



Energy Transition Pathways for the 2030 Agenda SDG 7 Roadmap for Georgia



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Energy Transition Pathways for the 2030 Agenda

SDG7 Roadmap for Georgia



National Expert SDG Tool for Energy Planning

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

Energy Transition Pathways for the 2030 Agenda

SDG7 Roadmap for Georgia

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MINISTRY OF ECONOMY
AND SUSTAINABLE
DEVELOPMENT
OF GEORGIA

NEXSTEP
National Expert SDG Tool for Energy Planning

Foreword: ESCAP

Energy is the key enabler of development for the Asia-Pacific region's rapidly growing economies.

Like many countries in the region, Georgia has shown strong growth of both its economy and its demand for energy in recent decades. However, the advent of the 2030 Agenda for Sustainable Development signalled the advent of a new era of development across the region, based on inclusiveness, resilience and environmental stewardship. The COVID-19 pandemic has reinforced the need to change the region's development trajectory and to build back better. In this endeavour, transitioning to a sustainable, secure and least-cost energy system can form a key part of the recovery as well as pave the way for a more sustainable and equitable society.

Georgia's endowment of renewable energy resources – hydro power in particular, but also its abundance of wind, solar, geothermal and biomass potential – means that the country is well-positioned to establish a sustainable energy future.

Georgia's Roadmap for achieving Sustainable Development Goal 7 presents a detailed assessment aimed at helping the country to reach a clean and green energy future. It details a range of technical opportunities and policy options for reducing emissions, saving energy and lowering costs. The road map offers an opportunity to leverage a least-cost sustainable energy development pathway, and to direct the investment savings to other critical sectors – such as the health sector – in building back better from COVID 19.

However, Georgia's SDG 7 Roadmap is about more than just affordable and clean energy. The measures identified and recommendations made will not only reduce energy intensity and grow Georgia's renewable energy sector – with flow-on benefits in employment and health – but will also reduce its reliance on imported natural gas and petroleum fuels. Furthermore, the Roadmap presents an assessment of how Georgia can leverage its clean energy potential to export electricity to neighbouring countries through enhanced power grid connectivity.

The Roadmap takes a holistic approach to the energy system. Energy for heating, transport, industry and agriculture are considered in detail in an assessment that considers the impacts across the entire system. This is important for evaluating complex measures such as the electrification of transport which affects management of the power grid, petroleum and transport sectors.

Georgia was a pioneer in using ESCAP's National Expert SDG Tool for Energy Planning (NEXSTEP) and was among the first countries in the region to develop a Sustainable Development Goal 7 Roadmap. The success of this cooperative effort is testament to our shared ambition for Georgia and the region to deliver on the sustainable energy vision of SDG 7. This Roadmap provides an example for other countries looking to understand how they can begin taking up the sustainable energy development opportunities within their own borders.

I look forward to Georgia's continuing leadership in delivering a secure, resilient and sustainable energy future as it builds back better from COVID-19.

Mr Kaveh Zahedi

Deputy Executive Secretary,
Sustainable Development,
United Nations Economic and Social
Commission for Asia and the Pacific

Foreword: Georgia

Georgia is committed to implementing the 2030 Agenda for Sustainable Development Goals (SDGs). The country has undertaken active measures to adjust the SDG targets and indicators according to its local conditions, challenges and opportunities. The implementation of the Sustainable Development Goals (SDGs) is mandatory for Georgia, and these types of documents help in meeting the commitments and, at the same time, facilitate the usage of local resources. The Government's policies and priorities are well-aligned with the SDGs – making them a very solid basis of the country's reform agenda.

It is noteworthy to highlight the fact that Georgia has made significant progress in putting itself well on track to achieving the 2030 Agenda. Notwithstanding this, there are still some challenges and sectors to be identified, where further work is needed to achieve the SDGs. Incorporation of the SDGs in national policy is one of the Government of Georgia's main achievements. This will be an essential component for incorporating the SDGs into the daily agenda of public institutions. One of the most important SDGs is SDG 7, which will be considered when developing national energy policies.

The Government has prioritized knowledge-based and innovation-driven economic development, and actively supports an increase of innovative activities by micro, small, and medium-sized enterprises; this includes start-ups and individuals and their participation in the digital economy. During the past five years, Georgia also took active steps towards responsible production and consumption.

Based on the foregoing, Georgia remains fully dedicated to the purpose of the implementation of the SDGs. The Ministry of Economy and Sustainable Development of Georgia expresses its gratitude to ESCAP, the counterparts and the experts involved for their work on "SDG 7 Roadmap for Georgia" and active cooperation. Sustainable development goals are getting more and more tangible and important. As a member of ESCAP, we look forward to continuing our cooperation.

Mr David Tvalabeishvili

Deputy Minister of Economy and
Sustainable Development of Georgia

Abbreviations and acronyms

BAU	business-as-usual	LCOE	Levelized Cost of Electricity
CBA	cost benefit analysis	LEAP	Long-range Energy Alternatives Planning
CCGT	combined cycle gas turbine	MCDA	Multi-Criteria Decision Analysis
CFBC	circulating fluidized bed combustion	MEPA	Ministry of Environmental Protection and Agriculture of Georgia
CPS	current policy scenario	MEPS	Minimum Energy Performance Standards
CTF	clean technology fund	MJ	megajoule
EE S&L	Energy Efficiency Labelling Program	MoESD	Ministry of Economy and Sustainable Development of Georgia
ESCAP	United Nations Economic and Social Commission for Asia and the Pacific	MT	million tons
ETS	Emission Trading System	MTF	Multi-Tier Framework
EV	electric vehicle	NAMA	Nationally Appropriate Mitigation Action
GEOSTAT	National Statistics Office of Georgia	NDC	nationally determined contributions
GHG	greenhouse gas	NEXSTEP	National Expert SDG Tool for Energy Planning
ICS	improved cooking stove	PA	Paris Agreement
IPCC	Intergovernmental Panel on Climate Change	PP	power plant
IRENA	International Renewable Energy Agency	SCGT	single cycle gas turbine
IRR	Internal Rate of Return	SDG	Sustainable Development Goal
Ktoe	thousand tonnes of oil equivalent		

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, more importantly, consider and capitalize on the interlinkages between Sustainable Development Goal 7 (SDG 7) and other SDGs. In this connection, 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 emission reduction targets (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 Georgia to develop 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, and 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.

A. Highlights of the roadmap

Georgia's progress towards achieving the SDG 7 targets is promising, but more needs to be done to achieve all SDG 7 targets by 2030 through a concerted effort and the establishment of an enabling policy framework. Georgia has successfully provided universal electricity access to its population; however, further promotion of electric cooking stoves is still required to connect the remaining 900,000 people with clean cooking technology and fuel between now and 2030. Energy efficiency improvement needs to be boosted across different sectors in order to achieve a 2.9 per cent annual improvement, reducing energy intensity to 3.8 megajoules per US\$ by 2030.

The existing trend indicates that the country will still miss the unconditional emission reduction target pledged under the Paris Agreement by a small margin. Emissions reduction can be achieved via demand side energy efficiency measures and through changing the fuel mix in the power sector. Achieving the unconditional NDC target, while at the same time meeting the SDG 7 targets, requires a 25.5 per cent share of renewable energy to be reached in the total final energy consumption (TFEC). The NEXSTEP analysis also shows that through the proposed improvement areas, Georgia's energy security can be further strengthened as these measures will reduce its reliance on natural gas imports.

The levelized cost of electricity from renewable power technologies has experienced a steep decline, becoming economically more competitive than the conventional fossil-fuel-based technologies. Georgia may leverage its abundant renewable energy potential, specifically hydropower, to provide clean electricity for its neighbouring countries. In addition to generating revenue from electricity sales, this also permits further emission reduction for these countries.

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

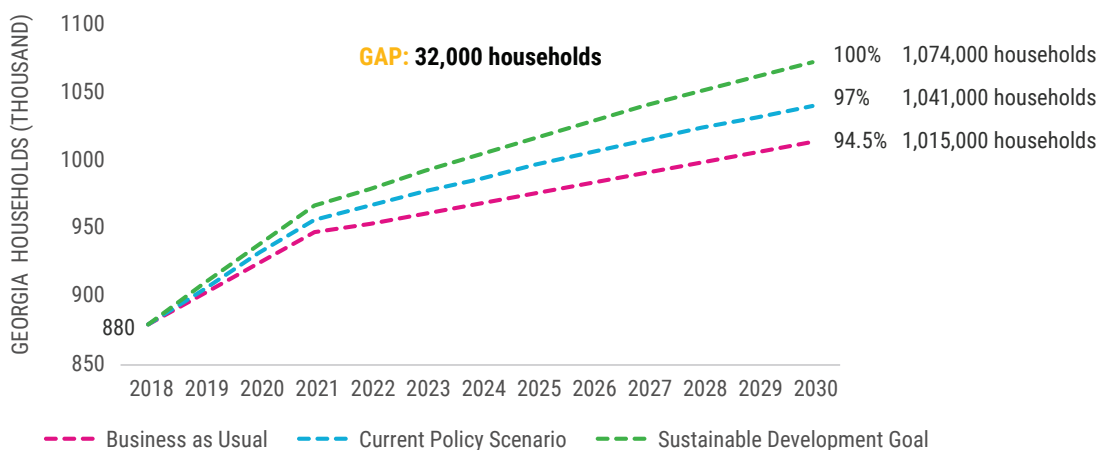
Universal access to electricity

Georgia already achieved universal access to electricity in 2010. The 2007 Energy Policy for Georgia prioritizes improvement of service quality and the protection of consumer interests.

Universal access to clean cooking

Georgia's access to clean cooking fuels and technologies was reported as 75.2 per cent in 2017. NEXSTEP analysis shows that the current rate of improvement of 2.7 per cent is not enough to achieve universal access to clean cooking (figure ES 1). Access to clean cooking will increase from 75.2 per cent in 2017 to 97 per cent in 2030, which will leave 109,000 people (32,000 households) in rural areas relying on inefficient and hazardous cooking fuels and technologies. Georgia needs to increase its efforts to achieve universal access to clean cooking fuels. This analysis indicates that electric cooking stoves will be the most feasible approach to ensuring universal access to clean cooking fuel by 2030.

Figure ES 1. Access to clean cooking in Georgia



Renewable energy

The share of renewable energy in TFEC was calculated at 25.9 per cent (including traditional biomass) in 2018. Based on the current policy scenario, the share of renewable energy will decrease to 22.7 per cent by 2030, mainly due to the substitution of traditional biomass cooking stoves by other non-biomass cooking stoves.¹ In the SDG scenario, the share of renewable energy in TFEC will need to reach 25.5 per cent (excluding traditional biomass) by 2030, which will ensure the achievement of Georgia's unconditional NDC target.

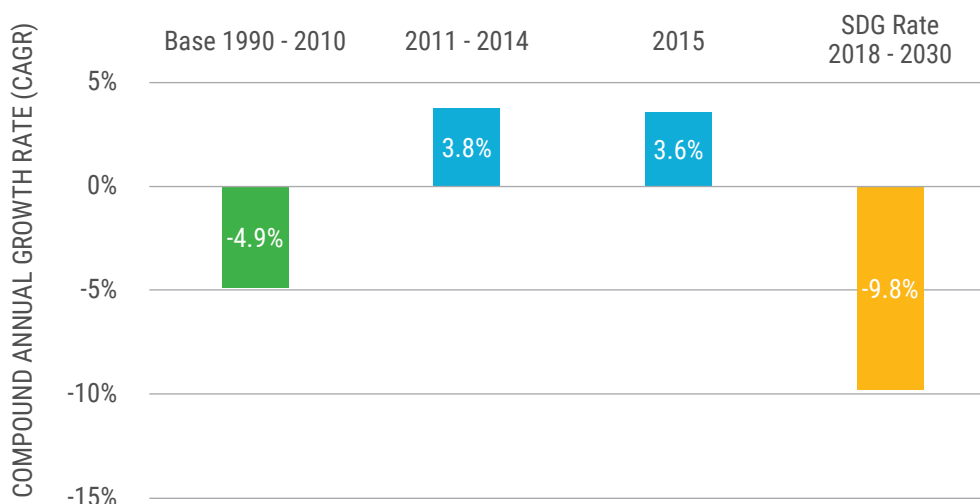
Energy efficiency

Energy intensity in Georgia declined at an average annual rate of 4.9 per cent from 1990 to 2010, driven by the structural changes in Georgia's economy due to the closure of energy-intensive industries and decline in output. Achieving the SDG 7.3 target requires an annual improvement of 9.8 per cent of primary energy intensity (figure ES 2) to achieve the SDG 7 target of 1.74 MJ/US\$ by 2030 – a drop from 5.3 MJ/US\$ in 2018.

