Energy Transition Pathways for the 2030 Agenda

SDG 7 Road Map for Kiribati

UNITED NATIONS ESCAP
Economic and Social Commission for Asia and the Pacific

NEXSTEP
National Expert SDG Tool for Energy Planning

Energy Transition Pathways for the 2030 Agenda

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

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Contents

Table of Contents

List of figures

List of tables

List of annex tables

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Foreword: Kiribati

"Energy is the cornerstone of sustainable development; however, how it is produced and consumed could impede our development."

Although Kiribati is blessed with abundant indigenous renewable energy resources especially from solar and biomass, it continues to depend heavily on imported fossil fuel for most of its energy needs resulting in high energy costs which hinders its developments. Kiribati while struggling with adapting to the impacts of climate change, it is also committed to mitigate its actions to support the UNFCCC 1.5 pathway and to meet its obligations under its Nationally Determined Contribution.

This Road Map for achieving Sustainable Development Goals provides an overview of key data, scenarios, assumptions, as well as technological and policy-oriented pathways for reducing emissions, saving energy, improving energy access, and lowering cost. It also helps Kiribatiin identifying key priority areas that needs addressing to attain objectives of SDG 7, and more importantly it emphasizes related recommendations to support sustainable energy transition at the national level including COVID-19 recovery approaches.

Achieving the SDG 7 roadmap will catalyse action to combat climate change which makes it the perfect time for Kiribati Government, the private sector, and consumers to intensify efforts to reduce reliance on fossil fuel and to move towards a clean and green alternative.

The Government of Kiribati sincerely acknowledges the great support of UN ESCAP for the development of this significant roadmap which is indeed valuable in guiding our energy transition journey that leaves no one behind. This roadmap is an essential tool as a basis for the development of renewable energy and energy efficiency initiatives as well as the development of future national energy policies.

As a small island developing member state, we are ambitious to achieve our obligations to reduce the impact of climate change as it poses a threat to livelihood of the Kiribati people.

Finally, it is customary to share with you our traditional blessing of Te Mauri (Good Health), Te Raoi (Peace), ao Te Tabomoa (Prosperity) be with us all as we progressively advance and evolutionarily operationalize this Energy Transition Pathway to a brighter and greener future.

Willie Tokataake
Honourable Minister
Ministry of Infrastructure and Sustainable Energy

Abbreviations and acronyms

BAU	business-as-usual
CBA	cost benefit analysis
CO_2	carbon dioxide
CPS	current policy scenario
EE	energy efficiency
ESCAP	United Nations Economic and Social Commission for Asia and the Pacific
EV	electric vehicle
GDP	gross domestic product
GHG	greenhouse gas
GW	gigawatt
GWh	gigawatt-hour
ICS	improved cooking stove
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency
IRR	Internal Rate of Return
$MTCO_{2\text{-}e}$	million tonnes of carbon dioxide equivalent
ktoe	thousand tonnes of oil equivalent
kWh	kilowatt-hour
LCOE	Levelized Cost of Electricity
LEAP	Low Emissions Analysis Platform
LPG	liquified petroleum gas
MCDA	Multi-Criteria Decision Analysis
MEPS	minimum energy performance standard
MISE	Ministry of Infrastructure and Sustainable Energy
MJ	megajoule
MTF	Multi-Tier Framework
Mtoe	million tonnes of oil equivalent
MW	megawatt
MWh	megawatt-hour
NDC	nationally determined contributions
NEMO	Next Energy Modelling system for Optimization
NEXSTEP	National Expert SDG Tool for Energy Planning
OECD	Organisation for Economic Co-operation and Development
PP	power plant
RE	renewable energy
SDG	Sustainable Development Goal
TFEC	total final energy consumption
TPES	total primary energy supply
US$	United States dollar
WHO	World Health Organization

Executive Summary

Transitioning the energy sector to achieve the 2030 Agenda for Sustainable Development and the objectives of the Paris Agreement presents a complex and difficult task for policymakers. It needs to ensure sustained economic growth as well as respond to increasing energy demand, reduce emissions, and consider and capitalize on the interlinkages between SDG 7 and other SDGs. To address this challenge, ESCAP has developed the National Expert SDG Tool for Energy Planning (NEXSTEP).[The NEXSTEP tool has been specially designed to perform analyses of the energy sector in the context of SDG 7 and NDC, with the aim that the output will provide a set of policy recommendations to achieve the SDG 7 and NDC targets.] This tool enables policymakers to make informed policy decisions to support the achievement of the SDG 7 targets as well as nationally determined contributions (NDCs). The initiative has been undertaken in response to the Ministerial Declaration of the Second Asian and Pacific Energy Forum (April 2018, Bangkok) and Commission Resolution 74/9, which endorsed its outcome. NEXSTEP also garnered the support of the Committee on Energy in its Second Session, with recommendations to expand the number of countries being supported by this tool.

The key objective of this SDG 7 Road Map[2] is to assist the Government of Kiribati to develop enabling policy measures to achieve the SDG 7 targets. This Road Map contains a matrix of technological options and enabling-policy measures for the Government of Kiribati to consider. It presents three scenarios (BAU, CPS and SDG scenarios) that have been developed using national data, 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 road map

In 2021, 90.8 per cent of Kiribati's population had access to electricity. However, only 35 per cent households were connected to grid electricity and 54.7 per cent had solar home systems that are used to operate only lights. These 54.7 per cent or 12,815 households need to be provided with grid quality electricity to enable them use electricity for more productive use. Universal access to clean cooking technology and fuel has been, and is likely to remain very low under the current policy scenario. It was 14.1 per cent in 2021, and estimated to increase to 65.5 per cent by 2030 in the current policy context. It remains a challenge for the country's 34.5 per cent of the population who will still rely on polluting cooking fuels and technology in 2030. Well-planned and concerted efforts will be needed to achieve universal access to clean cooking by 2030.

As an island nation, which is currently heavily reliant on imported energy resources, energy security is high on Kiribati's development agenda. Therefore, key aims of the country should include diversification of the power generation mix, with a focus on indigenous sources (i.e., solar and wind) and a reduction in the reliance on imported petroleum fuel. This aligns with the SDG7 target for renewable energy, as such a goal will require the share of renewable energy (RE) in the total final energy consumption (TFEC) to grow significantly from the 2021 share of 0.4 per cent (excluding traditional biomass).

Furthermore, energy efficiency improvement needs to be boosted across different sectors since energy intensity in Kiribati increased significantly from 6.8 MJ/US$_{2017}$ (GDP measured in constant terms at 2017 PPP) in 2010 to 8.4 MJ/US$_{2017}$ in 2021. It is suggested that the country adopts the global improvement rate of 3.4 per cent.

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

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

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

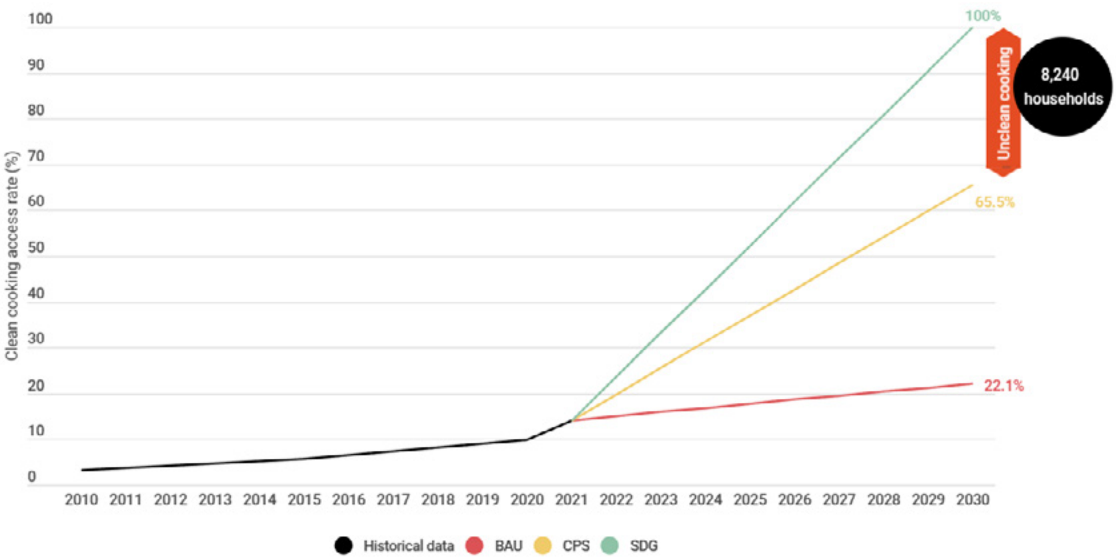
1. Universal access to electricity

Achieving universal access to electricity is a priority for the Government of Kiribati. The Kiribati Integrated Energy Roadmap (KIER) 2017-2025 (International Renewable Energy Agency, 2017) states the objective to reach a rate of 100 per cent by 2025. However, due to a slower rate of electrification since COVID-19, it is expected that the 100 per cent access rate will be achieved in 2030. The NEXSTEP analysis suggests that mini/off-grid systems technologies (i.e., solar mini-grid and solar home systems) would be the more appropriate technologies, based on the technology's cost-effectiveness and climate resiliency, while allowing faster implementation.

2. Universal access to clean cooking technology

Under the current policy setting, the clean cooking access is projected to reach only 65.5 per cent in 2030 from 14.1 per cent in 2021 (figure ES 1). This leaves more than one-third of households still relying on polluting solid fuel stoves (assuming biomass as the primary fuel) in 2030. This will expose the population to negative health impacts, including non-communicable diseases such as stroke, ischaemic heart disease, chronic obstructive pulmonary disease and lung cancer, particularly among women and children (World Health Organization, 2022a). In a worst-case business-as-usual (BAU) scenario, where the current implementation is being halted, the clean cooking access might be as low as 22.1 per cent.

Figure ES 1. Kiribati's access to clean cooking under the BAU, CPS and SDG scenarios[3]



NEXSTEP suggests that liquified petroleum gas (LPG) stoves and improved cooking stoves (ICS) may provide the better alternatives as long-term solutions. Considering a cleaner energy source, LPG stoves may be the most appropriate technology for some households. However, considering the lack of indigenous fossil fuel resources and domestic LPG production, ICS are a better option than LPG cooking stoves for Kiribati, as this reduces the reliance on imported fuels.

3. Renewable energy

The share of modern renewable energy (excluding traditional biomass usage in residential cooking) in the total final energy consumption (TFEC) was 0.4 per cent in 2021. Based on current policies, the

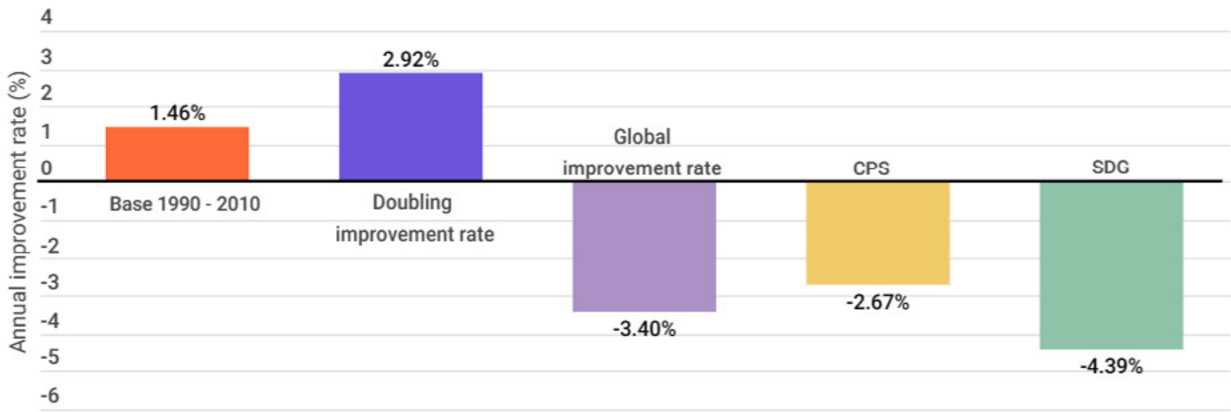
3 Historical trend projection based on the year 2000 access rate data provided by ESCAP (2022a) as well as the 2021 access rate provided by the national consultant.

share of renewable energy is projected to increase to 11.8 per cent by 2030. The increase is due to the projected increase in renewable electricity. In the SDG scenario, the share of renewable energy is projected to improve to 34.9 per cent of TFEC in 2030. The additional 23.1 percentage point increase can be attributed to the phasing out of traditional biomass usage as well as the application of several energy efficiency measures, which are projected to reduce TFEC by 6.7 ktoe, compared with the current policy settings.

4. Energy efficiency

A doubling of the 1990-2010 improvement rate is required to achieve the SDG 7.3 target. However, energy intensity in Kiribati increased at an average annual rate of 1.46 per cent from 5.1 MJ/US$$_{2017}$ in 1990 to 6.8 MJ/US$$_{2017}$ in 2020. The energy intensity increased further in 2021 at 8.4 MJ/US$$_{2017}$ due to the increasing energy demand and the contraction of GDP during the pandemic. It is, therefore, suggested that Kiribati follow the global improvement rate of 3.4 per cent (figure ES 2).

Figure ES 2. Kiribati energy efficiency target



Source: Calculated based on data from the Asia-Pacific Energy Portal (ESCAP, 2022a).

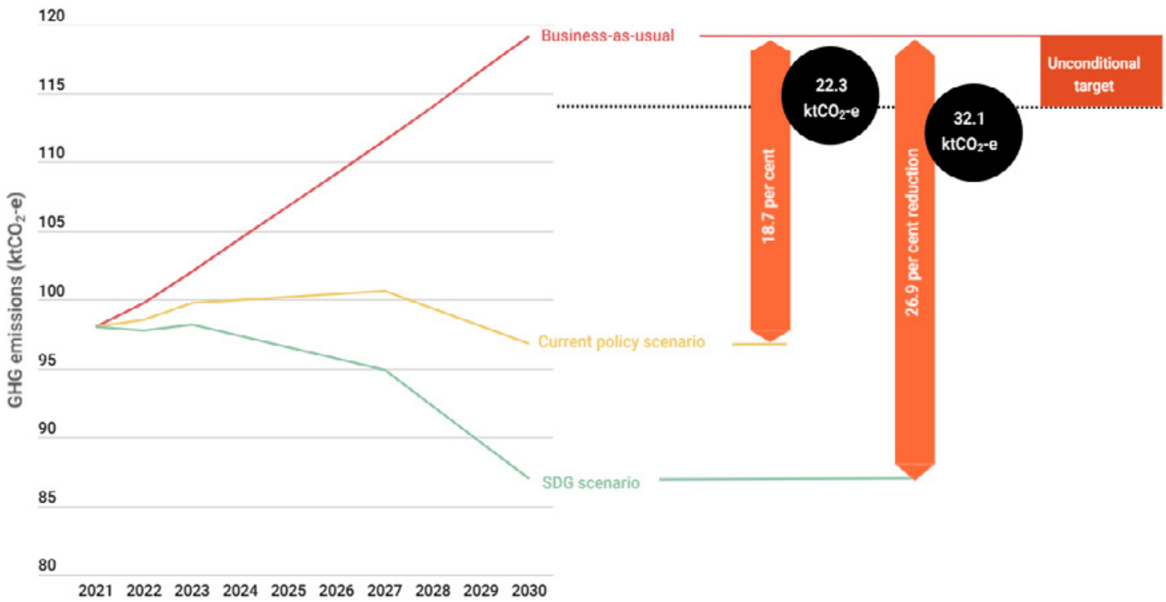
Under the current policy settings, the energy intensity is projected to drop to 6.6 MJ/USD$_{2017}$. The energy efficiency target is met under the SDG scenario, reaching 5.6 MJ/$_{2017}$ by 2030. This is primarily due to the phase-out of inefficient cooking technologies and replacement with more efficient LPG stoves and ICS. In addition, further energy intensity reduction can be realised through the additional proposed measures for residential and transport sectors. Increasing the adoption of minimum energy performance standards and labelling (MEPSL) for lighting, refrigeration and air-conditioning as well as introducing electric vehicles for government ministries can be a viable solution for Kiribati to reduce the energy demand.

