining and quarrying | US$180.4 million |

Growth rate per annum: 4.94%.

**Transportation:**

**Annex table 5. Transport, billion passenger-km**

|  |  |  |  |
| --- | --- | --- | --- |
|  | 2018 | 2025 | 2030 |
| Passenger car | 28.52 | 41.72 | 49.21 |
| Motorcycle | 0.16 | 0.23 | 0.28 |
| Bus | 35.29 | 51.61 | 60.89 |
| Tractor | 0.06 | 0.08 | 0.1 |
| Crane truck | 0.05 | 0.07 | 0.09 |

**Residential:**

**Annex table 6. Residential urbanization, percentage**

|  |  |  |  |
| --- | --- | --- | --- |
|  | 2018 | 2025 | 2030 |
| Rural | 58.4 | 61.6 | 63.9 |
| Urban | 55.3 | 60 | 63.4 |

**Commercial:**

**Annex table 7. Commercial floor space**

|  |  |
| --- | --- |
| Parameter | Value |
| Commercial floor space (remains constant during 2018-2030) | 9380823 m2 |

**Annex III. Economic analysis data**

The NEXSTEP Economic model analyses the power plant technologies based on technical and economic parameters to estimate levelized cost of electricity.

**Annex table 8. Economic analysis parameters**

|  |  |
| --- | --- |
| **Economic parameters** | |
| Nominal discount rate | 8.00% |
| Inflation rate | 2.50% |
| Standard Conversion Factor (SCF) | 0.90 |
| Carbon price | 0.00 US$/Ton CO2e |
| Electricity tariff | 0.056 US$/kWh |
| Skilled workforce | 80% |
| Shadow Wage Rate Factor (SWRF) | 0.75 |

**Annex table 9. Fuel price for power plant technologies**

|  |  |
| --- | --- |
| **Fuel Price (World Price)** | |
| Coal | 70 US$/ton coal |
| Natural gas | 5 US$/MMBtu |

**Annex table 10. Georgia technology capacity factor/efficiency and cost data**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Technologies** | **Capacity/factor/ efficiency (%)** | **CAPEX/MW (US$/MW)** | **Fixed O&M (US$/MW)** | **Variable O&M (US$/MWH)** |
| Hydro PP | 31.8 | 1,800,000 | 37,700 | 0.0 |
| Solar photovoltaic PP | 18 | 995,000 | 15,000 | 0.0 |
| Onshore wind | 37 | 1,633,000 | 60,000 | 0.0 |
| Sub-critical pulverised coal | 33 | 1,650,000 | 45,250 | 0.0 |
| Single cycle gas turbine | 35 | 770,000 | 23,200 | 0.1 |
| Combined cycle gas turbine | 55 | 950,000 | 23,200 | 0.1 |

## Annex IV. Summary of scenarios

This annex presents a summary of key messages of all the scenarios that have been developed (a matrix of scenarios is presented) and analysed using NEXSTEP to provide further information on the overall analysis and the roadmap.

### Business as usual scenario

#### Scenario description

The BAU scenario forecasts a hypothetical energy scenario if no actions or polices were taken to help advancing the energy transition to reach the SDG 7 and NDC targets. In addition, the power system continues to expand based on the 2019 capacity share till 2030.

#### SDG 7.1.1. Universal access to electricity

Nepal’s 2019 electricity access rate was 86%. Based on historical projection between 2010-2019, it is expected that a 100% access rate can be achieved in 2024.

#### SDG 7.1.2. Universal access to clean cooking

The current access rate is 46.5%. In projecting the increase in clean cooking access rate for the BAU scenario, NEXSTEP assumes no further initiatives in installing biogas digester and ICS but considers the autonomous penetration of electric stoves and LPG stoves. With that, the clean cooking access rate is projected to reach 63.7% in 2030.

#### SDG 7.2. Renewable energy

RE share in TFEC is projected to reach 27.9% in 2030 (excluding traditional biomass usage in residential cooking sector). The RE share in power generation shall continue to be 100% in 2030.