¹ In 2018, 24 per cent cooking energy was supplied by biomass.

The SDG 7.3 target for Georgia is not feasible; therefore, a revised target of 3.8 MJ/US\$ by 2030, a 2.9 per cent annual improvement which is in line with global targets, is recommended. In the current policy scenario, energy efficiency measures, if implemented, indicate that Georgia will only achieve a 2.2 per cent annual improvement in primary energy intensity by 2030.

Figure ES 2. Georgia's energy efficiency target

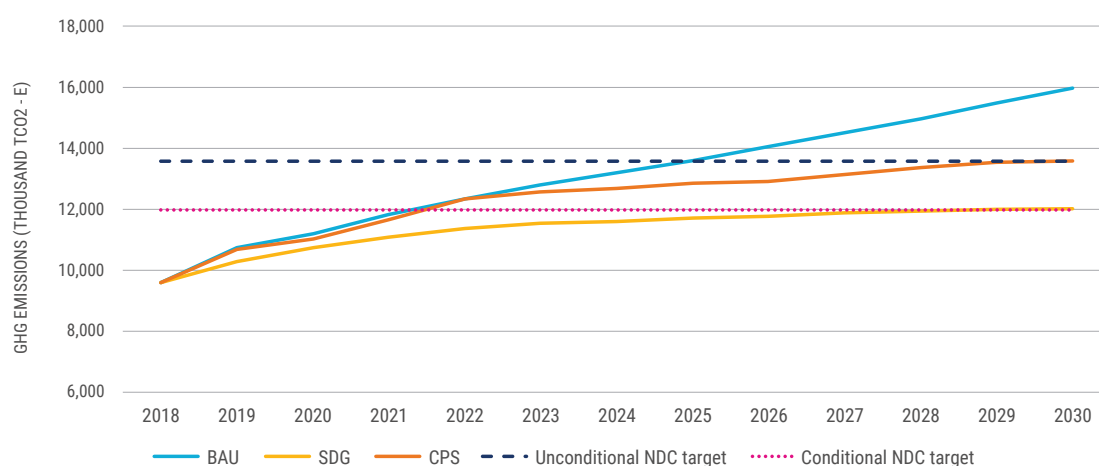


There are ample opportunities for Georgia to achieve this target as well as even implement a higher rate of improvement. These include, for example, minimum energy efficiency standards (MEPS), rapid deployment of electric vehicles and improved energy efficiency in new commercial buildings. These opportunities are discussed in later sections of this report.

Nationally Determined Contributions

Georgia's current policies in the energy sector will achieve the NDC unconditional target of 15 per cent reduction of GHG emissions compared to business-as-usual (BAU) by 2030. Energy sector emissions in the BAU scenario are modelled to reach 15.97 million tonnes CO_{2-e} (MtCO_{2-e}) by 2030. Emissions in the current policy scenario are projected to reach 13.58 MtCO_{2-e} by 2030, which will miss the NDC unconditional target of 15 per cent reduction in GHG emissions by a small margin of 8,000 tCO_{2-e}.

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



C. Important policy directions

The key policy recommendations to help Georgia accelerate the energy transition to achieve SDG 7 and NDC targets include:

- (i) **Targeted interventions in rural areas are required to achieve universal access to clean cooking in rural areas.** The electric cooking stove is the recommended technology option for Georgia to achieve this target. This option should be prioritized for the rural areas, which are grid-connected but still rely on traditional biomass cooking stoves. Implementation of this programme will cost the Government US\$1.28 million to achieve universal access to clean fuels and technologies for cooking by 2030;
- (ii) **Decarbonisation of heat is a major challenge overlooked by current policies.** The NEXSTEP analysis recommends the adoption of energy-efficient heat pumps to replace old natural gas boilers in Georgian households. Such a measure not only decreases Georgia's energy intensity, but also reduces reliance on natural gas imports;
- (iii) **Electrification of transport is a viable solution with cheap electricity from hydropower.** The NEXSTEP analysis recommends a long-term electrification strategy for Georgia. Fuel-switching from oil products to electricity will enhance energy security by reducing import as well as reduce emissions and establish Georgia as a leader in sustainable transport;
- (iv) **Investment in wind and solar power should be promoted.** The levelized cost of electricity analysis recommends increasing investments in wind and solar power. Georgia can achieve additional benefits by reducing natural gas imports as well as reduced vulnerability to hydropower seasonal variation and emission reductions in line with NDC targets. The additional investment needed to increase the share of wind and solar in power generation can be supported by a price on carbon. It has been estimated that a carbon price of US\$40/tCO_{2e} would level the playing field for renewables as well as attract investors;
- (v) **Georgia has the potential to export 10 TWh per annum of clean electricity in 2030.** The NEXSTEP analysis includes the target of 10 TWh annual electricity exports as outlined in the "Ten-Year Network Development Plan" of Georgia, 2018-2029. Georgia may leverage its cheap and abundant renewable energy sources for electricity generation, boosting its electricity sales in more lucrative electricity markets in neighbouring countries.

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1. Introduction

1.1 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, more importantly, consider and capitalize on the interlinkages between SDG 7 and other SDGs. In this connection, ESCAP developed NEXSTEP. This tool enables policymakers to make informed policy decisions to support the achievement of the SDG 7 targets as well as emission reduction targets (NDCs). The initiative was 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.

1.2 SDG 7 targets and indicators

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

- **Target 7.1.** “By 2030, ensure universal access to affordable, reliable and modern energy services.” Two indicators are used to measure this target: (a) the proportion of the population with access to electricity; and (b) the proportion of the population with primary reliance on clean cooking fuels and technology.
- **Target 7.2.** “By 2030, increase substantially the share of renewable energy in the global energy mix”. This is measured by the renewable energy



share in 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.

1.3 Nationally Determined Contributions

The NDC represents pledges by a country to reduce national emissions and is the steppingstones to the implementation of the Paris Agreement. Since the energy sector is the largest contributor to GHG emissions in most countries, decarbonizing energy systems should be given a high priority. Key approaches to reducing emissions from the energy sector include increasing renewable energy in the generation mix and improving energy efficiency. In its NDC document, Georgia has pledged to reduce GHG emission by 15 per cent (unconditional) compared to BAU and 25 per cent (conditional) with international support compared to BAU by 2030.



2. 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.

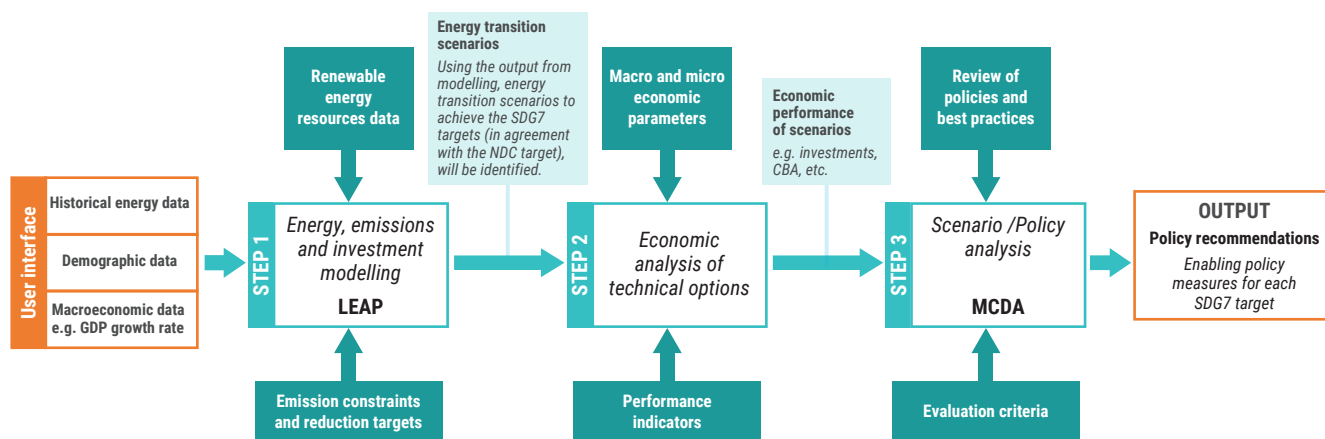
2.1. Key methodological steps

(a) 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.

(b) 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

Figure 1. Different components of the NEXSTEP methodology

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.

analysis helps to present several economic parameters and indicators that would be useful for policymakers in making an informed policy decision.

(c) 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 preferences 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.

2.2. 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.

(a) The BAU scenario: This scenario follows historical demand trends, based on simple projections, by 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 that reflects 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.

- (b) Current policy scenario: Inherited and modified from the BAU scenario, this scenario considers all policies and plans currently in place as of 2019 as well as the commitments under the NDC by 2030. These are, for example, the National Renewable Energy Action Plan (NREAP) of Georgia and the National Energy Efficiency Action Plan (NEEAP) of Georgia.
- (c) SDG 7 scenario: This scenario aims to achieve the SDG 7 targets, including universal access to electricity and to 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 understand how it contributes to the SDG 7 target. Finally, an emission reduction target has been used to estimate the optimum share of renewable energy in TFEC, which is considered to be a substantial increase;
- (d) 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.

2.3. 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.

2.3.1. 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.

2.3.2. Cost parameters

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

- (a) 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;
- (b) 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;
- (c) Decommissioning cost – the costs of the retirement of power plants related to environmental remediation, regulatory frameworks and demolition costs;
- (d) Sunk cost – existing infrastructure investments are not included in the economic analysis, since no additional investment is required for the project;
- (e) External cost – refers to any additional externalities that place costs on society.
- (f) 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.

2.4. 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
- Carbon price
- 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



3. Overview of the Georgia's energy sector



3.1. Current situation

Geography: Georgia is located in the mountainous region of south Caucasus, at the crossroads between Western Asia and Eastern Europe. The country covers an area of 69,700 square kilometres, bounded in the west by the Black Sea, in the north by Russia, the south by Turkey and Armenia, and the south-east by Azerbaijan.

Population: The population of Georgia declined from 5 million people in 1991 to 3.72 million in 2018. During 2008-2018, the population decline averaged 0.3 per cent annually due to low fertility and outmigration.

Economy: Following the breakup of the Soviet Union in 1991 and an ensuing civil war, the Georgian economy contracted by more than 65 per cent to 1993. Georgia moved to a market-based economy system, and with deep economic and governance reforms it has achieved the status of “star reformer” and in 2019 was ranked seventh place globally for ease of doing business (World Bank, 2020b). According to the World Bank, Georgia is classified as an upper middle-income country with a gross domestic product (GDP) per capita of US\$4,764 in 2019. During the decade of 2010-2019, Georgia experienced strong economic growth with an annual GDP per capita increase of 4.8 per cent (World Bank, 2020a).

Energy: The key piece of legislation regulating the country's energy sector is the 1997 Georgian Law on Electricity and Natural Gas, which has been amended several times since 2006 and incorporates some European Union market economy principles.

Georgia's energy policy, the *2007 Main Directions of the State Policy in Energy Sector of Georgia*, sets the objectives that the country is pursuing in the energy sector with focus on energy security using indigenous renewable energy. The Energy Policy

for Georgia was updated in 2015, but it maintained the same key directions of the previous policy, and aims to provide Georgia with a long-term state vision. Finally, the 2013 Social-Economic Development Strategy of Georgia, “Georgia 2020”, tackles priority issues to achieve long-term inclusive growth.

3.2. National energy profile

Georgia achieved universal access to electricity in 2010. The 2007 *Energy Policy for Georgia* prioritizes improvement of service quality and protection of consumer interests.

Access to clean cooking fuels was measured at 75.2 per cent in 2017, based on the Georgia 2017 Energy Consumption in Household Survey carried out by the National Statistics Office of Georgia (GEOSTAT, 2017). The renewable energy share in TFEC was calculated at 25.9 per cent in 2018. Figure 2 shows Georgia’s planned capacity expansion for electricity generation. The figure is based on data from the Ministry of Economy and Sustainable Development (MoESD), renewable energy capacity expansion is based on potential. Hydropower capacity expansion is planned to increase from 3,266 MW in 2019 to 6,501 MW by 2030.