5. Nationally determined contribution

Kiribati's intended nationally determined contribution (Government of Kiribati, 2016) sets ambitious targets to reduce greenhouse gas (GHG) emissions by 13.7 per cent by 2025 and by 12.8 by 2030 compared to a BAU scenario. Subject to international assistance, Kiribati aims to reduce its emissions by 61.8 per cent by 2030.

Using the energy sector emissions projection for 2030 from the INDC document, the unconditional and conditional targets for the energy sector are estimated to be 3.8 per cent and 52.8 per cent, respectively. Figure ES 3 shows that this reduction in emissions is set to be achieved through an improved energy mix and green transportation. The unconditional NDC target is met in CPS and SDG scenarios while the conditional NDC target is met in the towards net zero (TNZ) scenario.

Figure ES 3. Comparison of emissions, by scenario, 2021-2030



C. Important policy directions

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

(1) **Strong policy measures are required to address the large gap in clean cooking by 2030** Achieving Achieving access to clean cooking fuels and technologies seems to be one of the biggest challenges for Kiribati. Adoption of LPG stoves and ICS in both urban and rural areas will significantly help to improve clean cooking access. In the long term, electric cooking stoves can be considered when their price becomes more affordable. The cost of deployment of LPG would require US$ 1.74 million, whereas the deployment of ICS would need US$ 0.79 million. Therefore, the total cost of clean cooking access would be US$ 2.53 million by 2030.

(2) **Increasing the efficiency of energy use in all economic sectors should be pursued.** The residential sector is the highest energy-consuming sector in Kiribati. Therefore, the adoption of MEPSL for lighting and refrigeration can be considered. Doubling the MEPS adoption rate from 30 per cent to 60 per cent and introducing MEPSL for electric fans and television in the residential sector can be implemented to achieve a more sustainable target, with an energy saving potential of 0.27 ktoe, and reduce emissions by 2.4 $ktCO_{2-e}$. The commercial and industrial sectors would have significant emission reduction potential through the improvement in cooling systems by 0.15 $ktCO_{2-e}$.

(3) **Energy efficiency and electric vehicle strategies provide multi-fold benefits in the long term.** The transport sector would have potential savings through fuel economy improvement for both passenger cars and motorcycles as well as introducing electric vehicles for government ministries while simultaneously encouraging the use of public transportation. Furthermore, routine maintenance and inspection for maritime transport will be beneficial to improve energy efficiency. Total energy saving potential in the transport sector will be 1.8 ktoe with 5.3 $ktCO_{2-e}$ of emission reduction. These measures can be coupled with adoption of electric vehicles to reduce the demand for oil products, hence reducing Kiribati's reliance on imported petroleum fuels. At the same time, it can contribute to climate mitigation and improve local air quality. An adoption rate of 5 per cent for passenger cars by 2030 can be introduced as a starting point in Kiribati, particularly on government fleets.

(4) **Increasing renewable in the power supply provides the highest potential in GHG emission reduction as well as improves energy security.** A projected decrease in grid emissions due to the implementation of renewable energy can realise a substantial GHG emission reduction. The deployment of solar PV system (ground, floating, and rooftop) will help to improve energy security through the utilization of indigenous resources.

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 a sustained economic growth, respond to increasing energy demand, reduce emissions as well as consider and capitalise on the interlinkages between SDG 7 and other SDGs. In this connection, the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) has developed the National Expert SDG Tool for Energy Planning (NEXSTEP). This tool enables policymakers to make informed policy decisions to support the achievement of the SDG 7 targets as well as nationally determined contributions (NDCs) emission reduction targets. The initiative has been undertaken in response to the Ministerial Declaration of the Second Asian and Pacific Energy Forum (April 2018, Bangkok) and Commission Resolution 74/9 which endorsed the meeting's outcome. NEXSTEP also garnered the support of the Committee on Energy in its Second Session, with recommendations to expand the number of countries being supported by this tool. The ministerial declaration advises ESCAP to support its member States, upon request, in developing national SDG 7 Road Maps.

7 AFFORDABLE AND CLEAN ENERGY

1.2. SDG 7 targets and indicators

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

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

In addition to the above-mentioned targets, the SDG 7 goal also includes target 7.A – promote access, technology and investments in clean energy, and target 7.B – expand and upgrade energy services for developing countries. These targets are not within the scope of NEXSTEP.

1.3. Nationally Determined Contribution

Nationally Determined Contributions (NDCs) represent pledges by each country to reduce national emissions and are the stepping-stones to the implementation of the Paris Agreement. Since the energy sector is the largest contributor to GHG emissions in most countries, decarbonizing energy systems should be given a high priority. Key approaches to reducing emissions from the energy sector include increasing renewable energy in the generation mix and improving energy efficiency.

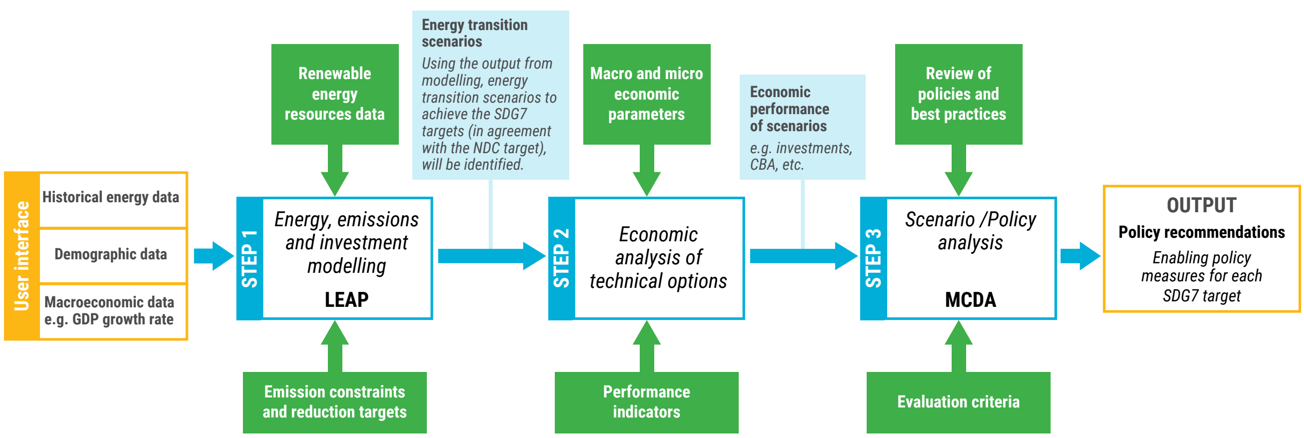
Kiribati's (intended) NDC sets an economic-wide conditional target of an overall 62.5 per cent and 61.8 per cent reduction below BAU by 2025 and 2030 respectively, with: (a) a 13.7 per cent reduction by 2025 and 12.8 per cent reduction by 2030 using the country's own resources (known as unconditional target); and (b) an additional 48.8 per cent by 2025 and 49 per cent by 2030 subject to international financial support (known as conditional target).

The 12.8 per cent of unconditional reduction in emissions is set to be achieved by renewable energy utilization (3.8 per cent) and mangrove forest enhancement (9 per cent). The additional 49 per cent of conditional reduction comes from additional implementation of renewable energy generation and energy efficient technologies (16.6 per cent) as well as the utilization of biofuels for electricity (16.4 per cent) and transport (16 per cent).

1.4. NEXSTEP methodology

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

Figure 1. Different components of the NEXSTEP methodology



1.4.1. Energy and emissions modelling

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

1.4.2. Economic analysis

The second step builds on the selection of appropriate technologies through an economic optimisation process which identifies the least-cost energy supply options for the country. A comparative assessment of selected power generation technologies is done using the

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

1.4.3. Scenario analysis

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

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

This step is performed using the NEXSTEP online portal[4] as a means to suggest the best way forward for the countries by prioritizing the scenarios. Stakeholders can update this scenario ranking using a different set of criteria and their weights. The top-ranked scenario from the MCDA process is used to inform the Government on the best possible energy transition pathway for the country.

4 Available at https://nexstepenergy.org/

2. Country overview

2.1. Demographic and macro-economic profile

Geography and climate: Kiribati is located in the centre of the Pacific Ocean astride the International Date Line and the equator. The country covers around 3.5 million km² of sea surface and a total of 811 km^2 of land area. Kiribati comprises of three groups of Islands, namely Gilbert, Line, and Phoenix islands. The Gilbert group lies in the western-most area of Kiribati and consists of a chain of 17 inhabited atoll islands including the capital island, South Tarawa. The Line group consists of three inhabited atolls including Kiritimati Island, which is the main administration island for the group. The Phoenix group, including the only inhabited Kanton Island, is situated between the Gilbert and the Line groups.

Situated very close to the equator, Kiribati has a hot and humid tropical climate with an average air temperature of 28.3°C and average rainfall of about 2,100 mm annually in Tarawa. Across Kiribati, the average temperature is relatively constant year-round, and the country faces the impacts of both El Niño (dry season) and La Niña (wet season) events. Kiribati communities are experiencing the rising of temperatures, declining coastal fishery stocks, and increasing intensity and frequency of storm and coastal inundation because of climate change (Sailing for Sustainability (Fiji); GH Sustainability, 2021).

Population and economy: In 2021, the country had a population of 121,388 people (World Bank, 2022a), with an average of 6 persons per household, which amounted to an estimated 20,679 households. The annual population growth rate is around 1.63 per cent. The urbanization rate in 2021 was 56.4 per cent, which is projected to grow to 64.3 per cent in 2030.

Kiribati's GDP in 2021 was estimated at US$ 180 million with a GDP growth rate of 2.27 per cent.

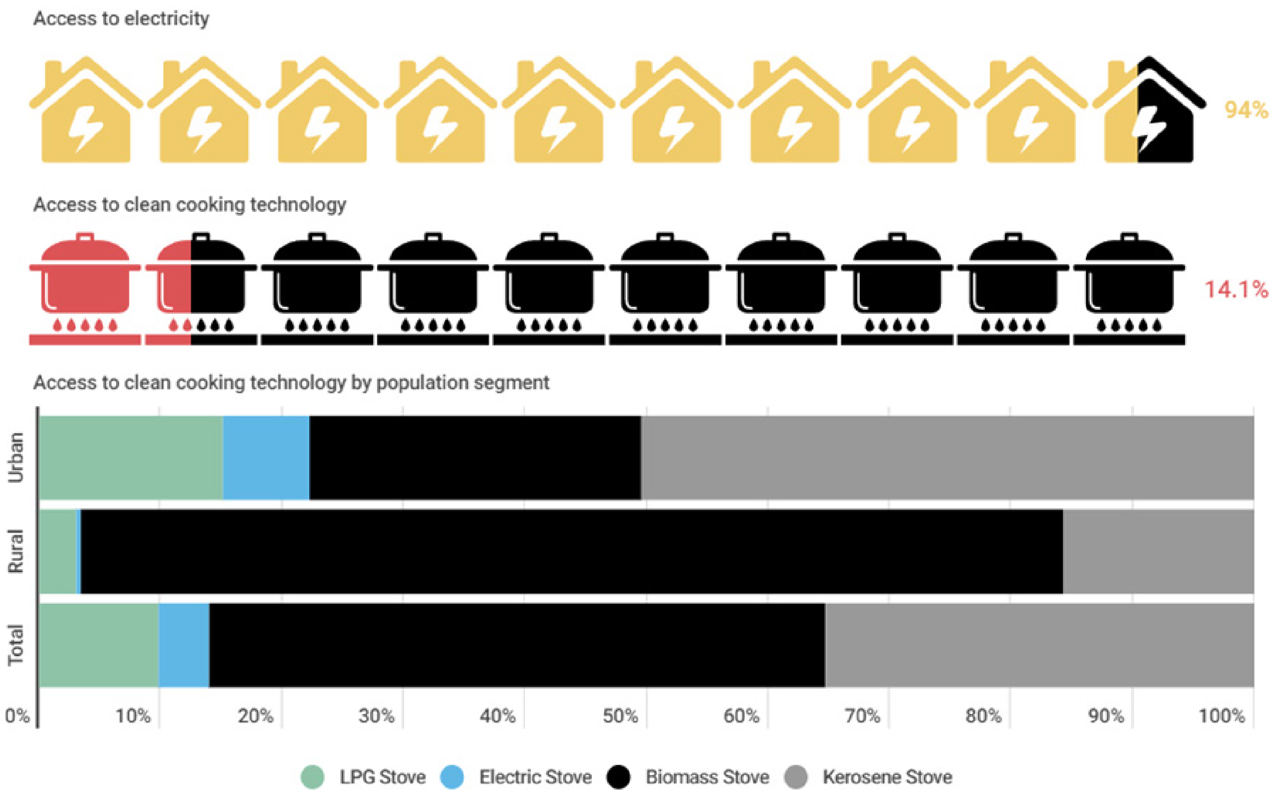
Kiribati is classified as a lower-middle income economy (World Bank, 2022b) with GDP per capita was US$ 1,483 in 2021. Like other countries in the world, Kiribati's economy has been impacted by COVID-19.

2.2. Energy sector overview

2.2.1. National energy profile

The electrification rate in Kiribati was 94 per cent in 2021. However, the clean cooking access rate was estimated at only 14.1 per cent. The remaining 85.9 per cent of the population, which corresponds to 17,771 households, still relied on unclean and polluting kerosene and biomass stoves as their primary cooking technology. Overall, liquefied petroleum gas (LPG) stoves were the most dominant primary clean cooking technology, with an estimated share of 9.9 per cent. This was followed by electric cooking stoves, which were estimated at 4.2 per cent (figure 2).

Figure 2. Electricity and clean cooking access share



The following details describe the estimated national energy consumption using data[5] collected with a bottom-up approach, such as activity level and energy intensity for the different sectors. The bottom-up estimation is generally in agreement with the national energy statistics in terms of total energy supply and total final energy consumption by fuel type. Energy balance data is currently only available for the Gilbert Island Group. In the absence of real data from Line and Phoenix islands, NEXSTEP applied a 10 per cent increase, in accordance with the population distribution, to the data points in the energy balance to estimate the national level data.