#### SDG 7.3 Energy efficiency

The energy intensity improvements at the end-use level are modelled as constant from 2019 to 2030. The primary energy intensity is a proxy for the measurement of energy efficiency improvement and is calculated as 4.12 MJ/$ in 2019. The total primary energy use in 2030 is 10,260 ktoe, an increase from 9,268 ktoe in 2019. This corresponds to an energy intensity of 3.26 MJ/USD2011.

#### Power generation

The electricity demand is expected to rise from 6,446 GWh in 2019 to 9,574 GWh in 2030. This increase will be dominated by the residential sector. The power system is modelled in a way that assumes the capacity expansion of the different power technologies is proportionate to the capacity share in 2019. 97.8% of the electricity supply is expected to be from large hydropower generation, with the remaining from mini hydro 0.95%, micro hydro 0.67% and solar 0.60%.

#### GHG Emissions

Nepal’s energy sector greenhouse gas emissions will reach 18.83 MTCO2-e by 2030.

#### Energy balance

### Current Policy Scenario

#### Scenario description

The CP scenario takes into account the energy sector targets pledged in Nepal’s second NDC, which was submitted in December 2020. The targets considered in the CP scenario include the following:

* Raise renewable capacity to 15,000 MW by 2030, of which 5-10% of the capacity shall be from renewable technologies that is not large hydropower
* 15 per cent of the total electricity supply shall be from renewable sources (not including large hydropower)
* Market sales of electric vehicles for private passenger 2- and 4-wheelers will be 25% in 2025, which will gradually raise to 90% in 2030
* Market sales of electric vehicles for public passenger 4-wheelers will be 20% in 2025, which will gradually raise to 60% in 2030
* Increase the share of electric stoves to 25% and disseminate an additional of 150,000 ICS and 200,000 household-scale biogas plants

In addition, NEXSTEP considers a maximum LPG stove penetration of 30% by 2030, based on the Government’s LPG policy.

#### SDG 7.1.1. Universal access to electricity

Universal access to electricity is expected to be reached by 2024, similar to the BAU scenario.

#### SDG 7.1.2. Universal access to clean cooking

Nepal’s clean cooking targets pledged in the 2nd NDC is considered in the CP scenario, while also considering a 30% limit on LPG stove penetration. The clean cooking access rate is expected to rise to 72.3% by 2030. This is an additional 8.6 percentage point increase from the BAU scenario.

#### SDG 7.2. Renewable energy

RE share in TFEC is projected to reach 35.9% in 2030 (excluding traditional biomass usage in residential cooking sector). The RE share in power generation shall continue to be 100% in 2030, of which 15% will be from non-large hydropower generation.

#### SDG 7.3. Energy efficiency

The total primary energy use is 9,318 kTOE, corresponding to an energy intensity of 2.96 MJ/USD2011, achieving the SDG energy efficiency target of 2.96 MJ/USD2011.

The energy savings (in terms of TFEC, compared to BAU scenario) achieved through the demand-side measures pledged in the NDC document is as follows:

*Clean cooking:*

1. Increased usage of clean cooking stoves in replacement of inefficient traditional biomass stoves – estimated reduction of 633.4 ktoe in 2030

*Transport:*

1. Market sales of electric vehicles for private passenger 2-wheelers will be 25% in 2025, which will gradually rise to 90% in 2030 – estimated reduction of 170.9 ktoe in 2030
2. Market sales of electric vehicles for private passenger 4-wheelers will be 25% in 2025, which will gradually rise to 90% in 2030 – estimated reduction of 57.8 ktoe in 2030
3. Market sales of electric vehicles for public passenger 4-wheelers will be 20% in 2025, which will gradually rise to 60% in 2030 – estimated reduction of 25.9 ktoe in 2030

Penetration of electric vehicles has been estimated based on a vehicle stock-turnover analysis.

#### GHG Emissions

In the second NDC document submitted to the United Nations Framework Convention on Climate Change (UNFCCC) in 2020, Nepal did not stipulate an overarching quantitative GHG emissions target for 2030. It has instead specified several quantified targets for several key sectors. These include ambitions in increasing access to clean and efficient cooking technologies, renewable power capacity and generation as well as transport electrification, as already described in the previous sections.