Energy efficiency is a key priority for the Government to achieve economic competitiveness in order to enhance economic growth. The rational use of energy is considered as an important means of lowering the country’s dependence on imported

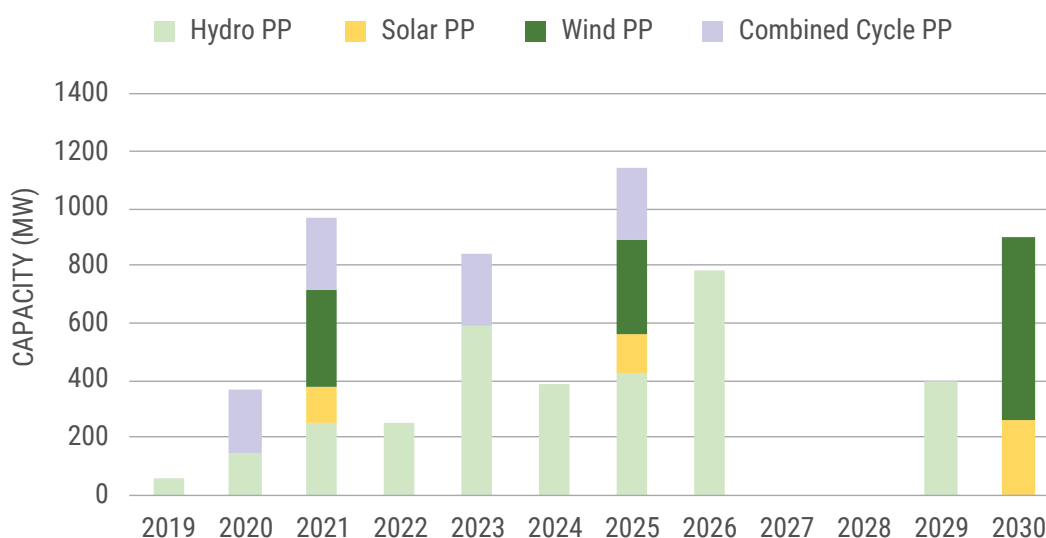
petroleum. One policy of ongoing significance is the 1997 Law on Electricity and Natural Gas, which focuses on efficiency improvement in electricity generation, transmission, import, export and consumption as well as natural gas supply and distribution.

3.3. National energy policies and targets

Scenario development in this study is based on energy policies and assumptions, as summarized in table 1, and highlighted below.

- The main directions of the State Policy in Energy Sector of Georgia (Energy Policy for Georgia): address the priorities and development opportunities in the energy sector of Georgia, and it considers the main directions towards energy security (Ministry of Energy of Georgia, 2015). The core national energy policy directions include:
 - » Diversification of supply sources, and optimal utilization of resources and reserves;
 - » Utilization of Georgia’s renewable energy resources;
 - » Gradual approximation of Georgia’s legislative and regulatory framework with the European Union’s energy acquisition;
 - » Energy market development and improvement of the energy trading mechanism;
 - » Strengthen Georgia’s role as a transit route in the region;

Figure 2. Georgia’s planned power plant capacity expansion



- » Georgia – regional platform for generation and trade of clean energy;
 - » Develop and implement an integrated approach to energy efficiency in Georgia;
 - » Taking into consideration environmental components in the implementation of the energy projects;
 - » Improving service quality and protection of consumer interests.
- National Renewable Energy Action Plan (NREAP) Georgia, 2019: NREAP outlines the current situation related to renewable energy in Georgia and proposes measures to meet the target of 30 per cent of energy consumed coming from renewable energy in 2020 (MoESD, 2019b).
 - National Energy Efficiency Action Plan (NEEAP) Georgia, 2019-2020: NEEAP establishes energy efficiency targets for 2020, 2025 and 2030. Georgia's indicative national energy efficiency targets mentioned in the National Energy Efficiency Action Plan (NEEAP) are to reduce primary energy consumption by 17 per cent and final energy consumption by 13 per cent compared with the BAU scenario in 2030. However, the analysis is based on MARKAL model assumptions using 2014 data (MoESD, 2019a).
 - Georgia's Intended Nationally Determined Contribution (INDC), 2015: Georgia has committed to a voluntary, unconditional target of reducing its greenhouse gas (GHG) emissions by 15 per cent and a conditional target of 25 per cent by 2030, subject to global agreement, access to financial resources and technology transfer (MEPA, 2015).

3.4. National energy resources

Georgia has abundant renewable energy resource potential in hydro, wind, solar, geothermal and biomass energy resources. According to NREAP, the estimated hydropower resource potential is 15,000 MW with a potential for electricity generation of 50 TWh per year, of which 22 per cent is currently being utilized in the country. Solar energy potential is high with annual solar irradiation varying from 1,250 to 1,800 kWh/m². Estimated solar potential for power generation is approximately 500 MW, as estimated by the Government. Wind energy potential is estimated at 1,500 MW, with an electricity generation potential of 4TWh per year. The frequency of strong winds in Georgia is observed on mountain peaks and passes, for example the Mta-sabueti region where the average annual wind speed is measured at 9.2 m/s. Georgia has significant untapped geothermal

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

Parameters	BAU	Current policy scenario	Sustainable Development Goal
Economic growth		4.8%	
Population growth		-0.2%	
Commercial floor space	9,380,823 m ² (data used in National Energy Efficiency Action Plan)		
Transport activity	12.25 billion vehicle km (based on own calculation using registered vehicle data provided by MoESD)		
Residential urbanization	63.9 % in 2030 (United Nations Population Statistics)		
Access to electricity	100 per cent	100 per cent	100 per cent
Access to clean cooking fuels	Based on historical improvement	Based on historical improvement and current policies	100 per cent access to clean cooking fuels and technologies by 2030
Energy efficiency	Remains constant	Based on implementation of current policies	2.9 per cent annual improvement in primary energy intensity
Power plants	Based on 2018 share	Based on MoESD data	Based on least – cost optimization

energy reserves and according to preliminary estimates the geothermal energy potential is 420 MW and thermal energy of 2.7 TWh per year. A study by Iceland's Viirkir – Orkint estimated geothermal resources to be in the range of 600 MW-12,000 MW (thermal). Geothermal energy could be used to supply clean energy to satisfy space heating demand and hot water for 500,000 to 1 million people, according to the Energy Sector Management Assistance Program (ESMAP, 2005).

3.5. National energy balance

The national energy balance of Georgia 2018 from the GEOSTAT is the starting point of the NEXSTEP analysis. The Total Primary Energy Supply (TPES) is dominated by natural gas and oil products, which are largely imported.

Figure 3 shows that the TPES of Georgia is 4,819,000 tonnes (ktoe) of oil equivalent. Georgia's TPES by fuel share is natural gas 2,013 ktoe (42 per cent), oil products 1,246 ktoe (26 per cent), hydropower 856 ktoe (18 per cent), coal 303 ktoe (6 per cent), biomass 271 ktoe (6 per cent), electricity 79 ktoe (2 per cent), other renewables (solar, wind) 28 ktoe (1 per cent) and crude oil 25 ktoe (0.5 per cent).

Georgia's total final energy consumption (TFEC) in 2018 was 4,390 ktoe (figure 4). TFEC by fuel: natural gas 1,512 ktoe (34 per cent), oil products 1,267 ktoe (29 per cent), electricity 1,026 ktoe (23 per cent), coal 294 ktoe (7 per cent), biomass 271 ktoe (7 per cent) and other renewables 19 ktoe (0.4 per cent).

Figure 3. Total Primary Energy Supply in 2018

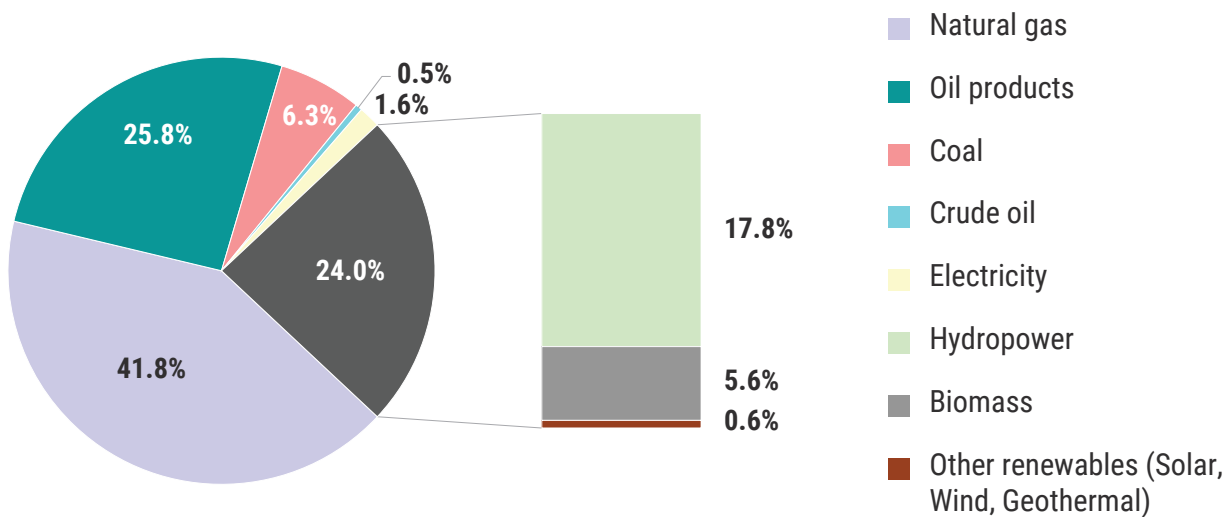
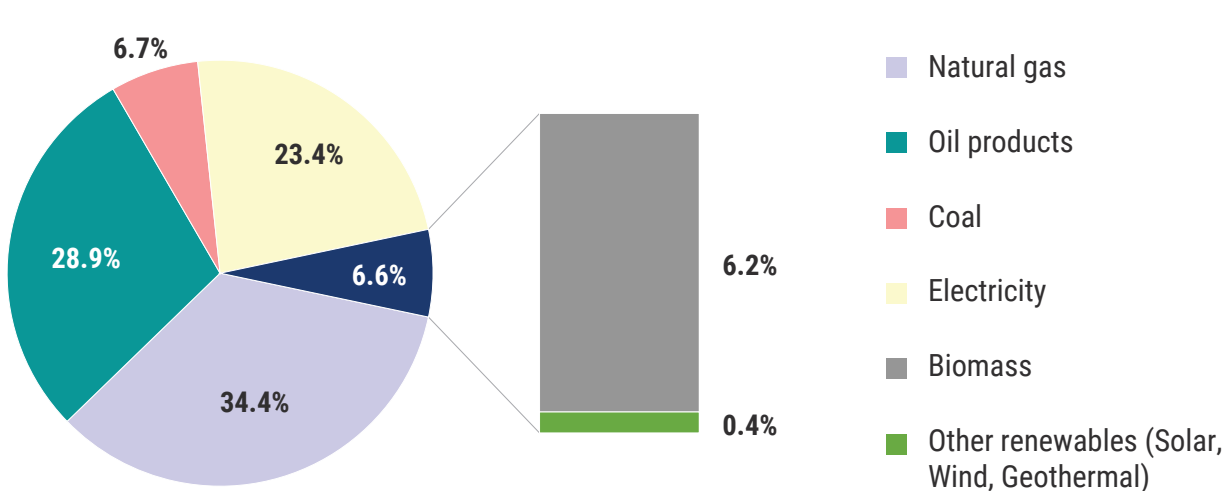