In 2021, the TFEC was 44.1 ktoe (figure 2). Most of the demand came from the residential sector (52.8 per cent) of which 92.7 per cent of energy was consumed for cooking purposes. Such a high share of residential cooking energy demand was

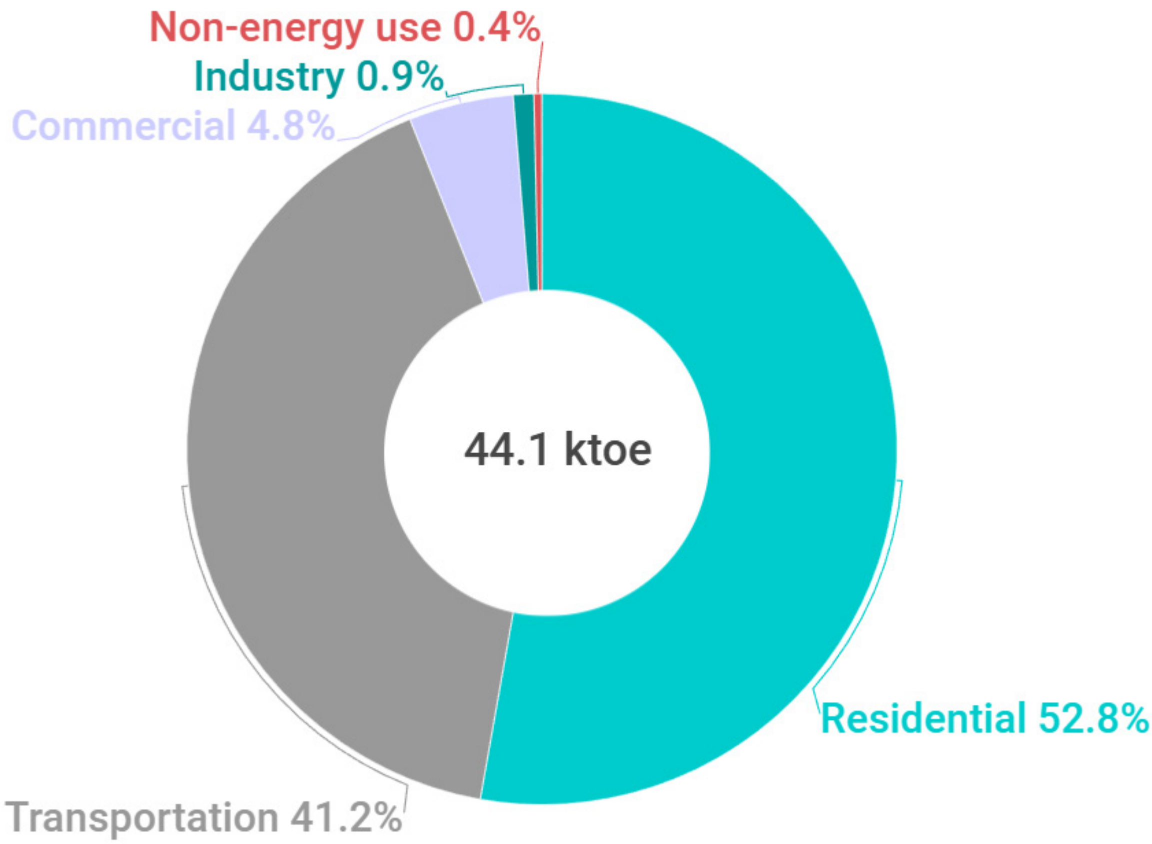
5 National data compiled by Ministry of Infrastructure and Sustainable Energy with reference to publicly available sources.

attributable to the widespread use of kerosene and inefficient traditional biomass fuels. In terms of electricity usage, 34.8 per cent was for refrigeration, 33.4 per cent was for lighting, 10.9 per cent was for cooking appliances, 5.2 per cent for electric fans, 4.1 per cent for television/video, and the remaining was for other appliances (stereo, computer, washing machine etc.).

The second largest energy-consuming sector is the transport sector, estimated at 41.2 per cent. Within the transport sector, 50 per cent of energy was consumed by marine transport (including fishing boats) and 43.5 per cent by road transport. The remaining went to the aviation sector.

The commercial sector stood in the third position (4.8 per cent) and was followed by the industry sector (0.9 per cent) and the non-energy use (0.5 per cent). Under NEXSTEP methodology, government buildings are categorized under commercial buildings since the energy intensity calculation is based on the floorspace area. In the commercial sector, private businesses accounted for 38.8 per cent of the energy demand followed by government buildings (25 per cent) and community services buildings (20.7 per cent). Hotels and restaurants, educational institutions and religious places consumed 8.6 per cent, 2.9 per cent and 3.9 per cent of commercial energy demand, respectively.

Figure 3. Total final energy consumption by sector in 2021



In terms of fuel usage in TFEC, biomass contributed the highest amount (45.6 per cent) followed by oil products. Oil products (including petroleum, diesel and crude oil) made up around 48.6 per cent of TFEC. The transport sector, which operated predominantly with internal combustion engine vehicles, was the main consuming sector for oil products. Other fuel use included electricity (5.9 per cent).

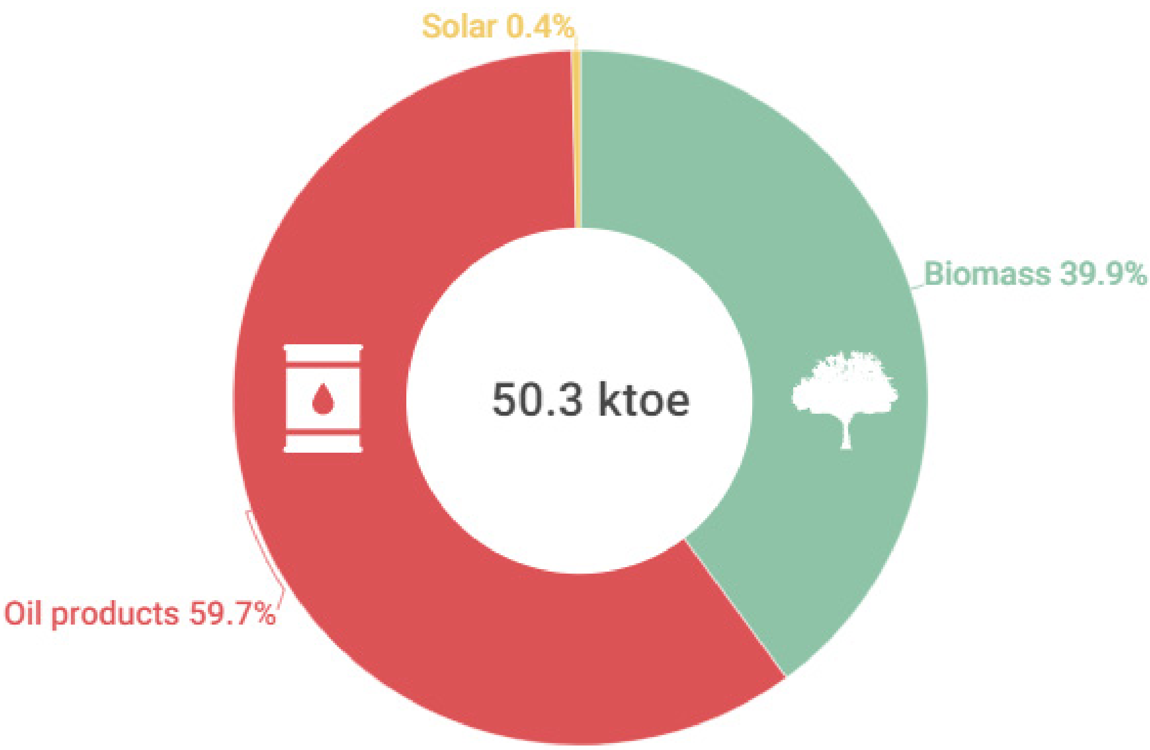
Modern renewable energy delivered approximately 46 per cent of TFEC in 2021. This includes traditional biomass usage in residential cooking, which corresponds to an estimated 20.1 ktoe (45.6

per cent of TFEC). If the traditional biomass was excluded, the renewable share was 0.4 per cent of TFEC. While endowed with an abundance of solar power potential, of which the installed solar power capacity contributed around 14 per cent of the total electricity produced in 2021, Kiribati has a high reliance on imported fuels (i.e., oil products) to meet its stationary and mobile fuel demands.

A doubling of the 1990-2010 improvement rate is required to achieve the SDG 7.3 target. However, energy intensity in Kiribati increased at an average annual rate of 1.46 per cent from 5.07 MJ/US$$_{2017}$ in 1990 to 6.77 MJ/US$$_{2017}$ in 2010. It is suggested that Kiribati follow the global improvement rate of 3.2 per cent.

Energy intensity in 2021 was calculated as 8.37 MJ/US$$_{2017}$. A significant increase in the energy intensity happens due to the increasing energy demand, the reduction of GDP during the pandemic and the additional 10 per cent calculation increase in the energy demand for the national level data. Total primary energy supply in 2021 was 50.3 ktoe. As shown in figure 4, biomass supplied the most energy, mainly in the residential sector for cooking. The energy supply mix was as follows: biomass, 39.9 per cent; oil products, 59.7 per cent; and solar, 0.4 per cent. Therefore, the indigenous production was around 40.3 per cent.

Figure 4. Total primary energy supply by fuel type in 2021



The total installed electrical generation capacity in 2021 was 9.2 MW. Total electricity generation was 34.97 GWh, comprising 92.7 per cent diesel generation and 7.3 per cent solar PV.

The energy sector emissions, from the combustion of fossil fuel, were calculated based on IPCC Tier 1 emission factors assigned in the LEAP model and expressed in terms of 100-year global warming potential (GWP) values. GHG emissions from the energy sector were estimated at 98 $ktCO_{2-e}$ in 2021. Emissions from the transport sector were the largest at 53.9 $ktCO_{2-e}$ arising from direct fuel combustions in internal combustion engines. The residential sector accounted for 14.2 $ktCO_{2-e}$ coming from solid fuel combustions for cooking. The total emissions attributable to electricity generation were estimated at 26.1 $ktCO_{2-e}$.

2.2.2. National energy policies, plans, strategies and institutions

The governance of Kiribati's energy sector is carried out by the Cabinet of Ministers and various government agencies. These include the Ministry of Infrastructure and Sustainable Energy (MISE), which is responsible for the planning, management and coordination of the energy sector. According to Energy Act 2022 (Government of Kiribati, 2022), the Energy Planning Division (EPD) has responsibilities in developing energy sector policies, performing planning and management functions, conducting monitoring, supervisory and regulatory functions to ensure that the implementation of the policy, promoting and facilitating energy efficiency, and providing advice and assistance on all energy-related matters and activities to the Minister. The Public Utilities Board (PUB) is a state-owned enterprise (SOE) responsible for provision of power, water supply and sewage services for South Tarawa. The Kiribati Green Energy Solution (KGES) is an SOE responsible for the provision of solar off-grid services in the rural areas. The Kiribati Oil Company (KOIL) is an SOE responsible for the importation and distribution of petroleum products throughout Kiribati. The Ministry of Line and Phoenix Islands Development (MLPID) is responsible for the electricity utility service on the Line and Phoenix Island groups.

Kiribati's energy sector development is guided by several national policies and articles of legislation. These have been used as guiding references for the NEXSTEP modelling in order to better understand the country context and to develop recommendations in adherence to the Government's overarching direction. Where applicable, the currently implemented and adopted policies or regulations are considered in the current policy scenario, in order to identify gaps in achieving the SDG 7 targets.[6] The key policies and strategic documents consulted are detailed below.

- **Kiribati National Energy Policy 2009** (Government of Kiribati, 2009) The Vision of the Kiribati National Energy Policy is "available, accessible, reliable, affordable, clean and sustainable energy options for the enhancement of economic growth and improvement of livelihoods in Kiribati". It aims to provide a general policy that satisfies the need to have a single comprehensive and balanced document to administer all energy and energy-related activities. More importantly, it provides a predictable and explicit framework within which public and private energy sector participants can make informed planning and investment decisions to manage their operations.
- **The Kiribati Joint Implementation Plan for Climate Change and Disaster Risk Management (KJIP) 2014-2023** (Government of Kiribati, 2014). aims to increase resilience through sustainable climate change adaptation and disaster risk reduction, using a whole of country approach including promoting the use of sustainable and renewable sources of energy and energy efficiency. One of the targets is that rural household access to clean and adequate lighting reaches 100 per cent.
- **Kiribati Visions for 20 years** (Government of Kiribati, 2016). is the long-term development blueprint of the country for the 2016-2036 period. The document sets out national priorities for action in the key areas, including energy, environmental and climate change issues. It calls for the development of sustainable energy resources to achieve self-sufficiency in energy supply and reduce the country's dependence on fossil fuel imports. The short-term implementation of the blueprint is presented in the Kiribati Development Plan 2020-2023.
- **Kiribati Development Plan 2020-2023** (Government of Kiribati, 2021) is the second development plan presented by the Government of Kiribati, to implement the Kiribati 20-year Vision, KV20. There are six key policies areas (KPAs): (i) harnessing human wealth; (ii) growing economic wealth and leaving no one behind; (iii) improving health; (iv) protecting and managing environment, and strengthening resilience; (v) good governance; and (vi) developing infrastructure.
- **Kiribati Cooking for Life Strategy** (Ministry of Works and Public Utilities, 2014). seeks to

6 Only policies with concrete measures are considered in the scenario modelling for the current policy scenario. plan/strategy policy documents without concrete measures enforced are not considered but are compared with scenario result findings in the "Revisiting Existing Policies" chapter.

capture 75 per cent of households in urban centres have access to modern sources of energy for cooking (LPG stoves) and have the remaining households use ICS for cooking.

- **Kiribati Integrated Energy Roadmap (KIER) 2017-2025** (International Renewable Energy Agency, 2017) is a medium-term strategy document prepared by International Renewable Energy Agency that sets targets for renewable and efficient energy to reduce fossil fuel consumption, and identifies specific activities and investments that are necessary to achieve these targets. By 2025, the Government plans to reduce fossil fuel consumption by 23 per cent in South Tarawa, 40 per cent on Kiritimati Island and 40 per cent in the outer islands by deploying more renewable energy generation. In addition, the Government plans to reduce fossil fuel usage (by 22 per cent on South Tarawa, 20 per cent on Kiritimati Island and 20 per cent on the outer islands) through the uptake of energy efficiency measures.
- **Kiribati's intended Nationally Determined Contribution (NDC)** (Government of Kiribati, 2016) sets ambitious targets to reduce greenhouse gas (GHG) emissions by 13.7 per cent by 2025 and by 12.8 per cent by 2030 compared to a BAU scenario. Subject to international assistance, Kiribati has the potential to reduce its emissions by more than 60 per cent (61.8 per cent) by 2030. To achieve these targets, the Government is promoting the maximum use of EE and RE technologies in public and private infrastructure, along with using coconut oil (CNO) as biodiesel for electricity generation and transport.
- **Energy Act 2022** (Government of Kiribati, 2022) sets legal and regulatory framework and institutional structure of the energy sector to establish more effective planning, coordination, and management of the energy sector. The act also facilitates the introduction of modern technologies, investment in sustainable renewable energy, electrification of outer Island, as well as establishment of minimum energy performance standards and labelling.

2.2.3. National energy resources and potentials

Kiribati depends on indigenous resources and energy imports to meet its energy needs. The technical potential for renewable energy in Kiribati is high, but its development and deployment has been limited because of several barriers.

Kiribati has substantial experience with solar PV technology. There are plans to further increase solar PV deployment within the next few years, but studies must be conducted to understand and ensure system reliability at high levels of renewable energy penetration. The technical potential for ground-mounted solar PV in South Tarawa is around 69.7 MW while the one in Kiritimati is around 482 MW. Roof-mounted solar also has potential and, in South Tarawa in particular, addresses concerns about land use. The theoretical potential for solar rooftop deployment was estimated at 2.5 acres/MW (Government of Kiribati, 2018)

No huge wind energy generation has been developed in Kiribati except for a small wind turbine below 5kW used by private owners, with their performance unknown. There are also some wind turbines in Kiritimati Island to power the water supply in the island. Based on wind speed data collected at 34 metres, the average wind speed in London (Kiritimati Island) is 6.7 m/s, and 6.6 m/s in Banana (Kiritimati Island). The average wind speed at 34 metres in South Tarawa is 5.7 m/s (Government of Kiribati, 2018).

Except for traditional biomass use for cooking and copra drying, there has been no development of biomass or biogas for energy production. There has been a recent feasibility study into the use of coconut oil (CNO) on Kiritimati Island. By using both CNO and other renewable energy sources such as wind and solar, Kiritimati Island could be powered by 100 per cent renewable energy. The Line Islands produce approximately 1,500 tons of copra per annum, equivalent to approximately 750,000 litres of diesel fuel. PUB has also indicated a strong interest in CNO for electricity generation with little risk to generator engines. However, with the huge, subsidized prize for copra, this will halt biofuel industry development in Kiribati.