In the current policy scenario, the total GHG emissions from the energy sector decrease from 20.1 MTCO2-e to 16.7 MTCO2-e. The substantial decrease is again due to the reduced combustion of traditional biomass. The transformation sector is emission-free, as all electricity is generated from hydro and solar only. In the demand sector, the largest contributor of GHG emissions in 2030 will be the transport sector (34.2 per cent), followed by the industry sector (31.3 per cent), residential sector (17.9 per cent), commercial sector (9.7 per cent) and others (6.9 per cent).

#### Electricity demand

The 2030 demand for electricity in the current policy scenario will be 12 Terawatt-hours (TWh), increasing from 6.4 TWh in 2019. The demand will be the highest in the residential sector at 6.8 TWh (56.8 per cent), followed by the industry sector (3.7 TWh, 30.6 per cent), the commercial sector (1.1 TWh, 9.6 per cent) and the transport sector (0.4 TWh, 3 per cent).

#### Power generation

Nepal’s installed electric power generation capacity in 2019 was 1,379 MW, of which 91.3 per cent was renewable generation capacity including large hydropower. As of 2019, the installed capacity available in Nepal was not sufficient to meet its local demand, particularly in the dry season, and 37 per cent of its electricity requirement was fulfilled by imported electricity from India. Nevertheless, it is expected that a total of 15,000 MW of new capacity will be installed by 2030, raising the total installed capacity to 16,378 MW. This includes 5,000 MW that will be designated for cross-border trade.

While the exact capacity shares of different power technologies are not available, the NEXSTEP analysis assumes that the export capacity will be fulfilled by large hydropower plants. Including the generation capacity for fulfilling local demand, the total installed capacity is assumed to be made up of large hydropower 90 per cent, mini-hydropower 3.5 per cent, micro-hydropower 3.5 per cent and solar PV 3 per cent. This conforms to the target set out in the NDC document, of which 5-10 per cent capacity will be mini- and micro-hydro power, solar, wind and bio-energy technologies.

In terms of power output, it is expected that the export capacity of the 5,000 MW of large hydropower will allow an estimated export of 22 TWh, assuming running at a capacity factor of 51 per cent. In fulfilling the domestic electricity demand, the NDC document stipulates a generation target of 15 per cent from small-scale renewables by 2030, not including large hydropower.

#### Power sector investment costs

Based on the assumed capacity expansion, Nepal will need to invest US$ 37.1 billion in the power sector.

#### Total net benefits from the power sector

The total net benefits from the power sector will be US$ 5.97 billion.

#### Energy balance

### SDG scenario

#### Scenario description

The SDG scenario reflects on the gaps yet to be filled by the CP scenario and proposes measures to allow the **achievement of the SDG targets**.

The CP scenario, which considers the Nepal’s NDC targets, is projected to achieve a 100% electricity access rate by 2024 and is achieving the energy intensity reduction target. Nonetheless, much effort is still required to close the gap in clean cooking.

#### SDG 7.1.1. Universal access to electricity

Universal access to electricity is expected to be reached by 2024, similar to the BAU and the CP scenarios. In view of Nepal’s challenging terrains and that majority of the unelectrified population is from the rural settlements, NEXSTEP suggests that decentralised grid generation may be the appropriate way-forward. These include the utilisation of mini-hydro, micro-hydroelectricity mini-grid at areas where there are substantial hydro resources. Solar PV mini-grid could also be considered for rural community, where mini-/micro hydro implementation is infeasible. Lastly, solar home systems (SHS) could be considered wherever the abovementioned technologies are not suitable due to either remoteness of the community or highly dispersedly settled households.

#### SDG 7.1.2. Universal access to clean cooking

Clean cooking access rate is expected to reach 72.3% by 2030 in the CP scenario. More effort is required to reach a 100% access rate. NEXSTEP proposes the use of electric cooking stove as the most appropriate technology in filling in the gap due to reasons: 1) zero air pollution 2) minimal follow up required (as opposed to ICS), 3) cost effective considering low electricity tariff and 4) availability of mini/micro-hydro resources in most areas of the country.