Figure 4. Total final energy consumption in 2018





3.6. Energy demand outlook

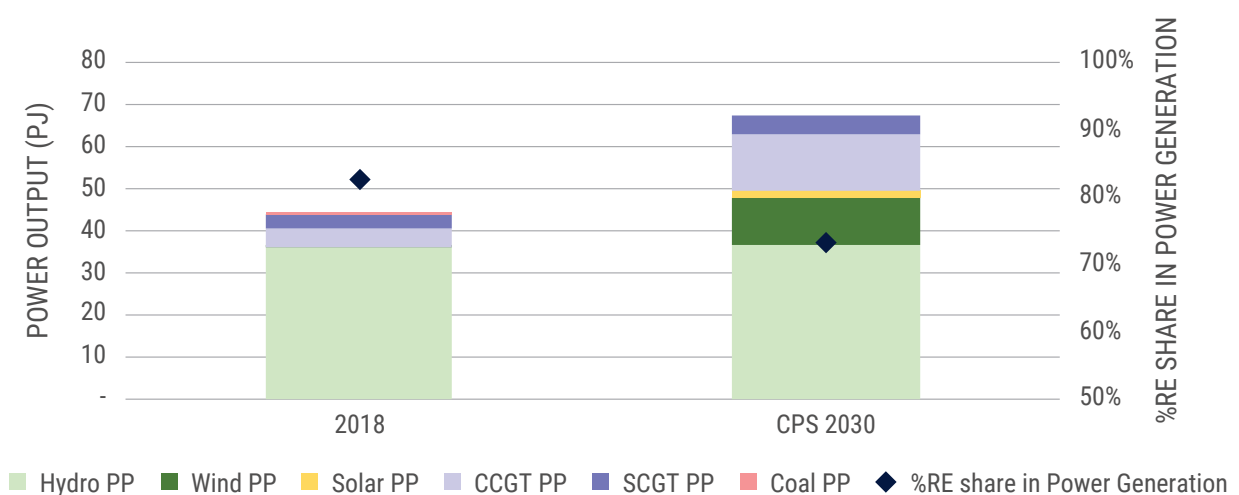
In the current policy scenario, TFEC will increase from 4,390 ktoe in 2018 to 5,758 ktoe in 2030. The sectoral shares are transport 2,059 ktoe (36 per cent), residential 1,254 ktoe (22 per cent), industrial 1,175 ktoe (20 per cent), commercial 729 ktoe (13 per cent), non-energy use 340 ktoe (6 per cent), non-specified 165 ktoe (3 per cent) and agriculture 37 ktoe (1 per cent).

3.7. Energy power generation outlook

Georgia's installed electric power generation capacity in 2018 was 4,153 MW, of which 3,208 MW (77 per cent) was hydropower and 0.5 per cent was wind. Other installed capacities include single cycle gas turbine (SCGT) 680 MW (16 per cent), combined cycle gas turbine (CCGT) 231 MW (6 per cent), and coal PP 13 MW (0.3 per cent),

In the NEXSTEP power generation analysis for Georgia, the current policy scenario uses planned

Figure 5. Power generation by technology type and renewable energy share percentage



capacity expansion data provided by MoESD (figure 2). In this scenario, the total power capacity built reaches 10,256 MW by 2030.

Hydropower remains the dominant source of electricity supply, reaching 54 per cent in 2030, compared with an 83 per cent share in 2018. Power output by other renewable generation, solar and wind, will increase to a total of 19.3 per cent in 2030 (16.7 per cent by wind and the remaining by solar). Figure 5 shows power generation by technology type and renewable energy share in power generation in 2018 and 2030.

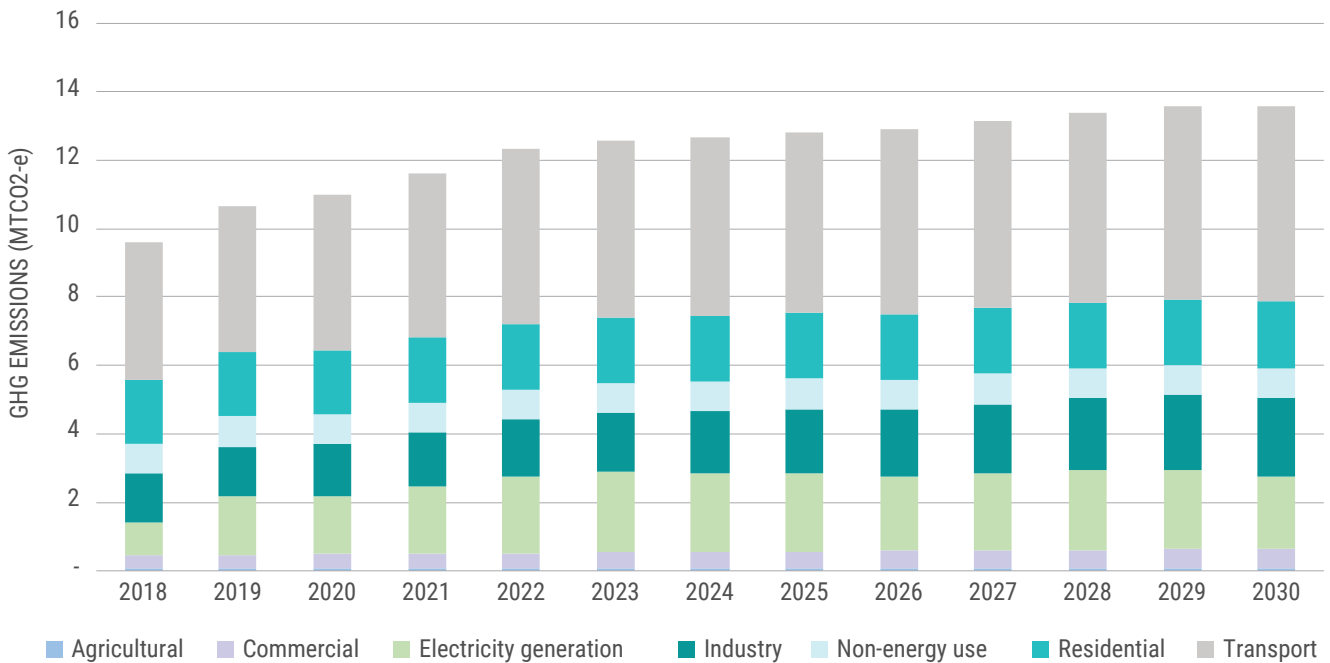
The 2030 demand for electricity in the current policy scenario will be 16.7 TWh in the current policy scenario. The demand will be the highest in the industry sector at 5.9 TWh (53 per cent) followed by the commercial sector at 5.4 TWh, the residential sector at 2.8 TWh (47 per cent), the transport sector at 0.6 TWh, the agricultural sector at 0.1 TWh and non-specified at 1.9 TWh.

3.8. Energy supply outlook

The energy supply outlook for Georgia during the analysis period is based on national energy resource constraints, which specify the resources available domestically and the resources that need to be imported. In the LEAP model, the national base year reserves for fossil-fuel resources and the annual yield from renewable energy resources are modelled as a constraint.

The TPES is forecast to increase from 4,815 ktoe in 2020 to 6,465 ktoe in 2030. The fuel shares in 2030 would be natural gas at 2,908 ktoe, oil products at 1,692 ktoe and hydropower at 870 ktoe. The high amount of natural gas used in the current policy scenario is partly due to MoESD’s planned capacity expansion that increases combined cycle gas turbine-fired power from 231 MW in 2018 to 1,211 MW in 2030. This will lead to an increase in natural gas import dependency for electricity generation from 408 ktoe in 2018 to 887 ktoe by 2030.

Figure 6. Georgia’s energy sector emissions outlook in the current policy scenario, 2018 -2030




3.9. Energy sector emissions outlook

The energy sector emissions, from the combustion of fossil fuel, for Georgia are calculated based on IPCC Tier 1 emission factors assigned in the LEAP model. In accordance with the NDC document submitted to the United Nations Framework Convention on Climate Change (UNFCCC), Georgia's emission reduction targets commit to a 15 per cent unconditional reduction and a 25 per cent conditional reduction with international support, compared with the emissions in the BAU

scenario in 2030. While these reduction targets include other non-energy sectors, the NEXSTEP analysis assumes the same percentages of reduction for the energy sector, using the emissions in the BAU scenario as the reference.

The NEXSTEP analysis uses the latest available 2018 data for Georgia's energy sector and energy demand growth assumptions, and estimates that under the current policy scenario the energy sector emissions in 2030 will reach 13,579 ktCO_{2-e} (figure 6), falling short of meeting the unconditional NDC target by only 8 ktCO_{2-e}.





4. 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.

4.1. 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.

4.2. SDG 7 targets

4.2.1. 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).

4.2.2. 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

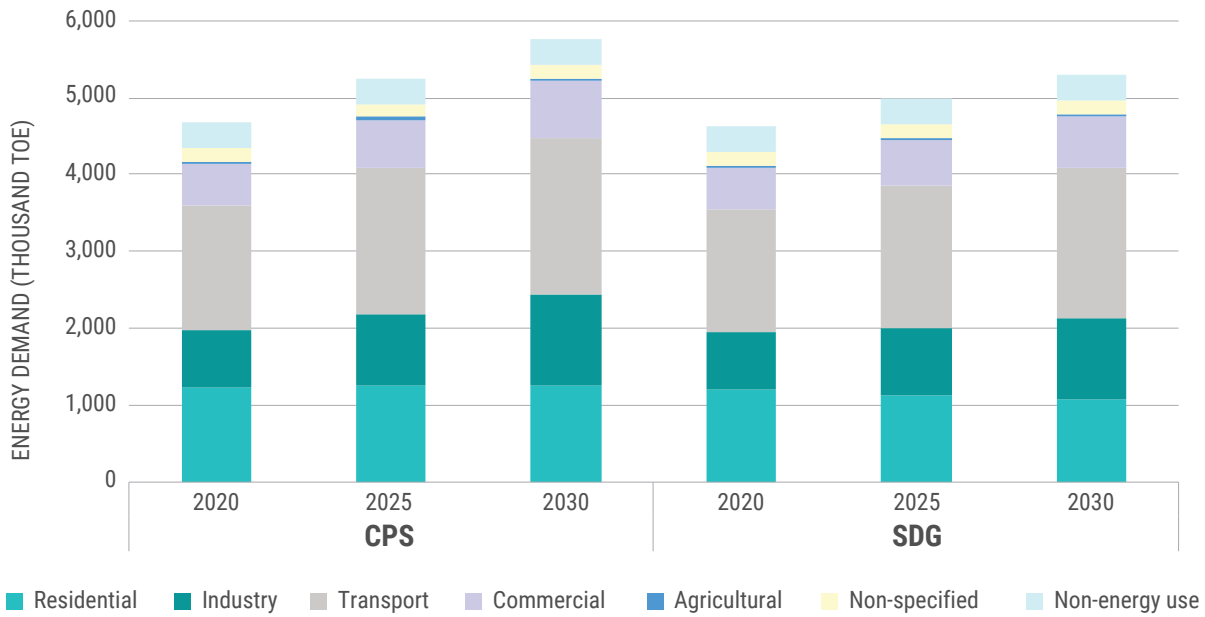
cooking fuels and technologies. Based on a detailed cost analysis and suitability of implementation (discussed further in section 4.4.1), NEXSTEP shows that electric cooking stoves can be used for the remaining 32,000 households to achieve universal access to clean cooking fuels and technologies. Implementation 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.

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



4.2.4. 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.

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).