A 1 MW Ocean Thermal Energy Conversion (OTEC) plant is planned for deployment in Kiribati in 2020. The Memorandum of Understanding (MoU) and Power Purchase Agreement (PPA) was signed between the Kiribati and Republic of Korea Governments initiating for this OTEC development in South Tarawa. The Korea Research Institute of Ships and Ocean Engineering (KRISO), supported by the Ministry of Ocean and Fisheries of Republic of Korea, started manufacturing the core components of the 1 MW OTEC plant and completed them in mid-2019. The original plan was to build an OTEC plant building (table 1) at the secured site in Bikenibeu after the basic survey in 2020. However, due to COVID-19 and limited financial resources, the project has been halted.

Table 1. **SWOT analysis of renewable energy resources in Kiribati**

	Strength	Weakness	Opportunites	Threats
Solar energy	- Abundant resource availability - Potential to deliver sustainable electricity	- Lack of financial mechanism - Grid instability	- Huge potential to meet the supply and demand gap - Reduction in GHG emissions	- High capital cost - High-cost for importing the components
Wind energy	- Widely distributed potential in Kiritimati	- Grid instability	- Windy areas have an opportunity to install wind farm in Kiritimati	- High capital cost
Biomass energy	- Availability of energy crops	- Huge subsidized prize for copra	- Opportunity to retrofit old thermal power plant	- Difficult to establish a suitable energy market
Ocean Thermal Energy Conversion	- Vast area of ocean	- Lack of expertise - Lack of funding	- Environmentally-friendly	- High capital cost - Limited commercial application

3. Modelling assumptions

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

3.1. Scenario definitions

NEXSTEP is designed for scenario analysis, using the LEAP modelling system to enable energy specialists to model energy system evolution based on current energy policies. The baseline year 2021 was chosen, as it is the most recent year with sufficient data information for modelling. In the NEXSTEP model for Kiribati, four scenarios have been modelled. These include three core scenarios: (a) BAU scenario; (b) current policy scenario (CPS); and (c) SDG scenario. In addition, one ambitious scenario has been developed: (d) towards net zero by 2050 scenario.

3.1.1. BAU scenario

This scenario follows historical demand trends, based on growth projections, such as using GDP and population growth. It does not consider the emission limits or renewable energy targets set out in policy and legislation. For each sector, the final energy demand is met by a fuel mix reflecting the current shares in TFEC, with the trend extrapolated to 2030. Essentially, this scenario aims to indicate what will happen if enabling policies are not implemented or the existing policies fail to achieve their intended outcomes. The main purpose of this scenario is to be able to compare the emissions trend with the baseline and estimate the emissions reduction target.

3.1.2. Current policies scenario

Inherited from the BAU scenario, this scenario considers initiatives implemented or scheduled to be implemented during the analysis period of 2021-2030. These are, for example, the power development plan and energy efficiency programmes. Otherwise, the energy intensities from different demand sectors are assumed constant throughout the analysis period, with demand growth as detailed in Annex II. Only policies with concrete measures are considered in the scenario modelling for the current policy scenario. Plan/strategy/policy documents without concrete measures enforced are not considered but are compared with scenario result findings later in this Road Map.

3.1.3. SDG scenario

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

3.1.4. Ambitious scenario

Like the SDG scenario, the ambitious scenario aims to achieve the SDG 7 targets. In addition, these scenarios also 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 by further improving its energy efficiency beyond the SDG 7.3 target and meeting its conditional NDC target.

Further analysis shows that there are ample opportunities for Kiribati to raise its ambition beyond just achieving the SDG 7 targets. More can be done from a whole-economy perspective for Kiribati to decarbonize its energy system and achieve a higher energy efficiency improvement rate. For example, additional energy efficiency measures can substantially increase energy savings and reduce fuel imports.

3.2. Assumptions

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

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

Parameters	Business as usual scenario	Current policy scenario	Sustainable Development Goal scenario
Economic growth	2.27 per cent per annum		
Population growth	1.63 per cent per annum		
Urbanization rate	56.4 per cent in 2021, growing to 64.3 per cent in 2030[7]		
Commercial floor space	Assumed annual energy consumption increasing at the same growth as GDP		
Industrial activity	Assumed annual energy consumption increasing at the same growth as GDP		
Transport activity	Passenger transport activities and freight transport activities are assumed to grow at a rate like the growth in GDP per capita		
Residential activity	The appliance ownership for electrical appliances is projected to grow at a rate like the growth in GDP per capita.		
Access to electricity	100 per cent access to electricity in the rural area can be achieved in 2025.		
Access to clean cooking fuels	Projected based on the historical penetration rate between the 2000-2020 period. Clean cooking access rate is projected to reach 22.1 per cent in 2030.	Projected based on the governmental measures under Kiribati's cooking for life strategy. The clean cooking access rate is projected to reach 65.5 per cent in 2030.	100 per cent clean cooking access rate through the promotion of LPG stoves and ICS.
Energy efficiency	Additional energy efficiency measures not applied	Improvement based on current policies, including the one in the KIER 2017 - 2025	Global improvement in energy intensity adopted
Power plant	Considers 2021 RE share in power generation and grid emissions	Considers capacity expansion in accordance with the South Tarawa Renewable Energy Project (STREP)	

7 This assumes that the urbanisation rate grows with an annual rate of 1.46 per cent, with reference to the national historical urbanisation growth from 2010 to 2020.

4. Energy transition outlook in the current policy scenario

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

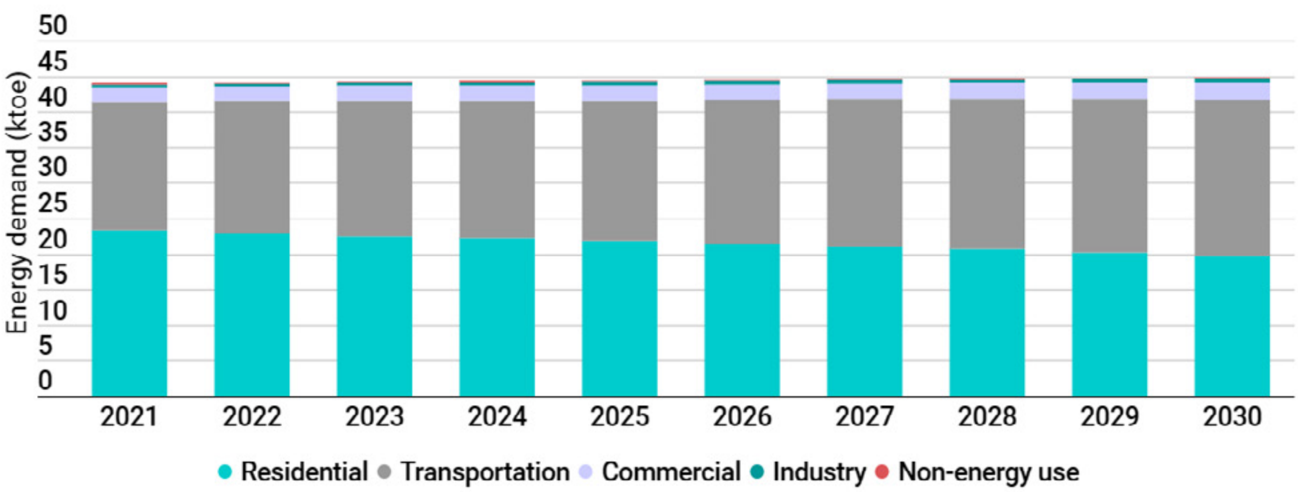
4.1. Demand

The CP scenario considers policy measures that have come into force or already have a concrete implementation timeline within the analysis period.[8] Otherwise, the energy intensities from the different demand sectors are assumed constant throughout the analysis period, with demand growth as detailed in table 1. The following policies have been considered.

- **Access to electricity:** Kiribati Integrated Energy Roadmap (KIER) 2017-2025 (International Renewable Energy Agency, 2017) states the objective to reach a rate of 100 per cent by 2025.
- **Clean cooking:** Kiribati Cooking for Life Strategy seeks to capture 75 per cent of households in urban centres having access to modern sources of energy for cooking (LPG stoves) and the remaining households use ICS for cooking by 2020. However, this target is extended up to 2025 under the KIER document.
- **Energy efficiency:** Kiribati Integrated Energy Roadmap (KIER) 2017-2025 (International Renewable Energy Agency, 2017) sets targets for energy efficiency to reduce fossil fuel consumption in the residential, commercial and industry sectors.
- **Power generation:** Currently, the South Tarawa Renewable Energy Project (STREP) with a capacity of Solar PV 5,000 kWp is under construction and will be connected to the South Tarawa grid by 2023. STREP will allow the South Tarawa grid to achieve 26 per cent renewable energy penetration, higher than the Kiribati Integrated Energy Roadmap (KIER) target for South Tarawa, which is 23 per cent renewable penetration by 2025.

Under the current policy setting, the demand for total final energy is expected to increase from 44.1 ktoe in 2021 to 44.8 ktoe in 2030, an average annual growth rate 0.2 per cent. The 5 ktoe reduction in energy demand compared to the BAU scenario is due to the adoption of energy efficiency measures in the residential, industry and commercial sectors. In 2030, the transport sector consumption will be, by far, still the largest at 49.1 per cent, followed by the residential sector 43.9 per cent, the commercial sector 5.5 per cent and the industrial sector 1.1 per cent. Figure 5 shows the forecast of TFEC by sector under the CP scenario. The sectoral energy efficiency measures are described further below.

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



8 Only policies with concrete and implemented measures are considered in the scenario modelling for the current policy scenario. To further explain, measures mentioned in strategy policy or planning documents that are yet to be enforced or implemented prior to December 2022 are not considered in the modelling of the current policy scenario.

4.1.1. Transport sector

Under the current policy setting, the transport sector will continue to dominate Kiribati's TFEC, with a 49.1 per cent share in 2030. The transport sector will consume 22 ktoe, an annual growth of 2.2 per cent, up from 18.1 ktoe in 2021. Kiribati's transport sector consists of land transport, maritime transport and aviation. Marine transport will consume 50.5 per cent of the energy requirement in the transport sector followed by land transport at 43.9 per cent.

Among the maritime transport categories in 2030, big passenger boats/ferries will consume the most at 5.3 ktoe (47.2 per cent), followed by fishing boats and small passenger boats (33 per cent), freight cargos/barges (18.1 per cent) as well as landing craft (1.8 per cent). Among the land vehicle categories in 2030, motorcycles will consume 3.3 ktoe, followed by private cars at 0.9 ktoe, buses and minibuses at 0.7 ktoe, and freight trucks/vans at 4.8 ktoe.

The Government of Kiribati has set strategies under the KIER to develop efficient lagoon and sea public transportation for nearby islands to South Tarawa (North Tarawa, Abaiang and Maiana) as well as to use transport fuel efficiently for the government sector. However, no specific technical details have been provided in the documents.

4.1.2. Residential sector

The residential sector will consume 19.7 ktoe, an annual growth of -1.8 per cent, down from 23.3 ktoe in 2021. The urban and rural split of energy consumption would be 29 per cent and 71 per cent, respectively. In terms of fuel, biomass will be the main energy source at just around 83 per cent, followed by oil products at 8.4 per cent and electricity at 8.6 per cent. Biomass and oil products are used mainly for cooking purposes. Electricity will be used mainly for refrigeration (35.2 per cent) and lighting (32.6 per cent), while the remainder will be used for televisions/videos, stereo, electric fans, washing machines, computers etc.

In the building sector, the Government targeted a total saving of up to 579 MWh (49.8 toe) by 2025 through the replacement of inefficient lighting (202 MWh/17.4 toe) and refrigerators/freezers (377 MWh/32.4 toe). Lighting Improvement Programmes covering replacement of inefficient incandescent lights with efficient light bulbs such as compact fluorescent lamps (CFLs) and LEDS. It requires awareness-raising for the general population. Kiribati participates in the Pacific Appliance Labelling and Standards (PALS) project implemented regionally by the Pacific Community. This mandates the use of more efficient electric appliances (e.g., freezers and refrigerators) through minimum energy performance standards and energy rating labels.

4.1.3. Industrial sector

In the CPS, the industrial sector will consume only 0.47 ktoe in 2030, an annual growth of 1.4 per cent, up from 0.41 ktoe in 2021. Within the industrial sector, 31.9 per cent of energy consumption will be by Kiribati Fishing Limited (KFL) and 50.7 per cent by Kiribati Copra Mill. Cenpac Producer Limited will account for 5.8 per cent of industrial energy use while the remainder will be used by Betio Shipyard, the Plant Vehicle Unit, Air Kiribati Limited and Kiribati Oil. In the industrial sector, the Government has targeted a total saving up to 20 per cent to be achieved in 2025 by improving the cooling loads.

4.1.4. Commercial sector

Total energy consumption in the commercial sector (including government buildings) under the CPS will increase from 2.1 ktoe in 2021, at an average annual growth of 1.8 per cent, to 2.5 ktoe in 2030. Private businesses, hotels and restaurants will account a total of 47.2 per cent of the energy demand followed by government buildings (24.9 per cent) and community service buildings (21.2 per cent). Under NEXSTEP methodology, government buildings are included in the commercial category. Worship centres and educational institutions will account for 3.9 per cent and 2.9 per cent of commercial's energy demand, respectively.

The Government of Kiribati in 2022 has also planned to save up to 857 MWh (73 toe) in the commercial sector (besides government buildings) through the replacement of inefficient lighting, AC and refrigerators[9] as well as through

9 Since the Energy Act had recently assented, the MEPS initiative will soon be implemented. The MEPSL regulation draft is now under review by PCREEE team. The enforcement of this regulation is anticipated to commence in August 2023.

the implementation of energy audit.[10] A proper walk-through energy audit is required to collect baseline information on energy consumption in commercial buildings. The building permits approval process should include energy efficiency measures in commercial buildings[11].

Table 3. Energy efficiency measures – CP scenario compared to the BAU Scenario by 2025 and 2030

Sector	Measure	2025		2030	
		Energy demand reduction (toe)	GHG emission reduction (tCO_{2-e})*	Energy demand reduction (toe)	GHG emission reduction (tCO_{2-e})*
Residential – cooking	Adoption of 75 per cent LPG in the urban households while the remaining urban using ICS by 2025 (Ministry of Works and Public Utilities, 2014)	1,824	1,310	4,784	4,436
Residential – MEPS lighting	Replacement of inefficient lighting in 2815 households by 2025 (International Renewable Energy Agency, 2017) (modelled as 7.6 per cent adoption of energy efficient lighting)	19	165	22	191
Residential – MEPS refrigeration	Replacement of inefficient refrigeration/fridge by 2025 (International Renewable Energy Agency, 2017) (modelled as 30 per cent adoption of energy efficient refrigeration/fridge)	32	278	38	330
Industry – cooling load	Improvement of cooling load by 20 per cent in 2025 (International Renewable Energy Agency, 2017)	34	295	38	330
Commercial – Government building	Improvement of cooling load by 20 per cent, lighting by 4 per cent, and office equipment by 5 per cent in 2025 (International Renewable Energy Agency, 2017)	27	235	30	261
Commercial – other building	Improvement of cooling load through the replacement of inefficient AC and refrigeration by 30 per cent in 2025 (International Renewable Energy Agency, 2017)	71	618	79	687
Total		**2,007**	**2,901**	**4,990,**	**6,235**

* GHG emission reduction for electrical appliance is calculated using the grid emission factor 0.747 kg CO_{2-e}/kWh.

10 EPD had conducted an energy audit for all government ministries and the audit findings presentation was conducted to audited ministries to capitalize on the findings and recommendations identified including energy efficiency measures. Follow up activities on this energy audit may be conducted.

11 MISE's Quality Control and Inspection Division (MISE's division) will integrate the energy efficiency standard into the Building Code once is it updated.

4.2. Power sector

Kiribati has an ambitious plan to accelerate the transition to cleaner energy supply utilizing solar energy. Currently, the installation for the South Tarawa Renewable Energy Project (STREP) with a capacity of Solar PV 5,000 kWp and Battery Storage 13,000 kWh is expected to be online in the fourth quarter of 2024. The renewable energy capacity (solar generation) will increase from 15.8 per cent in 2021 to 48.3 per cent in 2030.