However, electric cooking stoves may not be suitable for households using off-grid electricity systems, as the appliance requires substantial power supply capacity. The better options would be the other modern and efficient technologies, such as improved cooking stoves, biogas digesters and LPG stoves. Such limitation should be considered while promoting clean cooking to ensure technological suitability. ICS and biogas digesters, to be disseminated as part of Nepal’s NDC commitment, can be reserved for households utilizing off-grid electricity systems.

Following table shows the cost comparison between the different clean cooking technologies, in terms of annualised cost. This is based on LPG fuel cost 0.85 US$/kg and assumed electricity tariff 0.09 US$/kWh.

*Annualized costs of different cooking fuels and technologies*

|  |  |
| --- | --- |
| Technology | Annualised cost (US$) |
| LPG | 154 |
| Electric Stove | 135 |
| ICS | 41 |
| Biogas Digester | 131 |

#### SDG 7.2. Renewable energy

RE share in TFEC is projected to reach 39% in 2030. The RE share in power generation shall continue to be 100% in 2030, of which 15% will be from non-large hydropower generation.

#### SDG 7.3. Energy efficiency

The total primary energy use is 7,746 ktoe corresponding to an energy intensity of 2.46 MJ/USD2011, well below achieving the SDG energy intensity target of 2.96 MJ/USD2011.

The energy savings resulted in the CP scenario (in terms of TFEC, compared to BAU scenario) achieved through the demand-side measures pledged in the NDC document are as follows:

*Clean cooking:*

1. Increased usage of clean cooking stoves in replacement of inefficient traditional biomass stoves – estimated reduction of 633 ktoe in 2030

*Transport:*

1. Market sales of electric vehicles for private passenger 2-wheelers will be 25% in 2025, which will gradually rise to 90% in 2030 – estimated reduction of 170.9 ktoe in 2030
2. Market sales of electric vehicles for private passenger 4-wheelers will be 25% in 2025, which will gradually rise to 90% in 2030 – estimated reduction of 57.8 ktoe in 2030
3. Market sales of electric vehicles for public passenger 4-wheelers will be 20% in 2025, which will gradually rise to 60% in 2030 – estimated reduction of 25.9 ktoe in 2030

Penetration of electric vehicles has been estimated based on a vehicle stock-turnover analysis.

Additional energy savings (in terms of TFEC, compared to CP scenario) is achieved through the replacing inefficient traditional biomass stoves and ICS (mud) with efficient electric cooking stoves in the SDG scenario. This reduces TFEC by further 1,599 ktoe.

#### GHG Emissions

The emissions from the BAU and CP scenarios are projected to reach 18.8 MTCO2-e and 16.7 MTCO2-ein 2030, respectively. The emission from the SDG scenario is projected to be 15.9 MTCO2-e in 2030, a 0.8 MTCO2-e reduction compared with the CP scenario. This also corresponds to a 15.4 per cent reduction in the BAU scenario. The sole improvement suggested in the SDG scenario with regard to the CP scenario is the phasing out of unclean biomass stoves.

#### Electricity demand

The electricity demand in the SDG scenario is projected to increase from 6.5 TWh in 2019 to 15.2 TWh in 2030. The electricity consumption per capita is estimated at 443 kWh per capita. This considers the assumed growth in different economic sectors as well as the increased demand due to the higher rate of adoption of electric cooking stoves. The sectoral split as projected is: the residential sector (10 TWh, 66 per cent); the industry sector (3.7 TWh, 24.1 per cent); the commercial sector (1.1 TWh, 7.6 per cent) and the transport sector (0.4 TWh, 2.4 per cent).

#### Power generation

In the SDG scenario, the power capacity expansion plan is as per the CP scenario, which is guided by the capacity target stipulated in the secondNDC document. While the exact capacity shares of different power technologies are not available, the NEXSTEP analysis assumes that the export capacity will be fulfilled by large hydropower plants. Including the generation capacity for fulfilling local demand, the total installed capacity is assumed to be made up of large hydropower 90 per cent, mini-hydropower 3.5 per cent, micro-hydropower 3.5 per cent and solar PV 3 per cent. This conforms to the target set out in the NDC document, of which 5-10 per cent capacity will be mini- and micro-hydro power, solar, wind and bio-energy technologies.