4.2.5. 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

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

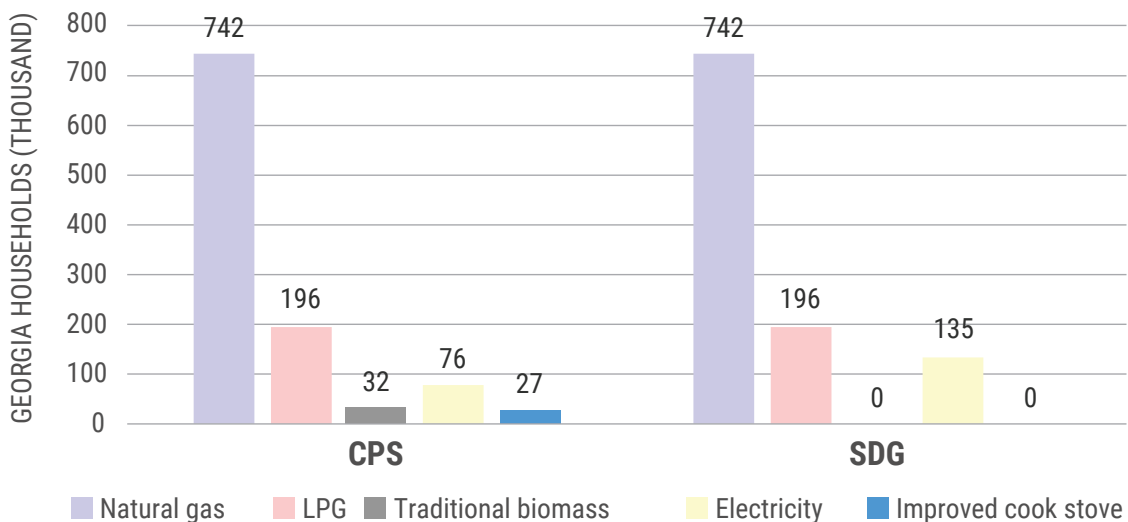
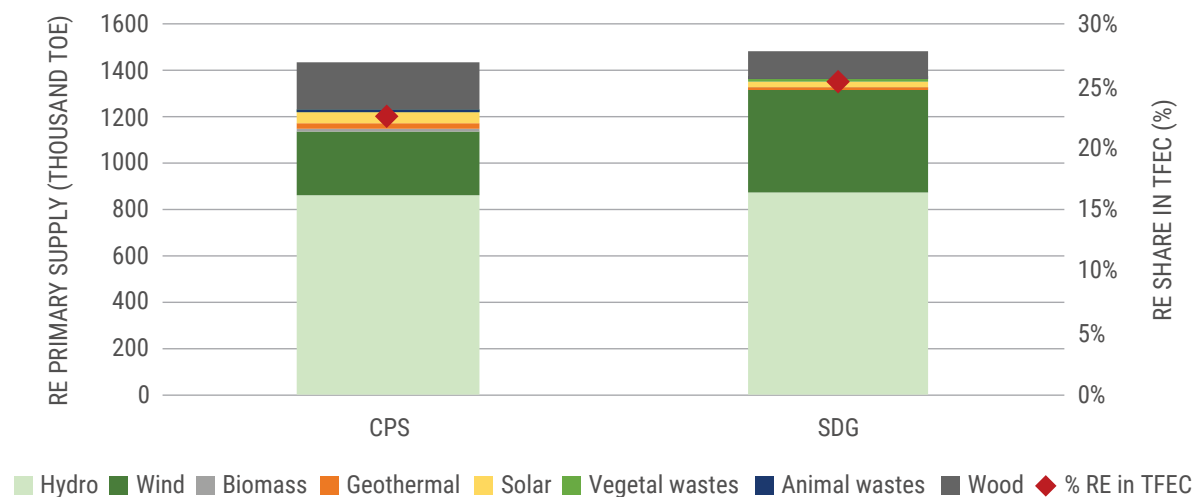


Figure 9. Renewable energy in TFEC, 2030

in the BAU scenario emission is projected to be 15,966,000 tonnes of CO_{2-e} (ktCO_{2-e}) by 2030. This sets the unconditional and conditional NDC targets of Georgia as 13,571 ktCO_{2-e} and 11,974 ktCO_{2-e}, respectively. Emissions in the current policy scenario are projected as 13,579 ktCO_{2-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 ktCO_{2-e} in 2030 which is set to achieve the NDC unconditional targets for the energy sector. Figure 11 shows the emissions in different scenarios.

4.3. 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), 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 the share 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.

4.4. Policy actions for achieving SDG 7

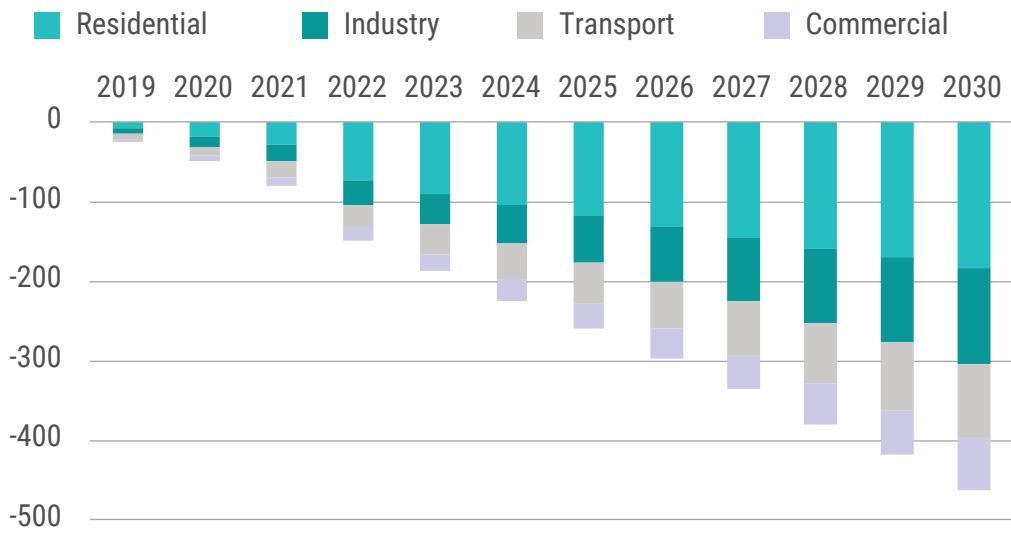
4.4.1. Promote electric cooking stoves to achieve universal access to clean cooking fuel

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 1990 and 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.

Figure 10. Energy efficiency savings in SDG scenario



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

(a) 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.

(b) 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

Figure 11. Emissions by scenario, 2030

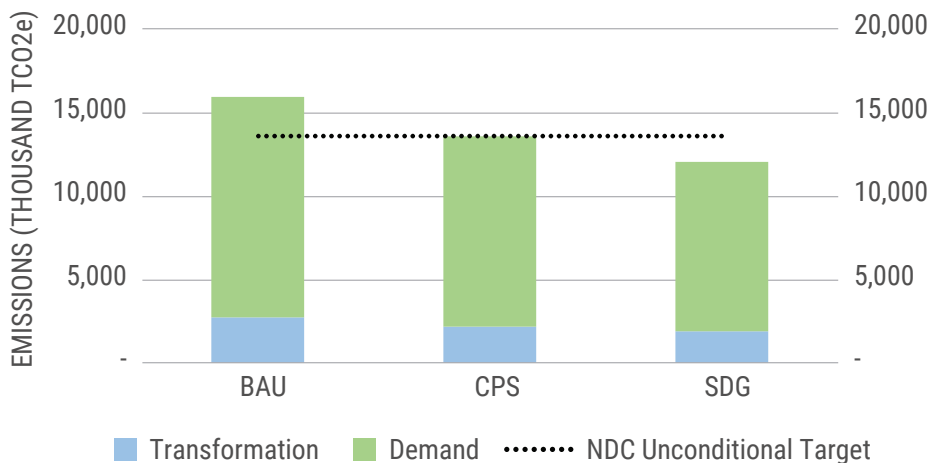
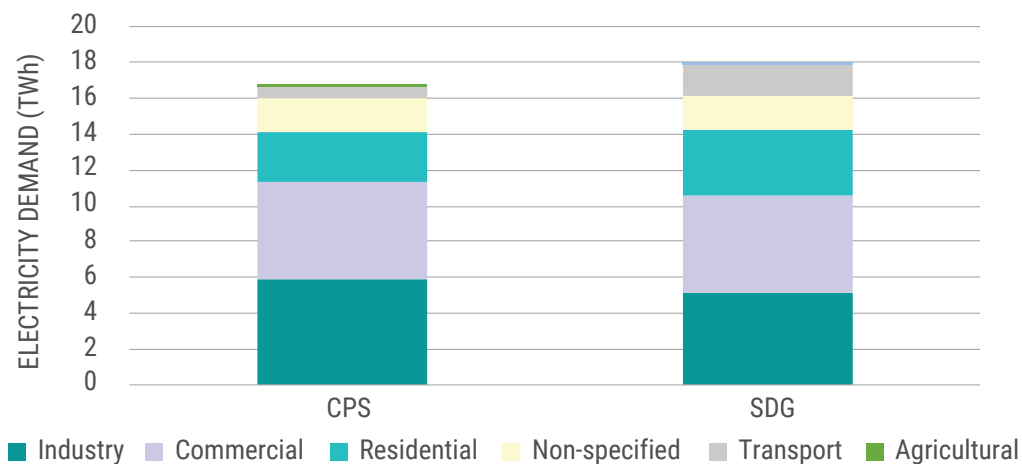
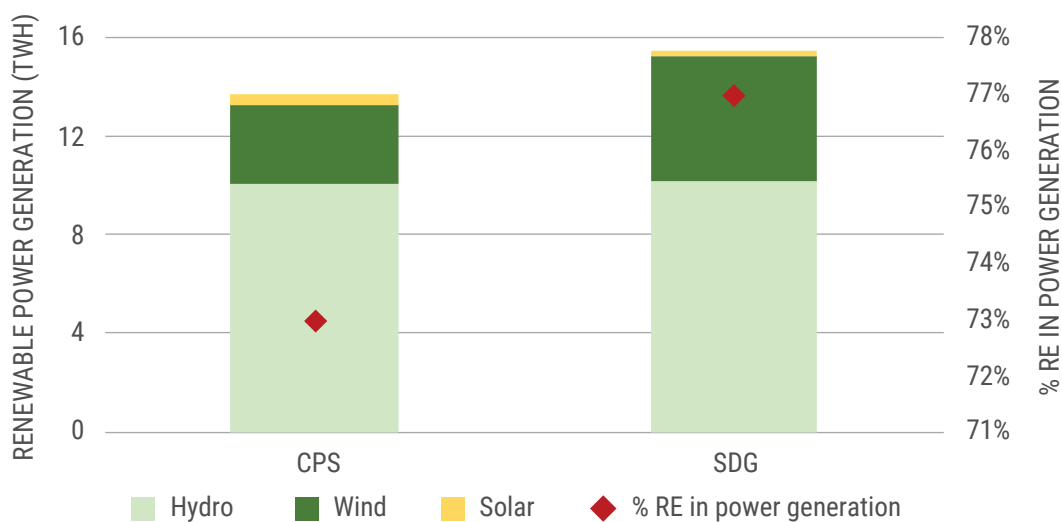


Figure 12. Electricity demand by sector, 2030**Figure 13. Renewable power generation, 2030**

of the cow, to produce enough feedstock for daily gas demand for a household.

(c) 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)³ 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.

(d) 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.

³ <http://documents.worldbank.org/curated/en/937711468320944879/pdf/88699-REVISED-LW16-Fin-Logo-OKR.pdf>

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

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

In the NEXSTEP 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 cent⁴ of passenger buses to electric buses by 2030 (3 ktoe).

Industrial sector – total savings: 114 ktoe

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

Commercial sector – total savings: 64 ktoe

- (i) 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).
- (ii) 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 This assumption is based on expert advice concerning what could be practically possible in the next decade.

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

4.4.3. 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.

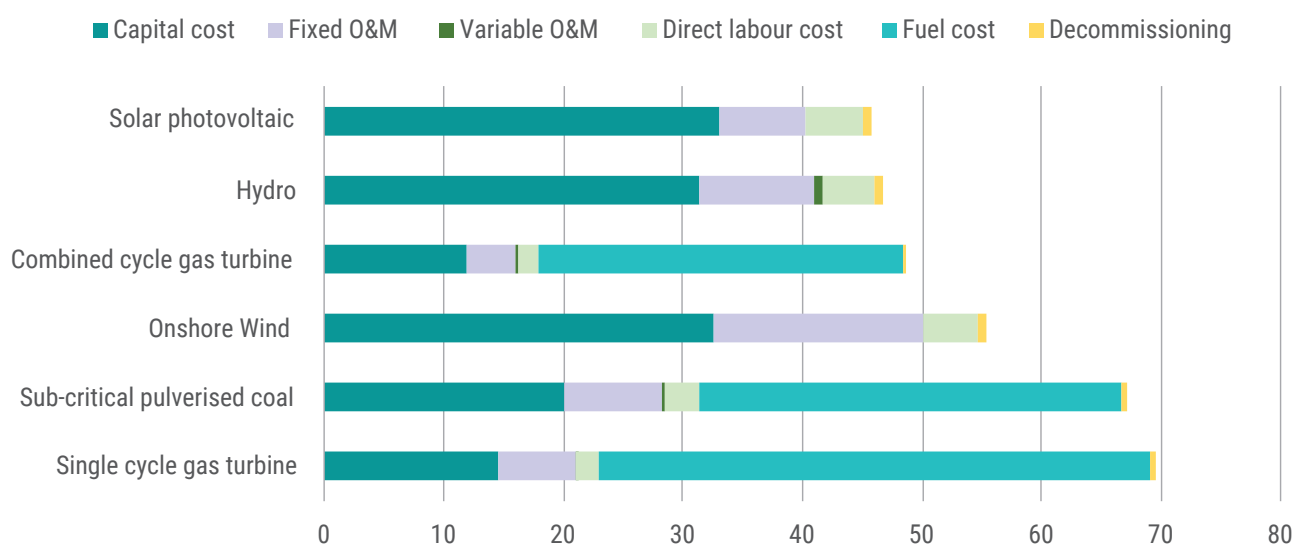
4.4.4. Leverage the declining cost of renewables

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 (US\$/MWh)



The background of the page is a dark, almost black, space-like field filled with intricate, glowing blue light trails. These trails are composed of numerous thin, overlapping lines that curve and swirl, creating a sense of dynamic movement and energy. Some trails are thicker and brighter, while others are thinner and more delicate. The overall effect is reminiscent of a complex network or a futuristic data visualization. In the bottom left corner, there is a large, solid yellow shape that serves as a background for the section header.