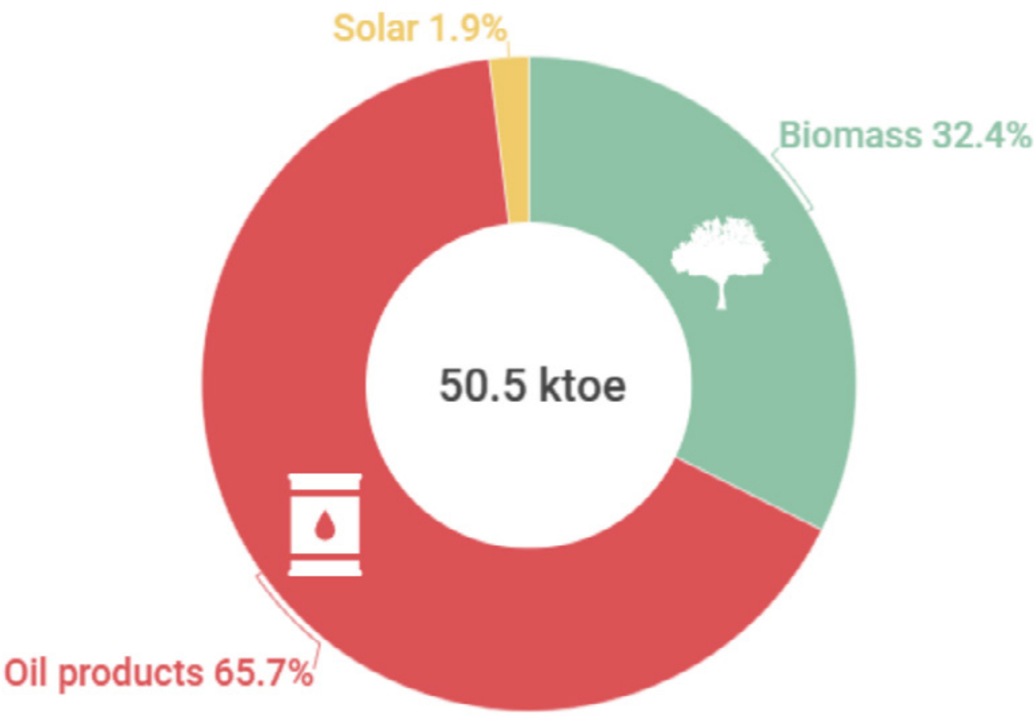
In the CP scenario, electricity generation is expected to rise from 35 GWh in 2021 to 40.3 GWh in 2030. The renewable energy share of electricity supply (solar generation) will increase from 7.3 per cent in 2021 to 28.3 per cent in 2030, with the remaining coming from diesel generation. The increased share is due to the rapid increase in solar capacities (as per the power capacity expansion plan) during the analysis period.

The total electricity requirement (considering both final energy demand as well as transmission and distribution losses) in the CP scenario by 2030 would be 42 GWh. It seems that Kiribati might not meet its electricity requirements under the current policy scenario through domestic generation under the current expansion plan. It might happen since some diesel generation is operated below its rated capacity.

4.3. Supply

In the current policy scenario, the TPES is forecasted to increase from 50.3 ktoe in 2021 to 50.5 ktoe in 2030. As shown in figure 6, oil products are the dominating fuel supply, followed by biomass and solar PV. The primary supply of solar energy has been ramped up significantly, compared with the value in 2021, from 0.2 ktoe to 1 ktoe.

Figure 6. Total primary energy supply by fuel type in 2030, CPS scenario



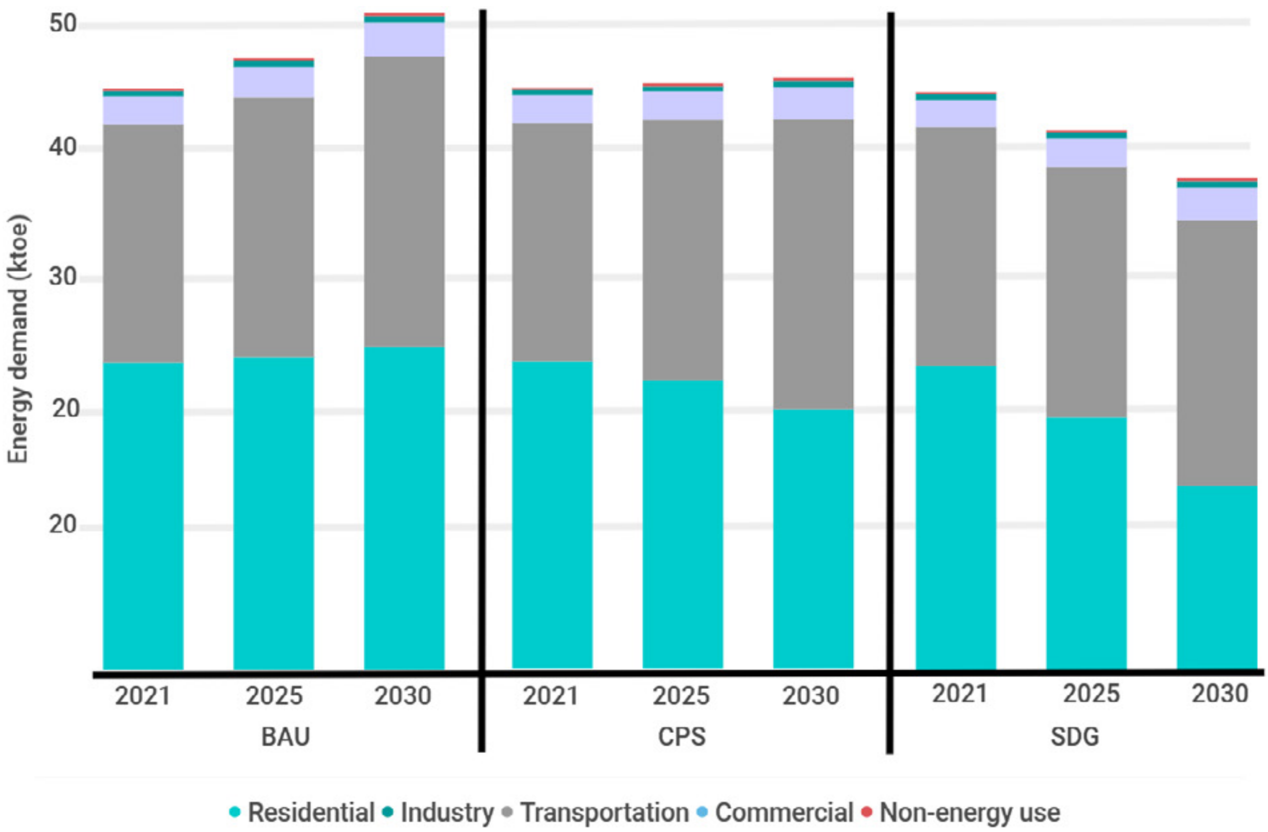
5. SDG scenario: An assessment of SDG 7 targets and indicators

In this section, first, a brief overview of the energy demand and supply under the SDG scenario is provided. Later, the results are evaluated against the SDG 7 and NDC targets and other relevant indicators. Finally, Kiribati's current energy policies are evaluated based on the outputs from the NEXSTEP analysis in order to highlight any policy gap.

5.1. Energy demand outlook

In the SDG scenario, TFEC decreases from 44.1 ktoe in 2021 to 37.5 ktoe in 2030, a reduction of 6.6 ktoe. Compared to the CPS scenario, in 2030 the demand will be reduced by 7.3 ktoe. This additional reduction compared to CPS is due to the phasing out of traditional kerosene and biomass fuel stoves in the residential sector as well as the adoption of higher energy efficiency measures. In 2030, the transport sector consumption will be by far still the largest at 53.9 per cent, followed by the residential sector at 37.8 per cent, the commercial sector at 6.6 per cent, and the industrial sector at 1.3 per cent. Figure 7 shows the comparison of TFEC between three main scenarios.

Figure 7. Comparison of energy demand between scenarios



5.2. SDG 7 targets

5.2.1. SDG 7.1.1, Access to electricity

The electrification rate in Kiribati was 94 per cent in 2021. While urban areas have been 100 per cent electrified, only 86 per cent of the rural population had access to electricity. In all scenarios, it is projected that 100 per cent access to electricity in the rural areas can be achieved in 2025. The NEXSTEP analysis proposes that decentralised renewable electricity systems, such as solar mini-grids and solar home systems, could be provided to the unconnected households. The ease of implementation, compared to extending the grid infrastructure, should allow the 100 per cent electrification target to be reached within the stipulated timeline. Table 4 explains the relevant policy that is likely to accelerate the access to electricity.

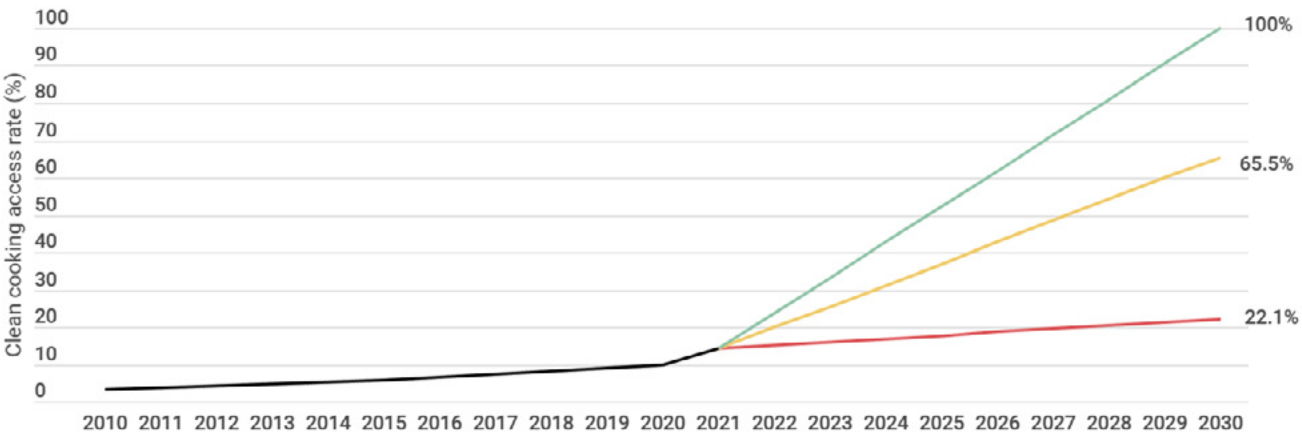
Table 4. Assessment of access to electricity

Existing policy	NEXSTEP analysis – gaps and recommendations
Kiribati Integrated Energy Roadmap (KIER) 2017-2025 (International Renewable Energy Agency, 2017) states the objective as reaching a rate of 100 per cent by 2025.	Kiribati will achieve universal access to electricity by 2023

5.2.2. SDG 7.1.2, Access to clean fuels and technologies for cooking

Accelerated effort is required to achieve universal access to clean cooking. As of 2021, 85.9 per cent of the population relied on polluting cooking technologies, specifically kerosene and solid fuel stoves (biomass as primary fuel). If the LPG stove is being captured by 75 per cent in urban centre under the current policy scenarios, access to clean cooking fuels and technologies will reach only 65.5 per cent in 2030, leaving 8,240 households relying on inefficient and hazardous cooking fuels and technologies. However, this percentage might be as low as 22.1 per cent (similar to the BAU scenario) since the current implementation progress is quite low. Under the SDG scenario, the clean cooking access rate is set to achieve universal access (100 per cent) by 2030 (figure 8).

Figure 8. Kiribati's access to clean cooking in the BAU, CPS and SDG scenarios



The NEXSTEP analysis indicates that LPG stoves and ICS provide the most appropriate solution for Kiribati due to cost and environmental effectiveness. Table 5 summarises the estimated annualized cost of different cooking technologies in the context of Kiribati. Annex IV summarizes the cost and technical assumptions used in the economic analysis. Considering the lack of indigenous fossil fuel resources and domestic LPG production, ICSs are a better transitional option than LPG cooking stoves for Kiribati, as this reduces the reliance on imported fuels.

Table 5. Annualized cost of cooking technologies

Technology	Annualized cost
Electric cooking stove	US$ 240
Improved cooking stove (ICS)	US$ 80
LPG stove	US$ 200

LPG stoves and ICS can play an intermediary role until cleaner options become more affordable. Electric cooking stoves may not be suitable for households using off-grid electricity systems in rural area, as the appliance requires substantial power supply capacity. In the long run, however, electric cooking stoves may be considered particularly to achieve the net zero target by 2050. Box 1 explains the basis for evaluation of clean cooking technologies. Table 6 summarises the gap assessment and recommendations to address the clean cooking in Kiribati.

Table 6. Assessment of access to clean cooking

Existing policy	NEXSTEP analysis – gaps and recommendations
Kiribati Cooking for Life Strategy (Ministry of Works and Public Utilities, 2014) seeks to capture 75 per cent of households in urban centre having access to modern sources of energy for cooking (LPG stoves) and the remaining households using ICS for cooking. However, this target is extended up to 2025 under the KIER document.	**Gap:** The NEXSTEP analysis projects that Kiribati may reach a 65.5 per cent clean cooking access rate in the current policy context (Kiribati Cooking for Life Strategy). **SDG scenario:** In consideration of comments from stakeholders, the NEXSTEP analysis suggests bridging the remaining gap with a combination of liquified petroleum gas (LPG) stoves in the urban area and improved cooking stoves (ICS) in the rural area.

Box 1. Clean cooking technology evaluated

Electric cooking stoves

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

Improved cooking stoves

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

LPG cooking stoves

LPG is constrained due to fuel import dependency and supply chain challenges. LPG cooking stoves generate lower indoor air pollution compared to ICS. They are classified as Level 4 in the World Bank Multi-Tier Framework (MTF)[12] for cooking exposure, and reduce indoor air pollution by 90 per cent compared to traditional cooking stoves.

12 Energy Planning Division (EPD) may work closely with the statistics office (SO) in improving its questionnaire relating to cooking. Some people in Kiribati have used improved cookstoves but these are not reflected in the SO's questionnaire as it only focuses on the source of energy for cooking but does not consider the type of cookstoves being used. By doing this, it will improve Kiribati energy target achievement.

5.2.3. SDG 7.2, Renewable energy

SDG 7.2 does not have a quantitative target but encourages a "substantial" increase of the renewable energy share in TFEC. The share of renewable energy (excluding traditional biomass usage) in TFEC in 2030 will be 32 per cent in the SDG scenario compared with 9.86per cent in the CP scenario (figure 9). The increase from 0.4 per cent in 2021, in the CPS, is attributable to the increased rate of increase in electricity consumption (which is dominantly fossil fuel-based). In the SDG scenario, renewable energy increases significantly as the energy system gets more efficient as well as due to the increase in efficient usage of biomass in ICSs. Table 7 further explains how the RE share will increase in the SDG scenario.