In terms of power output, it is expected that the export capacity of the 5,000 MW of large hydropower will allow an estimated export of 22 TWh, assuming running at a capacity factor of 51 per cent. In fulfilling the domestic electricity demand, the NDC document stipulates a generation target of 15 per cent from small-scale renewables by 2030, not including large hydropower.

#### Power sector investment costs

The projected total investment for the planned power capacities is $37.1 billion (capital cost for power plants only), of which 33 per cent is for the 5,000 MW hydropower plants designated for electricity export.

#### Total net benefits from the power sector

The total net benefit (or “total net cost” as it returns a negative value) over the 12-year analysis period is expected to be -$4.2 billion. This is due to the relatively low sales tariff of electricity in the country (see box 2). When optimized for least-cost and demand, the model suggests that the planned power capacity expansion outpaces the electricity demand forecasted in NEXSTEP, whereby, an estimated 54 per cent (5.2 GW) of the total expected large hydropower capacity may be able to fulfil the electricity demand in 2030. Therefore, the current expansion plan is likely to lead to a substantial amount of curtailed energy – for example, the curtailed energy production from large hydropower plants is expected to increase to 28.9 TWh in 2030. Notwithstanding this, curtailed energy production of 9.4 TWh can be expected from the optimized model, due to a supply-demand mismatch related to the seasonal variation of rainfall. NEXSTEP proposes two possible solutions to avoid curtailment – 1) increasing electricity export and building storage type hydropower.

#### Energy balance

### Ambitious Scenario

One ambitious scenario has been developed raising the ambitions beyond SDG 7 targets and the NDC. The key messages of the scenario are summarized below.

#### Enhancing Energy Efficiency scenario

##### Scenario description

This ambitious scenario looks at raising Nepal’s ambition beyond the SDG 7 and the NDC targets. Energy access targets are achieved as in the SDG scenario, while the power sector expansion and supply mix follow the CP and the SDG scenarios. In addition to the measures already applied in the SDG and CP scenarios, there are ample energy savings potential in the residential, transport, commercial and industry sectors, as explored in this scenario.

##### SDG 7.1.1. Universal access to electricity

Universal access to electricity is expected to be reached by 2024, similar to the BAU and the CP scenarios. In view of Nepal’s challenging terrains and that majority of the unelectrified population is from the rural settlements, NEXSTEP suggests that decentralised grid generation may be the appropriate way-forward. These include the utilisation of mini-hydro, micro-hydroelectricity mini-grid at areas where there are substantial hydro resources. Solar PV mini-grid could also be considered for rural community, where mini-/micro hydro implementation is infeasible. Lastly, solar home systems (SHS) could be considered wherever the abovementioned technologies are not suitable due to either remoteness of the community or highly dispersedly settled households.

##### SDG 7.1.2. Universal access to clean cooking

Clean cooking access rate is expected to reach 72.3% by 2030 in the CP scenario. More effort is required to reach a 100% access rate. NEXSTEP proposes the use of electric cooking stove as the most appropriate technology in filling in the gap due to reasons: 1) zero air pollution 2) minimal follow up required (as opposed to ICS), 3) cost effective considering low electricity tariff and 4) availability of mini/micro-hydro resources in most areas of the country.

However, electric cooking stoves may not be suitable for households using off-grid electricity systems, as the appliance requires substantial power supply capacity. The better options would be the other modern and efficient technologies, such as improved cooking stoves, biogas digesters and LPG stoves. Such limitation should be considered while promoting clean cooking to ensure technological suitability. ICS and biogas digesters, to be disseminated as part of Nepal’s NDC commitment, can be reserved for households utilizing off-grid electricity systems.

Following table shows the cost comparison between the different clean cooking technologies, in terms of annualised cost. This is based on LPG fuel cost 0.85 US$/kg and assumed electricity tariff 0.09 US$/kWh.