5. 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:

- (a) **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.
- (b) **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. This scenario also analyses the impact of a US\$40/tCO_{2-e} carbon price on electricity generation.
- (c) **Sustainable transport scenario.** This scenario 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. This scenario also analyses the impact of a US\$40/tCO_{2-e} carbon price on electricity generation.
- (d) **Decarbonising the power sector to enhance NDC scenario.** This scenario is the most ambitious one, in which the power sector is completely decarbonized by phasing out all fossil fuel-based power generation by 2030. This scenario also analyses the impact of a US\$40/tCO_{2-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.

5.1. 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.

5.1.1. 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 per cent). 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).

5.1.2. 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.

5.1.3. 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.

5.1.4. GHG emissions

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

5.2. Sustainable heating scenario

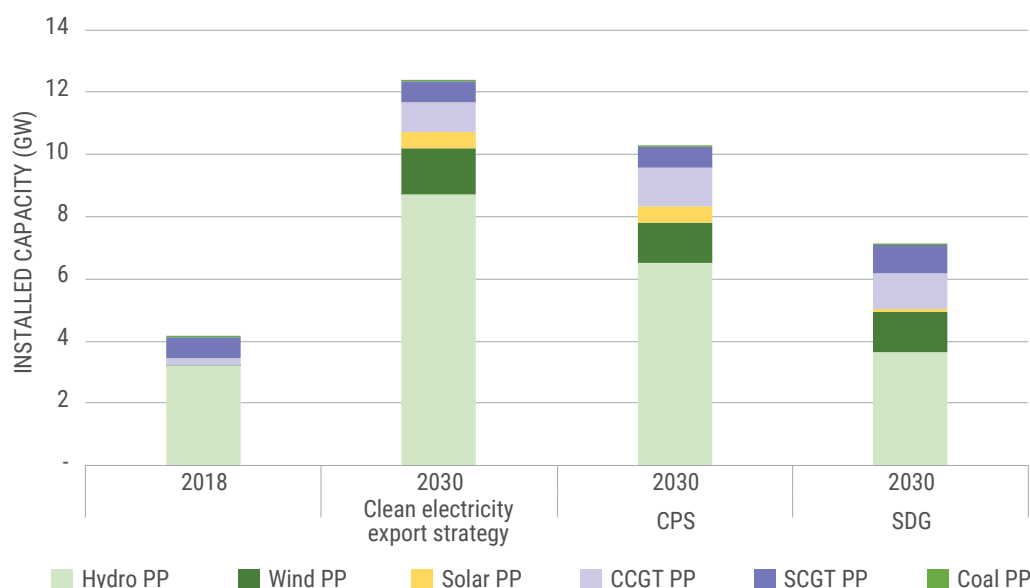
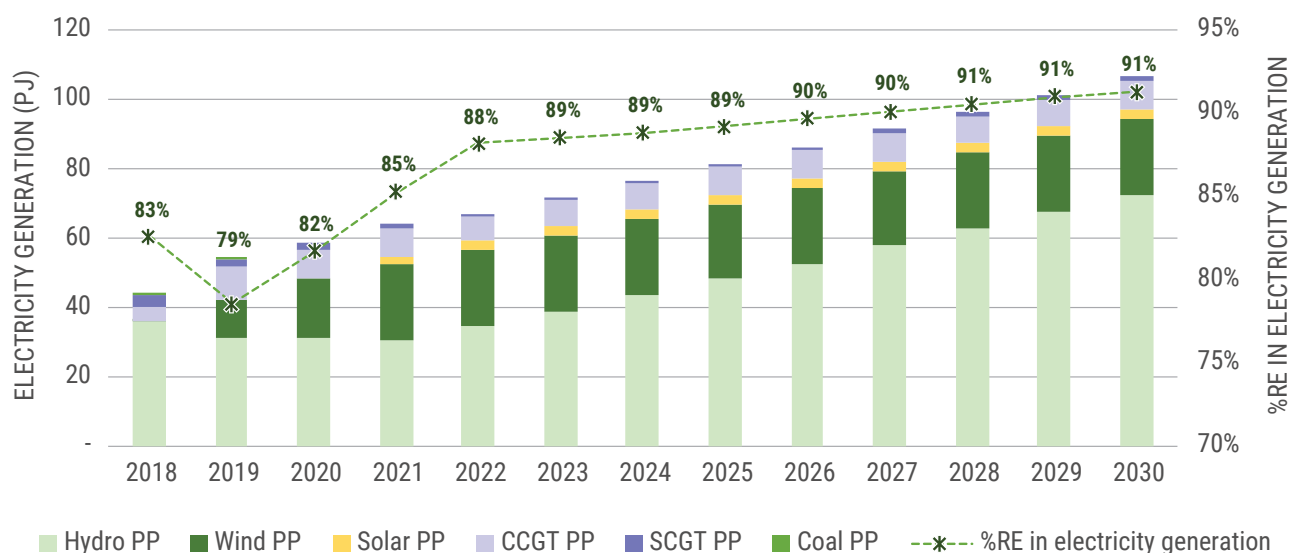
Due to Georgia's continental climate, the residential demand for space heating and water heating is substantial. Space heating demand constitutes around 57 per cent of the total residential energy demand, while water heating demand is around 8 per cent of the total residential demand. To put this into 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.

Box 2. Carbon pricing

A carbon price of US\$40/tCO_{2-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/tCO_{2-e} – US\$ 80/ tCO_{2-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 tCO_{2-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.

Figure 15. Total installed power capacity in 2018 and 2030**Figure 16. Electricity generation by power technologies, 2018-2030**

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:

- (i) increasing the use of heat pumps in households to 60 per cent share (replacing natural gas heating);
- (ii) 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.

5.2.1. 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.

5.3. 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.

5.3.1. 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 18 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.

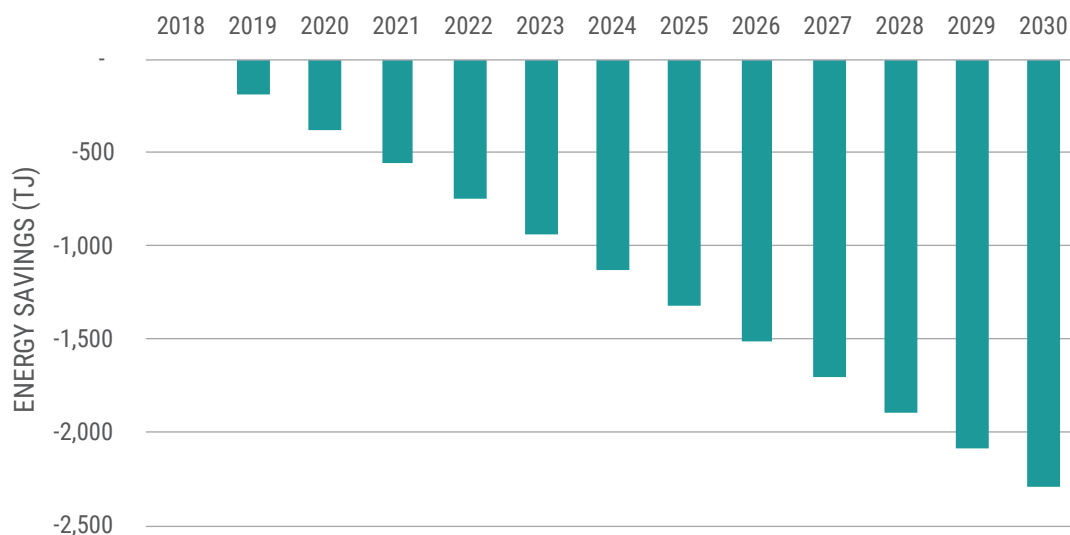
5.4. Decarbonising the power sector to enhance the NDC scenario

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.

5.4.1. 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,

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



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 19 compares the installed capacities in this scenario, the SDG scenario and the current policy scenario.

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).

5.4.2. 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.

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

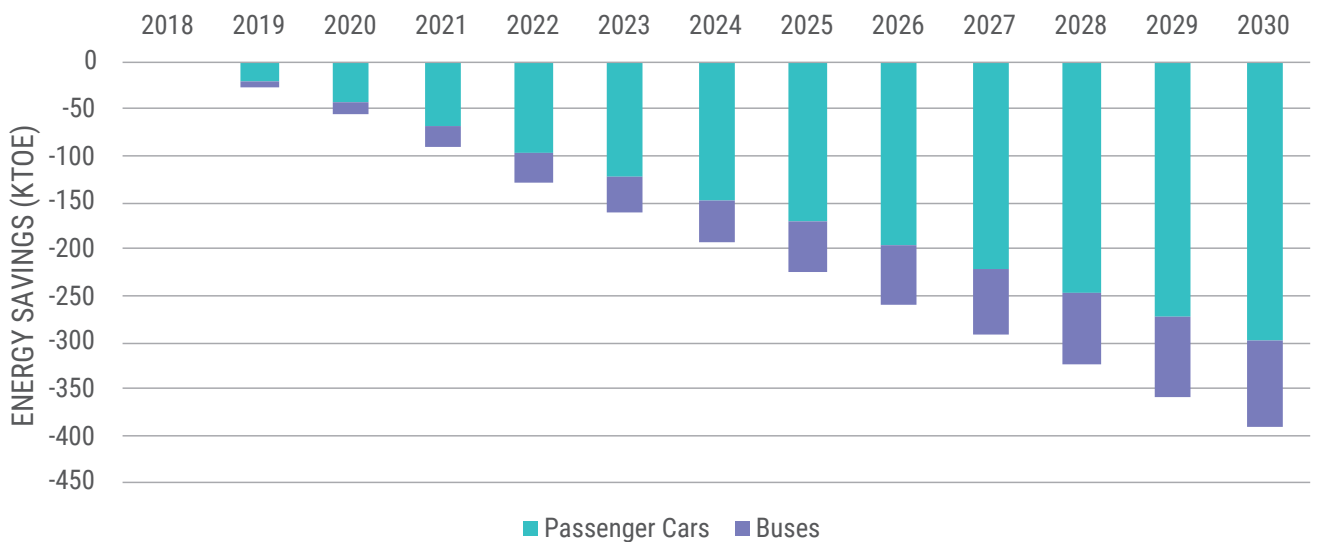
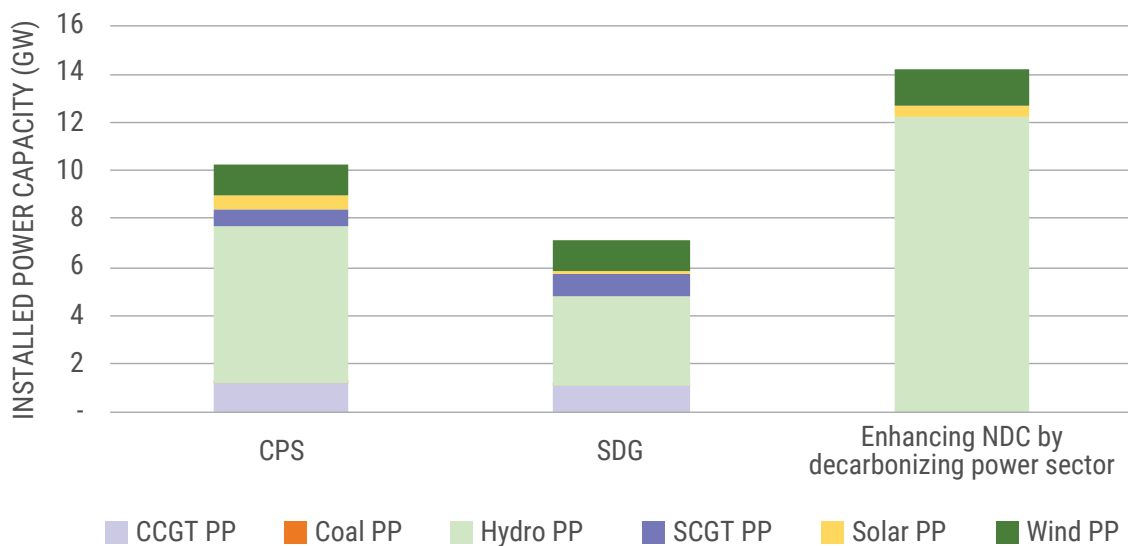


Figure 19. Installed power capacity in 2030





6. Policy recommendations

6.1. 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:

- (a) Universal access to electricity to be achieved;
- (b) Universal access to clean cooking fuel to be achieved;
- (c) Renewable energy share in the total final energy consumption to increase;
- (d) Energy efficiency improvement should be doubled, and where there is an economic benefit it should be further enhanced;

- (e) The unconditional NDC target should be achieved. Where possible, the conditional target should be achieved if it is economically viable.
- (f) Total investment should be kept low, but the net benefit should be high. This was done by assigning both indicators the same weight to ensure that a scenario is chosen on the value-for-money basis;
- (g) Carbon pricing should be introduced to encourage investments in clean energy.