Figure 9. Renewable energy in TPES and TFEC, 2030

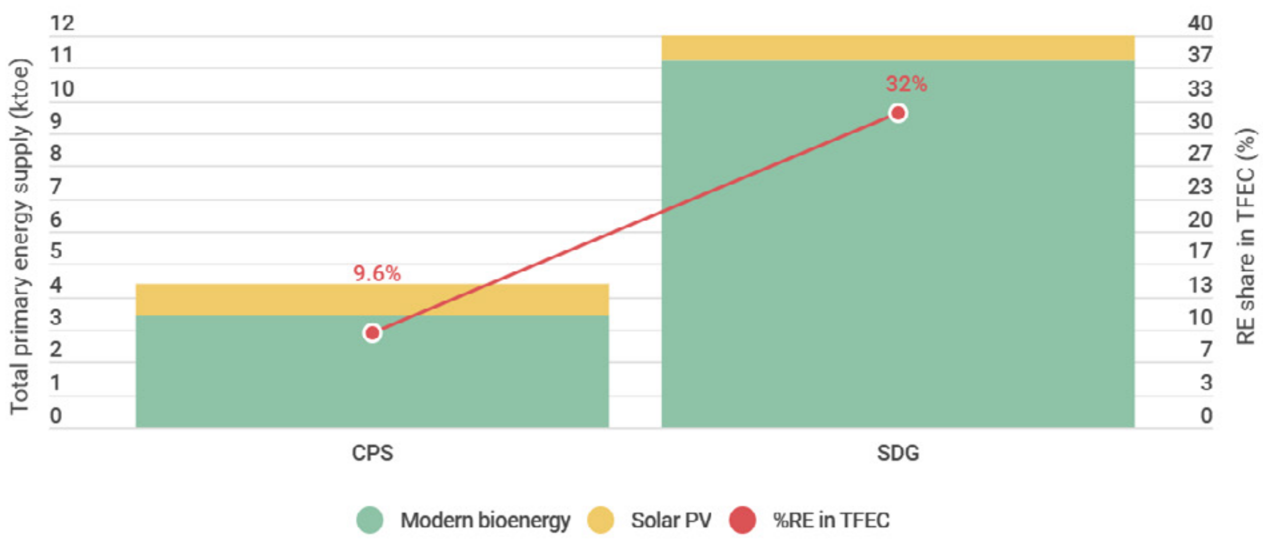


Table 7. Assessment of renewable energy share in TFEC

Existing policy	NEXSTEP analysis – gaps and recommendations
Kiribati Integrated Energy Roadmap (KIER) 2017-2025 (International Renewable Energy Agency, 2017) sets targets for renewable energy to reduce fossil fuel consumption. By 2025, the Government plans to reduce fossil fuel consumption by 23 per cent in South Tarawa, 40 per cent on Kiritimati Island and 40 per cent in the outer islands by deploying more renewable energy generation.	**CP scenario** The renewable share in TFEC is projected to be 9.6 per cent in the CP scenario due to the increase of planned renewable power capacities. The current South Tarawa Renewable Energy Project (STREP) will allow the South Tarawa grid to achieve 26 per cent renewable energy penetration, higher than the Kiribati Integrated Energy Roadmap (KIER) target for South Tarawa, which is 23 per cent renewable penetration by 2025. **SDG scenario** The renewable energy share in TFEC is projected to be 32 per cent in 2030. This increase is attributable to the phasing out of inefficient traditional biomass and kerosene stoves and replacing them with improved cooking stoves. This also results from the improvement in energy efficiency.

5.2.4. SDG 7.3, Energy efficiency

A doubling of the 1990-2010 improvement rate is required to achieve the SDG 7.3 target. However, the energy intensity of Kiribati increased at an average annual rate of 1.46 per cent between 1990 and 2010. It means that doubling the rate will cause the energy intensity to be higher.

Therefore, it is suggested that Kiribati achieve a global improvement rate of 3.2 per cent where the energy intensity in 2030 would need to be 6.24 MJ/USD_{2017}.

Under the CP scenario, the energy efficiency improvement target will not be achieved as the energy intensity will only be reduced to 6.86 MJ/USD_{2017}. The energy intensity in 2030 is expected to be further reduced in the SDG scenario to 5.86 MJ/USD_{2017} (3.9 per cent EE improvement rate), meeting the global energy efficiency target for SDG7. This is primarily due to the additional measures in the SDG scenario, such as the additional phase-out of inefficient cooking technologies in rural area. These are replaced with more efficient stoves. In addition, further energy intensity reduction can be realised through the additional proposed measures for residential and transport sectors. Increasing the adoption of MEPS for lighting, refrigeration and air-conditioning as well as introducing MEPS for electric fans and television can be a viable solution for Kiribati to reduce the energy demand. Further details of the energy efficiency measure and their impacts are provided below.

(a) Transport sector

Kiribati can save the energy demand by encouraging mass transit and public transport systems as well as improving fuel standards. NEXSTEP analysed a case for an increase in passenger-km of public transport by 10 per cent and improvement of fuel economy for passenger cars by 25 per cent from 12 km/l to 15 km/l. These shares are an indicative case to demonstrate how such changes in the transport sector will have an impact on energy saving and emission reduction. In addition, NEXSTEP suggests the implementation of routine inspection and maintenance in the maritime transport. As shown in table 8, there will be an additional 1.8 ktoe energy saving and 5.2 $ktCO_{2-e}$ GHG emission reduction compared with the CP scenario.

Table 8. Energy saving and GHG emission reduction in the transport sector under the SDG scenario by 2030, compared to BAU

Sector	Measure	2030	
		Energy demand reduction (toe)	GHG emission reduction (tCO_{2-e})
Transport – public transport	Increase public transport utilisation by 10 per cent for road transport.	172	493
Transport – fuel economy	Improve 25 per cent of passenger car and motorbike fuel economy.	732	2,100
Transport – marine transport	Implement routine inspection and maintenance in the maritime transport to reduce energy consumption by 8 per cent.	888	2,605
Total		**1,792**	**5,198**

(b) Residential sector

An additional 5.5 ktoe energy saving in the residential sector can be attained by 2030 in the SDG scenario (table 9). A substantial decrease in demand from the residential sector occurs due to the phasing out of unclean and inefficient cooking stoves in rural areas.

Furthermore, since the residential sector has a significant share of energy demand, in this scenario, more intensive energy efficiency measures are considered. The measures include a higher adoption of energy efficient equipment compared to the share presented in the CP scenario. In addition, MEPS for television and video is introduced in this scenario. These measures can provide an additional savings for the residential sector in Kiribati.

Table 9. Energy saving and GHG emission reduction in the residential sector under the SDG scenario by 2030, compared to CPS

Sector	Measure	2030	
		Energy demand reduction (toe)	GHG emission reduction (tCO_{2-e})*
Residential cooking	Additional adoption of LPG and ICS in the rural area	5,304	2,579
Residential MEPS lighting	Increase the adoption of EE lighting (58.4 per cent penetration of EE appliance)	145	1,260
Residential MEPS refrigeration	Increase the adoption of EE refrigeration (59.1 per cent penetration of EE appliance)	37	321
Residential MEPS electric fan	Promote the adoption of EE fan (58.9 per cent penetration of EE appliance)	18	156
Residential MEPS television and video	Promote the adoption of EE television and video (52.7 per cent penetration of EE appliance)	6	52
Total		**5,510**	**4,368**

* GHG emission reduction for electrical appliance is calculated using the grid emission factor 0.747 kg CO_{2-e}/kWh.

Figure 10 shows additional energy saving opportunities under the SDG scenario, compared with the CP scenario, and table 10 further explains each energy efficiency measure as well as identifies gaps.

Figure 10. Additional energy saving measures under the SDG scenario compared to the CP scenario

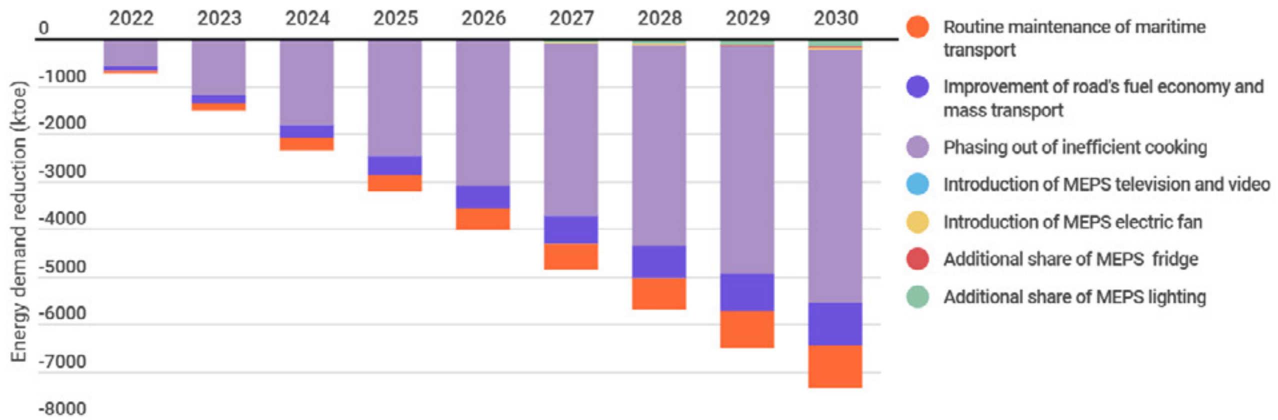


Table 10. Assessment of energy efficiency

Existing policy	NEXSTEP analysis – gaps and recommendations
Kiribati Integrated Energy Roadmap (KIER) 2017-2025 (International Renewable Energy Agency, 2017) sets targets for energy efficiency to reduce fossil fuel consumption. By 2025, the Government plans to reduce fossil fuel usage (by 22 per cent on South Tarawa, 20 per cent on Kiritimati Island and 20 per cent on the outer islands) through the uptake of energy efficiency measures.	**Gap(s):** The CP scenario will not achieve the energy efficiency improvement target of 3.2 per cent or 6.24 MJ/USD$_{2017}$ in 2030. It is projected that the energy intensity will be 6.86 MJ/USD2017 in 2030. **SDG scenario:** The energy intensity is further reduced to 5.86MJ/USD$_{2017}$ in 2030 or 3.9 per cent EE improvement rate, which exceeds the global energy efficiency target. Achievement of this target requires phasing out inefficient cooking technologies, increasing MEPS adoption, encouragement of mass transport, improvement of passenger car fuel economy, and routine inspection of maritime transportation to realise an additional energy demand reduction of 7.3 ktoe in 2030, compared with the CP scenarios.

5.3. Energy supply outlook

Under the SDG scenario, the total primary energy supply is estimated to be 43.1 ktoe by 2030, a 7.3 ktoe reduction compared with the CP scenario. The phasing out of traditional biomass for cooking will reduce biomass supply by 5.2 ktoe. The remaining reduction comes from oil products due to additional energy efficiency improvements. The substantial decrease in primary energy supply not only reduces Kiribati's energy intensity, but also enhances its energy security by reducing the need for fuel imports.

The demand for electricity in 2030 is projected to be 33.6 GWh in the SDG scenario, a decrease of 2.4 GWh compared with the CPS. A reduction in electricity demand by the residential sector can be expected as it becomes more efficient with an increasing share of efficient appliance. The electricity demand in the residential sector will be 17.2 GWh, while in the commercial and industry/government sectors it will be 12.1 GWh and 4.3 GWh, respectively. It is estimated that 11.4 GWh of electricity demand will be fulfilled by a total of 5.4 MW by solar systems. The remaining will be fulfilled by the current capacity of 4.25 MW diesel system.

5.4. Nationally Determined Contribution targets

The energy sector emissions, from the combustion of fossil fuel, are calculated based on IPCC Tier 1 emission factors assigned in the LEAP model and expressed in terms of 100-year global warming potential (GWP) values. For the combustion of biomass and biomass products, the carbon emissions are not attributed to the energy sector, but are accounted for in the agriculture, forest and land-use change (AFOLU)[13] as per the accounting system suggested by IPCC. Nevertheless, the emissions of other GHGs, such as methane and nitrous oxide, are included in the total emissions in the energy sector.

Under the CPS, total emissions are expected to grow from 98 ktCO$_{2\text{-e}}$ in 2021 to 105.2 ktCO$_{2\text{-e}}$ in 2030. This corresponds to a 20.5 ktCO$_{2\text{-e}}$ (16.3 per cent) reduction compared with the BAU scenario

13 The AFOLU sector is not within the scope of NEXSTEP

meeting the unconditional NDC target. The decrease in GHG emissions, relative to the BAU scenario, is due to the higher RE share in electricity supply.

Figure 11 shows additional emissions reduction under the SDG scenario, compared with the CP scenario. In the SDG scenario, total emissions are expected to grow to 97.5 $ktCO_{2-e}$ by 2030. This corresponds to a 28.3 $ktCO_{2-e}$ (or a 22.5 per cent) reduction compared with the BAU scenario, which exceeds the unconditional NDC target of 3.8 per cent in the energy sector. The additional decrease in GHG emissions compared with the CP scenario is due to measures discussed in the previous section. Figure 12 summarizes the SDG 7 indicators from three different main scenarios.

Figure 11. Additional emission reduction measures under the SDG scenario

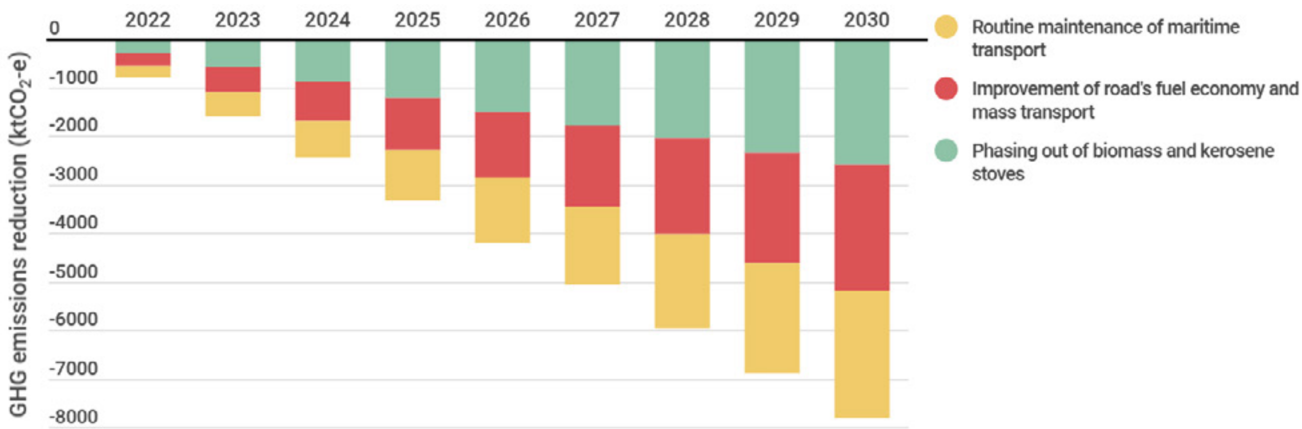
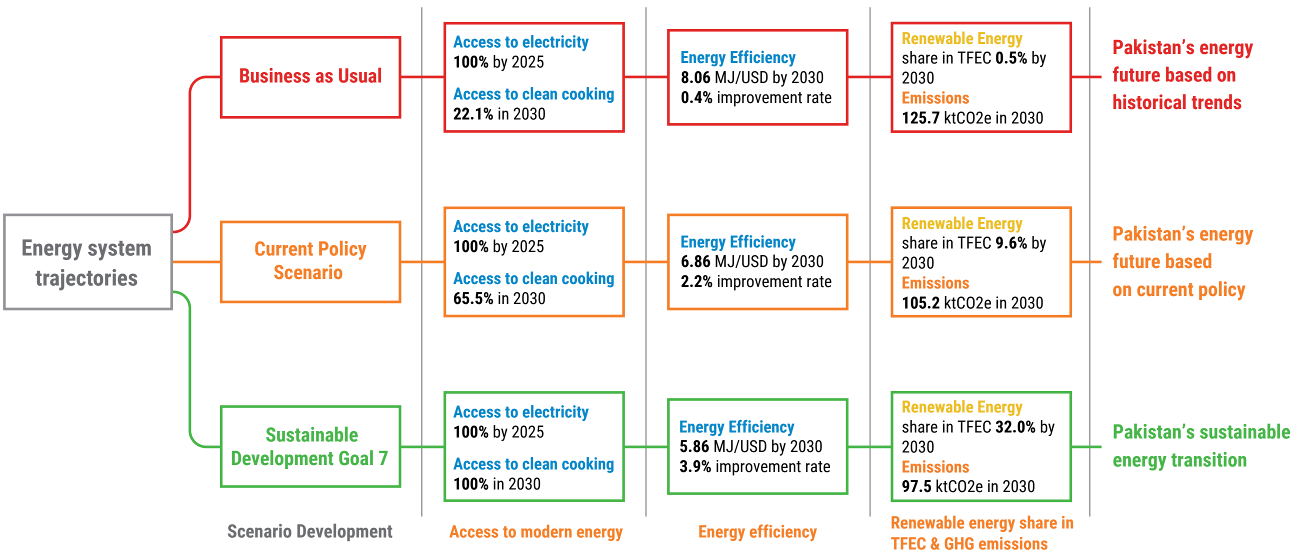


Figure 12. Summary of SDG 7 indicators for different main scenarios



6. Going beyond SDG 7

The SDG scenario, as discussed in the previous chapter, sets out various strategies for facilitating an economy-wide, energy-efficiency improvement in alignment with the 2030 Agenda for Sustainable Development and the Paris Agreement. It also identifies appropriate technology options in advancing sustainable energy transition in Kiribati. These allow GHG emission reduction sufficient to meet the unconditional NDC target and a modest increase in the renewable energy share in TFEC. However, Kiribati could consider more ambitious pathways going beyond just achieving the SDG7 targets. This chapter discusses Kiribati's potential to raise its ambition in energy transition.