*Annualized costs of different cooking fuels and technologies*

|  |  |
| --- | --- |
| Technology | Annualised cost (US$) |
| LPG | 154 |
| Electric Stove | 135 |
| ICS | 41 |
| Biogas Digester | 131 |

##### SDG 7.2. Renewable energy

RE share in TFEC is projected to reach 41.2% in 2030. This increase in share is due to the increased energy efficiency in this scenario – an important synergy between energy efficiency and renewable energy share. The RE share in power generation shall continue to be 100% in 2030, of which 15% will be from non-large hydropower generation.

##### SDG 7.3. Energy efficiency

The EE scenario explores various energy efficiency strategies across the residential, industry, transport and commercial sectors. It is noted that the proposed measures have an estimated accumulated potential to reduce the final energy demand by 1,091 ktoe in 2030, compared with the SDG scenario. The energy intensity in 2030 is 2.11 MJ/USD2011. These sectoral energy efficiency measures are further described below.

1. *Residential sector – total estimated savings of 286.7 ktoe*

The Minimum Energy Performance Standard (MEPS) has yet to be established in Nepal, which has the potential to improve the overall efficiency of household appliances. The EE scenario explores the possible savings gained from setting up MEPS for common household appliances, while at the same time mandating the use of efficient LED light bulbs. In addition, increasing the penetration of electric space heating is expected to have a huge impact on energy demand. The measures and estimated savings based on NEXSTEP modelling are detailed in the following table.

**Energy efficiency measures and estimated savings in the residential sector**

|  |  |  |
| --- | --- | --- |
| **Actions** | **Timeframe** | **Estimated savings in 2030 (ktoe)** |
| Phasing out of inefficient light bulbs with efficient LED light bulbs | By 2030 | 51.8 |
| Introducing MEPS |  |  |
| *All new refrigerators and freezers* | From 2024 onwards | 8.65 |
| *All new televisions* | From 2024 onwards | 12.5 |
| *All new water pumps* | From 2024 onwards | 3.4 |
| *All electric fans* | From 2024 onwards | 1.0 |
| *All washing machines* | From 2024 onwards | 6.2 |
| *All air conditioners* | From 2024 onwards | 3.0 |
| Double the penetration of electric space heating (with heat pumps) in the urban residential sector, from 39 per cent share to an 80 per cent share | By 2030 | 200.1 |
| **Total** |  | **286. 7** |

*(b) Transport sector – total estimated savings of 219.5 ktoe*

The Government of Nepal aims to step up on transport electrification by increasing the market share for electric private and public four wheelers as well as private four-wheelers. Such ambition is laudable as it contributes positively to energy savings and GHG emission reduction. In addition, it improves Nepal’s energy security by lessening the dependency on imported petroleum products. The EE scenario further explores the possibility of having more ambitious transport electrification strategies.[[12]](#footnote-13) The estimated potential is relative to the CP and the SDG scenarios. The measures and estimated savings are detailed in the following table.

**Energy efficiency measures and estimated savings in the transport sector**

|  |  |  |
| --- | --- | --- |
| **Actions** | **Timeframe** | **Estimated saving in 2030 (ktoe)** |
| Increase market sales of electric vehicles for private passenger two-wheelers | 50 per cent in 2024  Gradually increase to 100 per cent in 2030 | 74.4 |
| Increase market sales of electric vehicles for private passenger four-wheelers | 50 per cent in 2024  Gradually increase to 100 per cent in 2030 | 25.2 |
| Increase market sales of electric vehicles for public passenger four-wheelers | 50 per cent in 2024  Gradually increase to 100 per cent in 2030 | 27.8 |
| Increase market sales of electric rickshaws | 50 per cent in 2024  Gradually increase to 100 per cent in 2030 | 42.9 |
| Increase market sales of electric buses | 50 per cent in 2024  Gradually increase to 100 per cent in 2030 | 17.5 |
| Increase market sales of electric minibuses | 50 per cent in 2024  Gradually increase to 100 per cent in 2030 | 31.7 |
| **Total** | | **219.5** |

*(c) Commercial sector – total estimated savings of 193 ktoe*

The current space heating practices are dominated by conventional fuel combustion, such as coal, LPG and biomass. These make up about 87 per cent of the energy consumption in the commercial sector. Substantial savings can be expected from increased use of solar thermal heating system and heat pump system by Increasing the penetration of solar thermal heating systems and heat pump systems to 25 per cent by 2030, respectively, in all commercial subsectors, creating an estimated reduction of 193 ktoe in 2030.