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.

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.

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. 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

6.2. 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

- (i) Replacing natural gas boilers in 60 per cent of households in Georgia with heat pumps to save an additional 55 ktoe annually in 2030.
- (ii) 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 cent⁵ 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\$.

6.3. 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 14) 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.

6.4. 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

⁵ This assumption has been based on expert advice on what could be practically possible in the next decade.

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.

6.5. 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 CO_{2-e} emissions and allow participants to trade an allowance of CO_{2-e} emissions under the cap. The mechanism results in a wealth transfer from high-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/tCO_{2-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 ktCO_{2-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.

6.6. 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"⁶ is an important guide for policymakers in developing strategies to reduce risks of renewable energy investment.

⁶ See https://www.undp.org/content/undp/en/home/librarypage/environment-energy/low_emission_climate-resilient-development/derisking-renewable-energy-investment.html.

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 (ADB, 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.

7

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

7.1. 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.

7.2. 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.

7.3. 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.



8. 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.

7.1. Universal access to clean cooking

Existing policy	NEXSTEP Analysis – Gaps and recommendations
<p>Nationally Appropriate Mitigation Action (NAMAs)</p> <p>NAMA aims to provide 15,000 rural households with fuel-efficient wood stoves.</p>	<p>Gaps:</p> <p>Georgia will fall short of achieving the SDG target, reaching only 97 per cent of the population with clean cooking fuel by 2030.</p> <p>Achieving SDG and ambitious scenarios:</p> <p>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.</p>

7.2. Renewable energy

Existing policy	NEXSTEP Analysis – Gaps and recommendations
<p>National Renewable Energy Action Plan (NREAP) Georgia, 2019</p> <p>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.</p>	<p>Gaps:</p> <p>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.</p> <p>Achieving the SDG scenario:</p> <p>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.</p> <p>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.</p> <p>Achieving ambitious scenarios:</p> <p>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.</p>

7.3. Energy efficiency

Existing policy	NEXSTEP Analysis – Gaps and recommendations
<p data-bbox="228 555 564 667">National Energy Efficiency Action Plan (NEEAP) Georgia, 2019-2020</p> <p data-bbox="228 770 564 958">NEEAP has identified several energy efficiency measures across different sectors to be implemented during 2019-2020.</p> <p data-bbox="228 1061 564 1473">It is estimated that a 14 per cent reduction can be 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.</p>	<p data-bbox="624 443 699 479">Gaps:</p> <p data-bbox="624 510 1406 658">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.</p> <p data-bbox="624 761 938 797">Achieving SDG scenario:</p> <p data-bbox="624 828 1406 940">The NEXSTEP analysis proposes several energy efficiency measures across different sectors. Altogether, the proposed measures allow the achievement of SDG target 7.3.</p> <p data-bbox="624 1043 1406 1232">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.</p> <p data-bbox="624 1335 1027 1370">Achieving ambitious scenarios:</p> <p data-bbox="624 1402 1406 1590">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.</p>



9. 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

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 make informed policy decisions that would help achieve 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.

Table 5. 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.

$$\text{Primary energy intensity} = \frac{\text{Total Primary Energy Supply (MJ)}}{\text{GDP (USD 2011 PPP)}}$$

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

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

Base period improvement rate for 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 Total final energy consumption, where TFEC is total final energy consumption, ELEC is gross electricity production and HEAT is gross heat production.

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

II. Key assumptions for NEXSTEP energy modelling

a. General parameters

Table 6. GDP and GDP growth rate

Parameter	Value
GDP (2018, current US\$) ⁷	17.6 billion
GDP growth rate ⁸	4.8%

Table 7. 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

b. Demand-side assumptions

Industry:

Table 8. 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\$ 1267.8 million
Mining and Quarrying	US\$ 180.4 million

Growth rate per annum: 4.94%

⁷ Source: GDP (current US\$), Georgia - World Bank national accounts data, and OECD National Accounts data files. (<https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=GE>)

⁸ Sourced from Energy Balance of Georgia 2018

Transportation:

Table 9. 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:

Table 10. Residential urbanization, percentage

	2018	2025	2030
Rural	58.4	61.6	63.9
Urban	55.3	60	63.4

Commercial:

Table 11. Commercial floor space

Parameter	Value
Commercial floor space (remains constant during 2018-2030)	9380823 m ²

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.

Table 12. 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 CO ₂ e
Electricity tariff	0.056 US\$/kWh
Skilled workforce	80%
Shadow Wage Rate Factor (SWRF)	0.75

Table 13. Fuel price for power plant technologies

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

Table 14. 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

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.

BAU

The Business as Usual (BAU) scenario analysis the energy system in Georgia if no action or policies were implemented related to Sustainable Development Goal 7 (SDG 7) targets and Nationally Determined Contribution (NDC) by 2030.

SDG 7.1.1 Universal access to electricity

Georgia achieved universal access to electricity in 2010. The SDG indicator is achieved across all scenarios.

SDG7.1.2 Universal access to clean cooking

The share of population with access to clean cooking fuels and technologies in the BAU scenario will be 94.5 per cent in 2030. In this scenario 59 thousand households will still be depending on inefficient and polluting cooking fuels and technologies in 2030.

SDG 7.2 Renewable Energy

The renewable energy share of TFEC in Georgia is projected to decrease from 25.9 per cent in 2018 to 20.2 per cent by 2030. The decrease is due to the projected increase in fossil fuel based clean cooking fuels such as natural gas and LPG.

SDG 7.3 Energy Efficiency

The energy intensity improvements at the end-use level is modelled as constant from 2018 - 2030. The primary energy intensity a proxy for the measurement of energy efficiency improvement is calculated as 5.3 MJ/\$ in 2018. In the BAU scenario, primary energy intensity is projected to be 4.59 MJ/\$ by 2030 and falls short of the recommended SDG rate of 3.8 MJ/\$ in 2030. In the component analysis of primary energy intensity trends, the improvement is mainly due to a higher GDP growth rate of 4.8 per cent compared to total primary energy supply growth rate of 3.4 per cent.

NDC Unconditional Target

Georgia's energy sector greenhouse gas emissions will reach 15,996 thousand tCO₂-e by 2030 and will be used as a baseline to compare scenarios emission reduction.

Investment Required \$ 9.6 billion

The investment costs in power sector is calculated based on the planned capacity expansion to meet future energy demand. The capital cost for technologies is included in the LEAP model using national technology data for Georgia's power sector.

Seasonal variation of hydropower is a major constraint for Georgia

The BAU scenario assumes the electric power system expansion continues based on current energy mix in 2018. Due to the high level of hydropower it leads to an increase in seasonal fluctuation, with curtailed energy production of 8.9 TWh in 2030.

Current Policy Scenario

The Current Policy Scenario (CPS) is based on the current national energy policies of Georgia.

SDG7.1.2 Universal access to clean cooking

Georgia currently has the following policies in place for clean cooking [6]:

- 'Efficient use of biomass for equitable, climate proof and sustainable rural Development' (11,500 rural households - Fuel Efficient Wood Stoves).
- 'The first gender sensitive Nationally Appropriate Mitigation Action (NAMA)' (15,000 rural households – Fuel Efficient Wood Stoves).

The share of population with access to clean cooking fuels and technologies in the current policy scenario will reach 97 per cent in 2030, up from 75.2 per cent in 2017. Despite this progress, 32 thousand households will still be depending on inefficient and polluting cooking fuels and technologies in 2030.

SDG 7.3 Energy Efficiency

The energy intensity improvements at the end-use level is modelled to improve, based on Government of Georgia's national policies in place (MEPA, 2019):

- Energy Efficiency improvements in public buildings and use of renewable energy
Renovate 27 public buildings in selected municipalities with total floor area of 70,000m².
- Vehicle improvement - Technical inspection of Vehicles
Technical inspection of all vehicles in Georgia
- Urban mobility - Improvement of buses.
Introduction of new 143 CNG busses in Tbilisi and 40 electric busses in Batumi.
- Changing clinker production method from wet to dry
The introduction of technology reduces energy consumption to 3.4 GJ/t -clinker.

The primary energy intensity, a proxy for the measurement of energy efficiency improvement is estimated to be 4.07 MJ/\$ and falls short of the recommended SDG rate of 3.8 MJ/\$ in 2030.

NDC Unconditional Target

Based on the Nationally Determined Contributions (NDC) document submitted to UNFCCC, Georgia has committed to reduce GHG emissions in the energy sector to 15 per cent unconditionally (without international aid) below the Business as Usual scenario. The emissions in current policy scenario will reach 13,579 thousand tCO₂-e by 2030, compared to 15,966 thousand tCO₂-e in the business as usual scenario, missing the NDC unconditional target by a slight margin.

Investment Required \$ 9.5 billion

Based on the planned capacity expansion data from the MoESD, Georgia will need to invest \$ 9.5 billion in the power sector. The investment costs in the current policy scenario are \$ 0.1 billion higher compared to business as usual scenario, mainly due to a change in the fuel mix from hydropower to less-capital intensive wind and solar power plants.

Natural gas import dependency

The CPS scenario is based on the MoESD capacity expansion. Due to the high level of planned combined cycle gas turbine-fired power from 231 MW in 2018 to 1,211 MW in 2030 it leads to an increase in natural gas import dependency for electricity generation from 408 ktoe in 2018 to 887 ktoe by 2030.

SDG scenario

The SDG scenario aims to achieve the SDG7 and NDC targets by 2030. LEAP software is used to model a range of scenarios-based options available in clean cooking fuels and technologies, electricity export strategies, decarbonizing heat, transport electrification and decarbonization of electric power generation.

SDG7.1.2 Universal access to clean cooking

Access to clean cooking fuels by using electric cook stove technology is evaluated in this scenario. The intervention will substitute traditional biomass cook stoves and cost \$ 40 per household, with an annualized cost of \$ 87 per household.

The implementation of this program will cost the Government of Georgia \$ 1.28 million to achieve universal access to clean fuels and technologies for cooking. The technology is classed as Level 5 in World Bank MTF for Indoor Air Quality Measurement. The capital cost of the technology varies from \$ 40 – 100, and it has high efficiency (74 per cent solid plate, 84 per cent induction).

Georgia has surplus clean electricity generation potential and a shift towards electric cook stoves is a feasible solution.

SDG 7.2 Renewable Energy

Renewable energy generation is projected to increase significantly and contribute 77 per cent of the total electricity generation in 2030, led by growth in wind power, hydropower and solar power technologies. CCGT power plants capacity addition will be reduced to 885 MW by 2030, compared to 980 MW capacity addition planned.