The measures that have been discussed in the previous chapter, have allowed an energy demand reduction of 7.3 ktoe and emission reduction of 7.7 MtCO2-e, relative to the CPS. With countries and cities pledging net-zero emissions by 2050, one ambitious scenario has been developed – the Towards Net Zero (TNZ) by the 2050 scenario. This scenario assesses the potential for Kiribati to achieve net zero for the entire energy sector by 2050. The longer timeframe for the net zero scenario will allow gradual decarbonization of direct fuel combustion technologies in the transport sectors.

Around three-quarters of current greenhouse gas emissions globally come from the energy sector. Although this sector might have a critical role in averting the worst impact of climate change, a significant challenge cannot be avoided. Limiting the temperature rise to 1.5C requires climate mitigation effort on an unprecedented scale and speed to reduce GHG emissions by about 45 per cent from 2010 levels by 2030, reaching net zero around 2050 (IPCC, 2018). Failing to act on the most pressing issue of this generation may lead to a catastrophic impact on human livelihoods. Kiribati is highly vulnerable to the impacts of climate change, with the greatest impacts likely to come from the rising of the sea level.

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

6.1. Demand sector strategy

The energy system of Kiribati is well-positioned for an accelerated decarbonization effort as some required net-zero technologies in decarbonizing its energy system are readily available, i.e., electric cooking stoves and renewable power technologies. Building on the SDG scenario, the TNZ 2050 scenario explores how the country can transition its demand side towards decarbonization of its whole economy. There are two different timeframes for the implementation of multiple renewable energy and energy efficiency measures.

6.1.1. Present until 2030

The total energy demand is expected to decrease further from 44.1 ktoe in 2021 to 32.4 ktoe in 2030, a reduction of about 5.1 ktoe relative to the SDG scenario. The transport sector consumption will remain the largest at 57 per cent, followed by the residential sector at 33.6 per cent, the commercial sector at 7.4 per cent, the industry sector at 1.4 per cent and the non-energy use at 0.6 per cent.

The energy demand reduction mainly stems from increased ambition in transport electrification. In the transport sector, NEXSTEP suggest the adoption of 20 per cent of electric passenger cars and motorcycles by 2030 as the starting point. Simultaneously, biofuel blending can be an opportunity for Kiribati to reduce fossil-fuel consumption as mentioned under the conditional target of intended NDC. NEXSTEP suggests a 20 per cent biofuel blending for buses, minibuses, trucks, vans and maritime transports. However, a mechanism must be developed to make biofuel as a viable alternative fuel since at this stage the government subsidy on copra is very high.

In the residential sector, NEXSTEP suggests the adoption of electric cooking stoves to reach at least a quarter of urban households by 2050. Although the electric cooking stove is more expensive compared with LPG stoves and ICS, in the long term they will provide more benefits in order to align with a net zero society.

Table 11. Proposed measures and their respective annual energy savings and GHG emission reduction in 2030, TNZ scenario compared to SDG

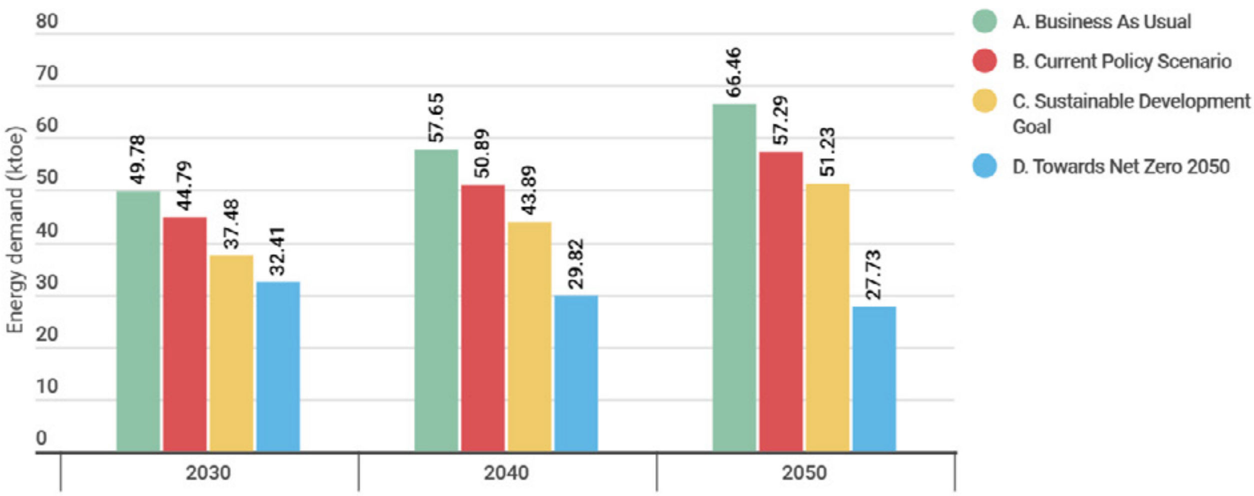
Sector	Measure	2030	
		Energy demand reduction (toe)	GHG emission reduction (tCO_{2-e})
Residential – electric cooking stoves	Increasing the share of electric cooking stove in urban area by 25 per cent to replace LPG stove and ICS	3,261	1,995
Transport – electric vehicles	The adoption of 20 per cent of electric passenger cars and motorcycles by 2030	476	3,288
Transport – Biofuel blending	A 20 percent biofuel blending for buses, minibuses, trucks, vans and maritime transport	1,256	9,440
Commercial – Fuel switching	Switching fossil-fuel based systems/technologies with electrical systems	73	1,351
Industrial – Fuel switching	Switching fossil-fuel based systems/technologies with electrical systems	12	92
Total		**5,078**	**16,166**

6.1.2. Beyond 2030

For the measures implemented beyond 2030, NEXSTEP suggests the utilization of 100 per cent electric cooking stoves by 2050 to achieve net zero in the residential sector. The adoption of 100 per cent e-mobility is also critical to decarbonize the transport sector, particularly for passenger transport (both land and marine transports). Simultaneously, a 100 per cent biofuel blend for freight transport can be implemented. In the commercial and industrial sectors, fuel switching has a significant role, particularly the switching of fossil fuel to electricity.

While this scenario requires an additional 7.4 ktoe (85.7 GWh) of electricity, compared to the BAU scenario, it requires the least amount of energy among all scenarios by 2050, as shown in figure 13. Energy demand in this scenario in 2050 is 38.7 ktoe less than the BAU scenario, 29.6 ktoe less than the CPS and 23.5 ktoe less than the SDG scenarios. Further implementation of energy efficiency would help to reduce this electricity demand.

Figure 13. Energy demand comparison among all scenarios



6.2. Supply sector strategy

Decarbonizing the electricity supply is key to deep decarbonization. A decarbonized electricity supply is also required to complement the hastened adoption of electricity-based technologies, such as electric vehicles and electric cooking stoves, to realise the greatest potential of electrification. Kiribati has an abundant solar potential. In addition to the existing solar projects, the following are a few pathways that the country may explore, in collaboration with citizens and/or private investors, to achieve a diversified renewable power supply objective:

a) **Rooftop solar PV installation can be promoted for both new and existing buildings.** Incentivising rooftop solar PV installation provides two benefits to the country – (1) reducing the financial burden on the country in establishing a utility-scale solar PV system, and (2) reduced land-use requirement for ground mounted PV systems. The Government may consider offering incentives to increase the uptake of solar PV rooftop systems;

b) **Retrofitting diesel generator with biodiesel is encouraged to fulfil electricity demand.** The retirement of fossil fuel- based power generation can be retrofitted with biodiesel system. This retrofitting would help the country to solve its rising electricity demand.

To decarbonize the power sector by 2030, around 6.9 MW of diesel generation in Kiribati must be retired. The retired fossil fuel generators can be retrofitted to utilize biodiesel. The addition of 2.7 MW of biodiesel is also required by 2030. To fulfil the increasing electricity demand due to electrification in 2050, NEXSTEP investigates the fact that the solar generation capacity must be increased to 84.5 MW.

In terms of power supply, the decarbonization of the whole economy will reduce the demand for fossil fuel. On the other hand, there will be a significant increase of renewable energy into Kiribati's energy system since the proposed power generation under this scenario will be 100 per cent renewable energy, coming mainly from solar generation combined with energy storage. This situation will improve the energy security of the country through indigenous generation by 2050.

6.3. Emission outlook

Decarbonizing the power sector would be beneficial to the country since it would significantly reduce GHG emissions in 2030 (compared to the BAU scenario) by 67.7 ktCO2-e (figure 14). Therefore, a total emission reduction (including the demand sector) will be around 53.9 per cent compared to BAU meeting the conditional NDC target. Moreover, transitioning to a fully renewable energy-based power system would be more cost-effective in the long term than to relying on fossil fuel-based power generation.

Figure 14. GHG emission comparison in Kiribati in the BAU, CPS, SDG and TNZ scenarios

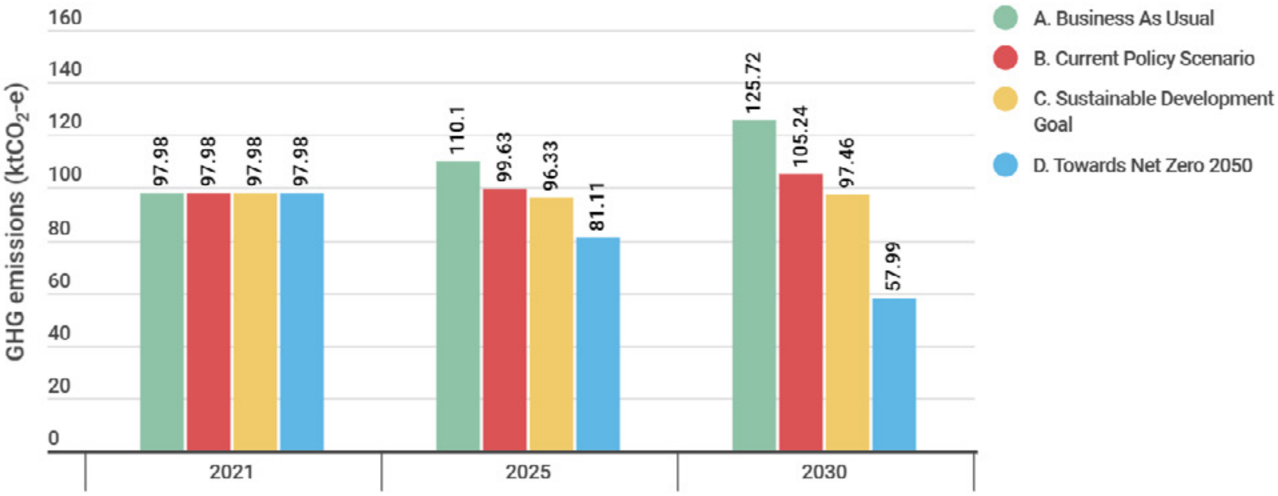
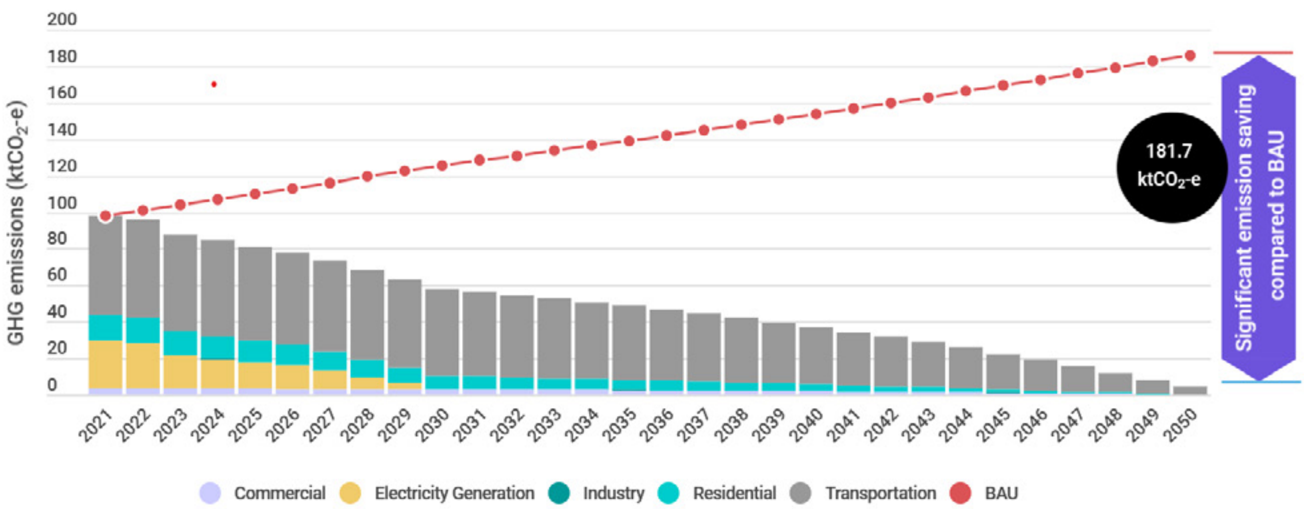


Figure 15 illustrates the GHG emissions in the demand sector under the BAU and TNZ scenarios by 2050. It appears that the emissions will increase by almost two times to 186.1 $ktCO_{2-e}$ in 2050 under the BAU scenario if no significant measures are implemented during this period. However, under the TNZ scenario, the emissions will almost reach zero in 2050. A very small amount of residual emission is due to certain limitations in fully decarbonizing the aviation sectors. Therefore, carbon sinks, such as reforestation or forest management, or other carbon capture technologies should be considered for absorbing the remaining carbon emissions.

Figure 15. GHG emission in Kiribati, 2022-2050, by sector in the TNZ scenario



7. Policy recommendations

7.1. Scenario evaluation

The current policy, SDG and the ambitious scenarios have been evaluated and ranked, using the Multi-Criteria Decision Analysis (MCDA) tool, with a set of 12 criteria and weights assigned to each criterion (table 12). 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 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; and

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

Table 12. Criteria with assigned weights for MCDA

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

Table 13 shows the summary of results obtained through this evaluation process. The scenario recommendation suggests that the ambitious scenario, "Towards Net Zero by 2050", is the highest-ranked energy transition pathway for Kiribati.

Table 13. Scenario ranking based on MCDA

Scenarios	Weighted scores	Rank
Towards Net Zero 2050	52.7	1
SDG scenario	44.7	2
Current policy scenario	28.4	3
Business-as-usual scenario	20.0	4

Based on the above analysis, this Road Map recommends that Kiribati consider the adoption of the Towards Net Zero by 2050 scenario. Since this scenario is further implemented after the implementation of SDG 7 scenario, Kiribati may also implement the suggestions given in the SDG 7 scenario.