*(d) Industry sector – total estimated savings of 392 ktoe*

The energy consumption by the industry sector is expected to increase from 1,532 ktoe in 2019 to 2,152 ktoe in 2030, assuming a constant energy intensity and no energy efficiency intervention applied, as modelled in the CP and SDG scenarios. A baseline study conducted in 2012 on a selected number of industries showed that there is potential for the industry sector in Nepal to be more efficient in its energy usage(PACE Nepal, 2012). The findings by the study have been incorporated in the EE scenario, with estimated savings detailed as follows:

1. Adoption of energy efficiency measures in the glass, cement and non-metal industry, with thermal energy saving potential of 41.7 per cent and electrical energy saving potential of 41.3 per cent – an estimated reduction of 288.3 ktoe;
2. Adoption of energy efficiency measures in the food and beverages industry, with thermal energy saving potential of 13 per cent and electrical energy saving potential of 9 per cent – an estimated reduction of 80.6 ktoe;
3. Adoption of energy efficiency measures in the iron and steel industry, with thermal energy saving potential of 28 per cent and electrical energy saving potential of 6.2 per cent – an estimated reduction of 23.1 ktoe.

##### GHG Emissions

The transport and the industry sectors are expected to be the two largest GHG emitting sectors in 2030, contributing around 32.8 per cent and 35.9 per cent, respectively, of GHG emissions in the SDG scenario. This generally stems from the fuel combustion in the internal combustion engine vehicles and industrial boilers for process heating purposes. It is expected that the GHG emissions will be reduced by a significant margin with the above-mentioned measures (figure 18). The emissions of the EE scenario is projected to be 13 MTCO2-e, a 31 per cent reduction from the BAU scenario.

##### Investment required: US$13.5 billion

The total cost of this scenario is US$37.1 billion by 2030.

##### Total net benefits from the power sector

The total net benefits from the power sector will be US$ 4.05 billion.

##### Energy balance

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1. Historical trend projected based on 2000 access rate data provided in ESCAP, 2021a, and 2019 access rate provided by the national consultant. [↑](#footnote-ref-2)
2. Author’s calculation based on collected and assumed data for 2019. [↑](#footnote-ref-3)
3. Only policies with concrete measures are considered in the scenario modelling. Target-setting policy documents without concrete measures (i.e., energy intensity improvement target stipulated in the Energy Efficiency Strategy. 2075) are not considered, but are compared with scenario result findings in the “Revisiting Existing Policies” chapter. [↑](#footnote-ref-4)
4. It was noted during the stakeholder consultation workshop that 5,000 MW would be designated for cross-border power trade. In addition, 5,000 MW out of the total 15,000 MW is the unconditional target, while the remainder is subject to international funding. However, as agreed during the stakeholder workshop, both conditional and unconditional targets stipulated in the second NDC document will be considered in the modelling of the current policy scenario. [↑](#footnote-ref-5)
5. As noted during the stakeholder consultation workshop held on1 March 2021, 5,000 MW of the stipulated target will be designated for cross-border power trade. [↑](#footnote-ref-6)
6. <http://documents.worldbank.org/curated/en/937711468320944879/pdf/88699-REVISED-LW16-Fin-Logo-OKR.pdf> [↑](#footnote-ref-7)
7. This assumption is based on expert advice concerning what could be practically possible in the next decade. [↑](#footnote-ref-8)
8. This assumption has been based on expert advice on what could be practically possible in the next decade. [↑](#footnote-ref-9)
9. See <https://www.undp.org/content/undp/en/home/librarypage/environment-energy/low_emission_climateresilientdevelopment/derisking-renewable-energy-investment.html>. [↑](#footnote-ref-10)
10. [↑](#footnote-ref-11)
11. [↑](#footnote-ref-12)
12. The penetration of electric vehicles has been estimated based on a stock-turnover analysis. [↑](#footnote-ref-13)