The total net benefits from the power sector will be \$4.9 billion, over \$4.1 billion higher compared to the current policy scenario. This is because of the lower capital costs in the optimized capacity, higher running fuel and O&M costs of fossil fuel-based power plant lifetime costs.

SDG 7.3 Energy Efficiency

Achievement of recommended SDG7 target of 3.8 MJ/\$ by 2030, will require 2.9 per cent reduction in energy intensity per year up to 2030. This equates to reducing TFEC of 462 ktoe by 2030, compared to current policy scenario. NEXSTEP analysis identified the following measures to support this reduction cost-effectively.

Residential Sector Energy Efficiency Measures

- i. Replacing natural gas boilers in 40 per cent of households in Georgia with heat pumps to save 109 ktoe annually in 2030.
- ii. Introduce MEPS for all new lights from 2022 onwards to replace existing incandescent bulbs 75W and CFL bulbs 20W, by LED bulbs 12W saving 47 ktoe annually in 2030.
- iii. Introduce MEPS for all new televisions from 2022 onwards, saving 14 ktoe annually in 2030.
- iv. Introduce MEPS for all new refrigerators from 2022 onwards, saving 9 ktoe annually in 2030.
- v. Introduce MEPS for all new washing machines from 2022 onwards, saving 2 ktoe annually in 2030.
- vi. Switch from traditional cooking to clean cooking (electric cookstove) saving 3 ktoe annually in 2030.

Transport Sector Energy Efficiency Measures

- vii. 100 per cent⁹ of passenger buses to electric buses by 2030, saving 93 ktoe annually in 2030.

Industrial Sector Energy Efficiency Measures

- viii. Change the wet process of clinker production in the cement industry to pre-heated process using pre-calciner kilns, saving 34 ktoe annually in 2030.
- ix. LED lighting across all industrial sectors saving 25 ktoe annually in 2030.
- x. Improved Boilers and Steam / Hot Water Distribution Systems in pulp and paper, food and beverage and chemical industry saving 31 ktoe annually in 2030.
- xi. Energy efficient motors, pumps, fans and compressors across all industries saving 24 ktoe annually in 2030.

Commercial Sector Energy Efficiency Measures

- xii. Plastic double-glazed windows and roof insulation across all government buildings in Georgia to reduce thermal energy consumption by 39 per cent, saving 39 ktoe annually in 2030.

⁹ This assumption has been based on expert advice on what could be practically possible in the next decade.

xiii. Plastic double-glazed windows in private buildings to reduce thermal energy consumption by 15 per cent, saving 25 ktoe annually in 2030.

A set of eight different sub-scenarios were developed under the SDG scenario. The key messages of these sub-scenarios are summarized below.

NDC Unconditional Target

Achievement of the unconditional target will require the 2030 emissions to drop to 13,570 thousand tCO₂-e compared to the 2030 BAU emissions of 15,966 thousand tCO₂-e. Based on emission constraints and NEMO-based optimization for least-cost electric generation the overall emissions from this scenario is 12,013 thousand tCO₂-e, a drop of 3,953 thousand tCO₂-e compared to the baseline. This will be achieved by:

- i. Reducing the consumption emissions by 3,102 thousand tCO₂-e. This is largely achieved by implementing energy efficiency measures and fuel switching in the transport sector.
- ii. Reducing the electricity generation emissions by 851 thousand tCO₂-e. This is achieved by changing the fuel mix in the power sector.

Investment Required \$ 4 billion

The total cost of this scenario is \$4 billion by 2030. This includes cost of:

- i. \$ 1.28 million to achieve access to clean cooking fuel.
- ii. \$ 4 billion to change the fuel mix in the power sector.

Ambitious Scenarios

A set of 4 different sub-scenarios were developed, raising the ambitions beyond SDG 7 targets and the NDC. The key messages of these scenarios are summarized below.

Clean electricity export

Electricity export

Georgia has potential to substantially increase clean electricity exports to neighbouring countries. In this scenario a target of 10 TWh in electricity exports by 2030 was modelled. The rationale is based on the "Ten Year Network Development Plan" of Georgia developed for 2018 – 2029 which projects electricity production will exceed of 30 TWh by 2029 and consumption will reach 22 TWh to make the 10 TWh export target possible for Georgia.

SDG 7.2 Renewable Energy

The share of renewable energy in total final energy consumption will be 29.8 per cent by 2030, which is the optimum share to ensure the achievement of other SDG7 targets and the NDC constraints.

The total net benefits from the power sector will be \$3.1 billion, over \$2.3 billion higher compared to the current policy scenario. This is because of the higher running fuel and O&M costs of fossil fuel-based power plant lifetime costs.

NDC Conditional Target

Georgia has committed to reduce GHG emissions in the energy sector to 25 per cent conditionally (with international aid) below the business as usual scenario. Achievement of the conditional target will require the 2030 emissions to drop to 11,975 thousand tCO₂-e compared to the 2030 BAU emissions of 15,966 thousand tCO₂-e.

Based on emission constraints and NEMO-based optimization for least-cost electric generation the overall emissions from this scenario is 11,132 thousand tCO₂-e, a drop of 4,834 thousand tCO₂-e compared to the baseline. This will be achieved by:

- i. Reducing the consumption emissions by 3,102 thousand tCO₂-e. This is largely achieved by implementing energy efficiency measures and fuel switching in the transport sector.
- ii. Reducing the electricity generation emissions by 1,732 thousand tCO₂-e. This is achieved by changing the fuel mix in the power sector.

Investment Required \$13.5 billion

The total cost of this scenario is \$ 13.5 billion by 2030. This includes cost of:

- i. \$1.28 million to achieve access to clean cooking fuel.
- ii. \$13.5 billion to change the fuel mix in the power sector.

Sustainable heating

Sustainable heating policies

NEXSTEP analysis in the sustainable heating scenario increases ambitions in residential sector heating in Georgia. The following policies are modelled:

- i. Replacing natural gas boilers in 60 per cent¹⁰ of households in Georgia with heat pumps to save 109 ktoe annually in 2030.
- ii. Replacing natural gas water heaters with solar water heaters in 30 per cent of Georgia households.

NDC Conditional Target

Georgia has committed to reduce GHG emissions in the energy sector to 25 per cent conditionally (with international aid) below the business as usual scenario. Achievement of the conditional target will require the 2030 emissions to drop to 11,975 Thousand tCO₂-e compared to the 2030 BAU emissions of 15,966 Thousand tCO₂-e.

Based on emission constraints and NEMO-based optimization for least-cost electric generation the overall emissions from this scenario is 11,114 Thousand tCO₂-e, a drop of 4,852 Thousand tCO₂-e compared to the baseline. This will be achieved by:

- i. Reducing the consumption emissions by 3,378 thousand tCO₂-e. This is largely achieved by implementing energy efficiency measures and fuel switching in the transport sector.
- ii. Reducing the electricity generation emissions by 1,473 thousand tCO₂-e. This is achieved by changing the fuel mix in the power sector.

Price on Carbon

The scenario analyses the implementation of a price on carbon policy of \$40 per ton of CO₂ emissions from the power sector. This shall provide the government carbon revenue of \$541 million by 2030.

Investment Required \$13.4 billion

The total cost of this scenario is \$13.4 billion by 2030. This includes cost of:

- i. \$1.28 million to achieve access to clean cooking fuel.
- ii. \$13.4 billion to change the fuel mix in the power sector.

Sustainable transport

Electrification of transport

NEXSTEP analysis in the sustainable transport scenario increases ambitions in the electrification of passenger vehicles. The following policy is modelled:

- i. 50 per cent¹¹ of passenger vehicles to electric cars by 2030, saving 298 ktoe annually in 2030.

NDC Conditional Target

Georgia has committed to reduce GHG emissions in the energy sector to 25 per cent conditionally (with international aid) below the business as usual scenario. Achievement of the conditional target will require the 2030 emissions to drop to 11,975 thousand tCO₂-e compared to the 2030 BAU emissions of 15,966 thousand tCO₂-e.

Based on emission constraints and NEMO-based optimization for least-cost electric generation the overall emissions from this scenario is 11,096 thousand tCO₂-e, a drop of 4,869 thousand tCO₂-e compared to the baseline. This will be achieved by:

- i. Reducing the consumption emissions by 4,818 thousand tCO₂-e. This is largely achieved by implementing energy efficiency measures and fuel switching in the transport sector.
- ii. Reducing the electricity generation emissions by 51 thousand tCO₂-e. This is achieved by changing the fuel mix in the power sector.

Price on Carbon

The scenario analyses the implementation of a carbon taxation policy of \$40 per ton of CO₂ emissions from the power sector. This shall provide the government carbon revenue of \$896 million by 2030.

¹⁰ Energy Consumption in Households 2017 for Georgia, 60.4 per cent of households are classified as individual house.

¹¹ This assumption has been based on expert advice on what could be practically possible in the next decade.

Investment Required \$11.4 billion

The total cost of this scenario is \$11.4 billion by 2030. This includes cost of:

- i. \$1.28 million to achieve access to clean cooking fuel.
- ii. \$11.4 billion to change the fuel mix in the power sector.

Decarbonizing power sector to enhance NDC**SDG 7.2 Renewable Energy**

The share of renewable energy in total final energy consumption will be 39.3 per cent by 2030, which is the optimum share to ensure the achievement of other SDG7 targets and the NDC constraints.

Renewable energy generation is projected to increase significantly and contribute 100 per cent of the total electricity generation in 2030, led by growth in hydro, wind and solar power technologies.

Enhancing NDC

Georgia can increase ambitions in the energy sector to reduce emissions by 45 per cent compared to the business as usual. Achievement of the ambitious target will require the 2030 emissions to drop to 8,781 thousand tCO₂-e compared to the 2030 BAU emissions of 15,966 thousand tCO₂-e.

Based on emission constraints and NEMO-based optimization for least-cost electric generation the overall emissions from this scenario is 8,399 thousand tCO₂-e, a drop of 7,566 thousand tCO₂-e compared to the baseline.

This will be achieved by:

- i. Reducing the consumption emissions by 4,818 thousand tCO₂-e. This is largely achieved by implementing energy efficiency measures and fuel switching in the transport sector.
- ii. Reducing the electricity generation emissions by 2,748 thousand tCO₂-e. This is achieved by changing the fuel mix in the power sector.

Price on Carbon

The scenario analyses the implementation of putting a price on carbon policy of \$40 per ton of CO₂ emissions from the power sector. This shall provide the government carbon revenue of \$108 million by 2030.

Investment Required \$19.1 billion

The total cost of this scenario is \$19.1 billion by 2030. This includes cost of:

- i. \$1.28 million to achieve access to clean cooking fuel.
- ii. \$19.1 billion to change the fuel mix in the power sector.

Table 15. Sustainable Development Goal Scenario Matrix

	SDG Scenario	Clean electricity export	Sustainable heating	Sustainable transport	Decarbonizing power sector to enhance NDC
Universal access to electricity	100%	100%	100%	100%	100%
Universal access to clean cooking	100%, via electric cooking stove	100% via electric cooking stove	100%, via electric cooking stove	100%, via electric cooking stove	100%, via electric cooking stove
Energy efficiency	SDG7 target; 3.75 MJ/US\$	High; 3.62 MJ/US\$	High; 3.62 MJ/US\$	High; 3.59 MJ/US\$	High; 3.25 MJ/US\$
Emission reduction/ NDC target	Unconditional; 12,013 ktCO ₂ -e	Conditional; 11,132 ktCO ₂ -e	Conditional; 11,114 ktCO ₂ -e	Conditional; 11,096 ktCO ₂ -e	Ambitious; 8,399 ktCO ₂ -e
Electricity export	Remains constant	10 TWh by 2030	10 TWh by 2030	10 TWh by 2030	10 TWh by 2030
Carbon price	None	None	\$ 40.0	\$ 40.0	\$ 40.0
Power generation optimization	Least-cost	Least-cost	Least-cost	Least-cost	FF phaseout
Renewable energy	Optimum; 25.5%	Optimum; 29.8%	Optimum: 30.4%	Optimum; 31.2%	Optimum; 39.3%
Total investment for the power sector	US\$ 4 billion	US\$ 13.5 billion	US\$ 13.4 billion	US\$ 11.4 billion	US\$ 19.1 billion
Net benefits from the power sector	US\$ 4.9 billion	US\$ 3.1 billion	US\$ 3.3 billion	US\$ 4.5 billion	US\$ -0.4 billion