7.2. Policy actions for achieving SDG 7

7.2.1. Liquified petroleum gas stoves and improved cooking stoves provide a sustainable solution with multifold benefits

The NEXSTEP analysis suggests the remaining clean cooking gap in Kiribati should be closed with the promotion of LPG stoves and ICS. Under the current policy, the Government of Kiribati has planned to increase the share of LPG stoves to around three- quarters of urban households. By 2030, around 8,703 more of households need to use LPG stoves. It will cost the Government around US$ 1.74 million. However, considering the lack of indigenous fossil fuel resources and domestic LPG production, ICS are a better option than LPG cooking stoves for Kiribati, as this reduces the reliance on imported fuels.

As shown in table 5 and discussed in subsection 5.2.2, ICS has the cheapest annualised cost, which will be more affordable for rural households. It will cost the Government around US$ 0.79 million to distribute ICS to 9,920 households. The adoption of improved cooking stoves is proposed as an appropriate transitional solution for closing the gap in rural areas within the short time frame. This builds on the traditional practice of using biomass as cooking fuel, which is abundant and cheap. In the long term, however, the Government must consider electric cooking stoves. Electric cooking stoves are a prime solution, capitalising on carbon-free electricity. They serve as a long-term solution with no added burden on fuel imports. Electric cooking stoves appear to be more and more efficient than other cooking stoves, including LPG stoves.

7.2.2. Raising the efficiency standards of household, commercial and industrial appliances to save running costs

The Government of Kiribati has planned a lighting improvement programme and has participated in the Pacific Appliance Labelling and Standards (PALS) project on the use of more efficient electric appliances (e.g., freezers and refrigerators) through minimum energy performance standards and energy rating labels. In addition to these appliances, NEXSTEP suggests that the Government should roll-out MEPS for electric fans, televisions and videos since these appliances consume a significant amount of electricity in the residential sector. It is critical for the Government to accelerate such ambitions by implementing the same saving for commercial and industrial appliances.

Complementing the roll out of MEPS, the Government of Kiribati may consider having an appliance replacement programme, such as providing subsidies to promote early retirement of existing inefficient appliances. This will allow a more rapid adoption of efficient appliances. There is also a need to create awareness among the population about the socio-economic advantages of energy savings. These measures might help accelerate the adoption of MEPS in the long term.

7.2.3. Increasing the efficiency of energy use in the transport sector should be pursued

It is also critical for the Government to reduce the demand in the transport sector. Mass transportation must be promoted to reduce the passenger-km by private vehicles. Simultaneously, policy measures that could assist in easing the pressure of growing fossil fuel demand could include imposing restrictions on energy-inefficient vehicle based on their engine size and model year. Therefore, the improvement of fuel efficiency standards using hybrid models for both passenger cars and motorcycles can be affordable pathways for a sustainable transition. In addition to road transport, maritime transport also has a significant energy saving potential since the consumption of fuel for maritime transport is quite significant in Kiribati. Routine maintenance and inspection for maritime transport might also be beneficial to improve energy efficiency. Total energy saving potential in the transport sector will be 1.7 ktoe with 5.2 $ktCO_{2-e}$ of emission reduction.

7.3. Policy recommendations to raise ambitions beyond SDG 7

7.3.1. Transport electrification and biofuel blending are major steps towards net zero 2050

Transition to a clean energy sector will require a shift from fossil fuel-powered transport to efficiently designed renewable energy technologies even though efforts today are hampered by the oversupply of fossil fuel-powered vehicles and vessels. Vigorous adoption of electric vehicles (EVs) might reduce the demand for oil products, hence reducing Kiribati's reliance on imported petroleum fuels. Another advantage of EVs is their ability to absorb excess renewable energy. With specialised networks and large numbers of EVs plugged into the grid at any one time, there is the possibility to use the combined stationary battery capacity as an element of load levelling. At the same time, it can contribute to climate mitigation and improve local air quality. An adoption rate of 20 per cent for passenger cars and motorcycles by 2030 has the potential to save energy by 0.5 ktoe and reduce emissions by 3.3 $ktCO_{2-e}$. In the short term, biofuel blending might be considered during the transition period up to 2030 as suggested in the intended NDC document. NEXSTEP recommends at least 20 per cent fuel blending to be implemented in Kiribati. Box 2 discusses the global progress of electric vehicles.

Box 2. Electric vehicle gains global interest

Electric vehicles have garnered great interest globally, growing exponentially during the past decade. Electric car sales passed two million globally in 2019, with a projected compound annual growth rate of 29 per cent through to 2030 (Deloitte, 2020). Various government policies have been introduced that directly or indirectly promote the adoption of electric vehicles as a means to achieve environmental and climate objectives. For example, 17 countries have stated their ambition to phase out internal combustion engines before 2050, while the European Union's stringent CO_2 emissions standard has accelerated the adoption of electric vehicles (IEA, 2022a).

Despite supply chain bottlenecks and the ongoing COVID-19 pandemic, electric car sales hit a new high in 2021. Sales nearly doubled to 6.6 million, representing a world sales share of approximately 9 per cent, compared to 2020, increasing the total number of EVs on the road to 16.5 million. In 2021, the sales share of EVs rose by 4 percentage points. China had the most sales in 2021, tripling those of 2020 with 3.3 million, followed by Europe with 2.3 million sales, an increase from 1.4 million in 2020. In 2021, 630 000 EVs were sold in the United States, doubling their market share to 4.5 per cent. Electric car sales increased more than twice as much in emerging nations, although they are still relatively small (IEA, 2022a).

7.3.2. Decarbonization of the power sector to meet national energy demand

As Kiribati moves towards net zero 2050 scenario, a projected decrease in grid emissions can realise a substantial GHG emission reduction. Although the required additional capacities could be challenging technically and economically, they will help to improve energy security through the utilization of indigenous resources. it is predicted that 84.8 MW of solar power plants and 9.6 MW of biodiesel generators will be required to fulfil the rising electricity demand in 2050 with a total investment of around US$ 280 million until 2050.

In addition to ground solar-PV projects, there are a few pathways that the country may explore, in collaboration with citizens and/or private investors, to achieve a diversified renewable power supply objective such as through rooftop solar PV installation and retrofitting diesel generator with biodiesel.

7.3.3. Green financing

Sustainable green transition in the energy sector often offers financial benefits in the long term. This could entail financial incentives to promote efficient vehicles or efficient household appliances. It should be noted that the transport and residential sectors have a high GHG mitigation potential, which in most scenarios are cost-effective in the long term. Cost savings can be expected due to the reduced usage of expensive imported oil products.

Accelerating green financing is critical to achieving the proposed sustainable energy transition. Policymakers need to work with central banks, regulatory authorities and investors to examine the possibility of developing a green finance policy and establishing a green finance bank or fund to help close the investment gap. Another option is green bonds to mobilize resources from domestic and international capital markets to finance climate solutions. Renewable energy technologies have relatively high financing costs in developing countries, which reflects their unattractive risk/return profile. This is because of their long-term horizon, high initial capital costs (including high infrastructure cost), unfavourable policy for grid access, illiquid equipment and project risks.

Policymakers can reduce high financing costs by using two methods – de-risking and direct incentives. De-risking has two basic forms – policy de-risking instruments that reduce risk, and financial de-risking instruments that transfer risk. Direct incentives are direct finance transfers or subsidies to low carbon investments. The United Nations Development Programme (2021) De-risking Renewable Energy Investment is an important guide for policymakers in developing strategies to reduce risks in renewable energy investment. An example of a funding mechanism in Thailand to promote energy efficiency and renewable energy is discussed in box 3.

Box 3. Case study – Energy Efficiency Revolving Fund in Thailand

In 2003, the Government of Thailand launched the Thai Energy Efficiency Revolving Fund (EERF) as part of its Energy Conservation Programme. The EERF works to overcome barriers within the Thai financial sector to stimulating adequate financing for energy efficiency and reducing the country's greenhouse gas emissions. It was aimed at strengthening the capacity of commercial banks to finance energy efficient (EE) projects, developed the energy service company (ESCO) revolving fund to enable smaller companies to access EE financing, and works with the Bureau of Investment to provide tax/duty exemptions for EE products. The establishment and implementation of EERF has been successful in supporting initial investments in energy efficiency and creating a self-sustained market by encouraging the involvement of commercial banks in this area. This fund was initiated in 2003 to attract investments in energy efficiency, create confidence of entrepreneurs and promote ESCOs as a vehicle to improve energy efficiency.

The fund was made available by Department of Alternative Energy Development and Efficiency (DEDE) with financial support from the Department of Energy. The total budget for five phases of the fund was US$ 245,100,000. Phase 5 of the fund operated from June 2010 to May 2013. During the first phase (2003-2006), the fund was made available to commercial banks without interest; however, an interest rate of 0.5 per cent was introduced from Phase 2 and was continued at the same rate through to phase 5. Facility owners, ESCOs and project developers were eligible to borrow from this fund for a maximum of seven years for EE and RE projects. Single loan size was capped at about US$ 1.56 million with an interest rate of 4 per cent. Until 2013, 295 project proposals were received (EE projects, 60 per cent and RE projects, 40 per cent) for a total investment of US$ 498.7 million, of which US$ 226 million was contributed by this fund and the remainder by financial institutions (Achavangkool, 2014)

8. Building back better from COVID-19


20%
100%
+10%
VOL.
-15%
Previous Close
Bid
Ask
Day's Range
52 Week Range
Volume

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

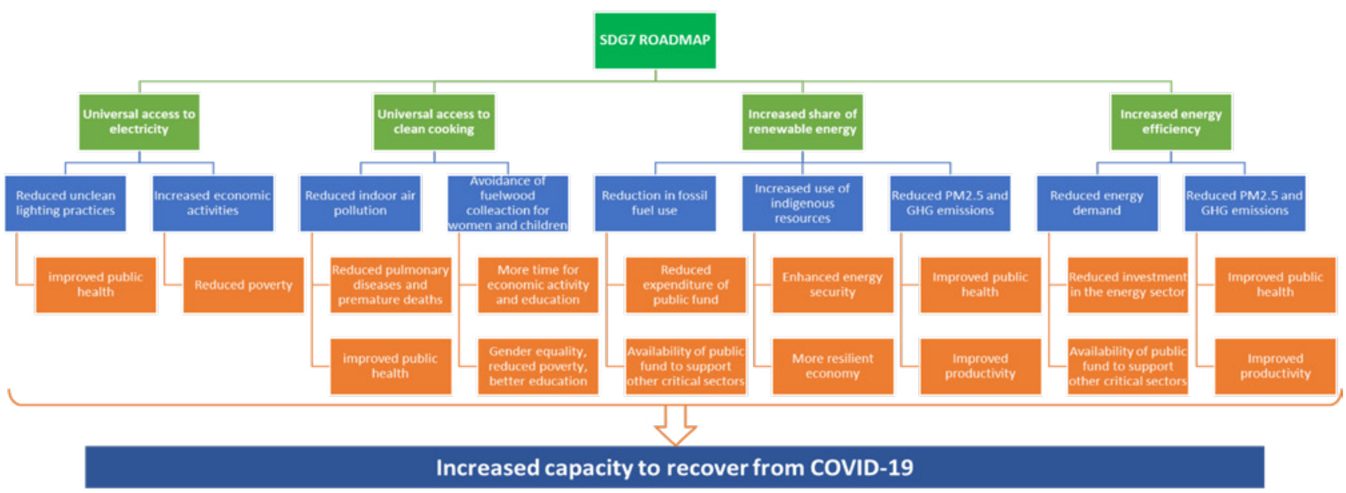
First, energy enables a range of essential services to be delivered – supporting health-care facilities, supplying clean water for essential hygiene, enabling communication and IT, and off-grid renewables refrigeration for vaccine storage. These services are only possible with reliable affordable supplies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

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

The COVID-19 pandemic has caused social and economic disruption globally, and Kiribati was no exception. With the Government of Kiribati's effective COVID-19 health strategies, according to WHO (2023), there have been 5,008 confirmed cases of COVID-19 with 18 deaths (as of 7 February 2023). A total of 215,382 vaccine doses have been administered (as of 16 January 2023). Notwithstanding, the country's GDP contracted by 0.5 per cent in 2020 (World Bank, 2022c). While grappling with the devastation caused by the pandemic, Kiribati should not lose sight of its progress and ambitions towards achieving the SDG targets. Kiribati should take the opportunity to build back better from this crisis, in order to become more resilient to face future challenges such as climate change.

Thus, it has never been more important to design a well-planned energy transition pathway that enables the country's energy sector to shield itself from the likely impacts of the COVID-19 pandemic and helps to build back better as part of the COVID-19 recovery. The SDG 7 roadmap has identified several key areas that will assist policymakers in strengthening policy measures to help recover from the COVID-19 impact while maintaining the momentum to achieving the 2030 Agenda for Sustainable Development and the Paris Agreement. Figure 16 presents how the SDG 7 Road Map will help to increase the capacity of Kiribati to recover from COVID-19.

Figure 16. SDG7 Road Map will increase the capacity of Kiribati to recover from COVID-19



8.1. Accelerating access to clean and modern energy services

Access to clean and modern energy services is essential in helping rural populations combat challenges related to COVID-19. Relying on traditional and hazardous technologies for cooking increases their susceptibility to the effects of the virus. Ongoing research is finding relationships between air pollution and the incidence of illness and death due to COVID-19. Recent research suggests that PM2.5[14] air pollution plays an important role in increased COVID-19 incidence and death rates. One such study reported that PM2.5 is a highly significant predictor of the number of confirmed cases of COVID-19 and related hospital admissions (Andrée, 2020). It is important to consider how the lack of access to clean cooking combines with COVID-19 to affect the most vulnerable people.

Kiribati had around 86 per cent of the population or around 17,700 households that lacked access to clean cooking fuel in 2021. Women and children disproportionately bear the greatest health burden from polluting fuels and technologies in homes as they typically labour over household chores such as cooking and collecting firewood, and spend more time exposed to harmful smoke from polluting stoves and fuels.

One potential medium-term impact of COVID-19 could be decreased investment in energy access, as national budgets come under strain and priorities shift. In addition, access to clean cooking technologies is a major development challenge that is often forgotten. WHO has warned about the severity of health impacts arising from the exposure to traditional use of biomass for cooking and space heating, and is encouraging policymakers to adopt measures to address this challenge. In 2019, around 0.3 per cent of the population lived with household air pollution-related diseases in Kiribati.[15]

The SDG 7 roadmap has analysed and identified technical options for connecting the remaining population to cleaner fuel for cooking and heating. The benefits resulting from this measure, in the form of reduced mortality and health impact outweigh the needed investment to advance the clean cooking rate and clean heating rate to reach 100 per cent. According to the World Bank (2022d), the cost of health damage from PM2.5 exposure in Kiribati is around US$15 million per year, which is significantly higher compared to the annual cost of providing clean cooking technologies of US$0.95 million per year.

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

The NEXSTEP analysis shows that there are ample opportunities for Kiribati to save energy by improving energy efficiency beyond the current practices. Several of these measures also provide cost savings and strengthen the country's energy security, making it less susceptible to fuel supply and price shocks. For example, the total energy saving potential in the transport sector through the introduction of mass transport, the improvement of fuel efficiency, and the regular inspection of maritime transport in the SDG scenario will be around 1.7 ktoe or around 61,555 barrels of oil equivalent in 2030. This will save Kiribati around US$5.78 million. Savings from this improvement can help investment in other sectors, such as health, social protection and stimulus, which are critical in responding to and recovering from the COVID-19 pandemic.

The electrification of the transport sector provides multiple additional benefits (in addition to energy saving), including the reduction of expenditure on importing petroleum products and reducing local air pollution. Increasing renewable power capacity as per currently planned with the aim of cross-border power trade also provides additional revenues for the country. Such measures are very important to solidifying the pathway to recovery from COVID-19 and building back better.

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

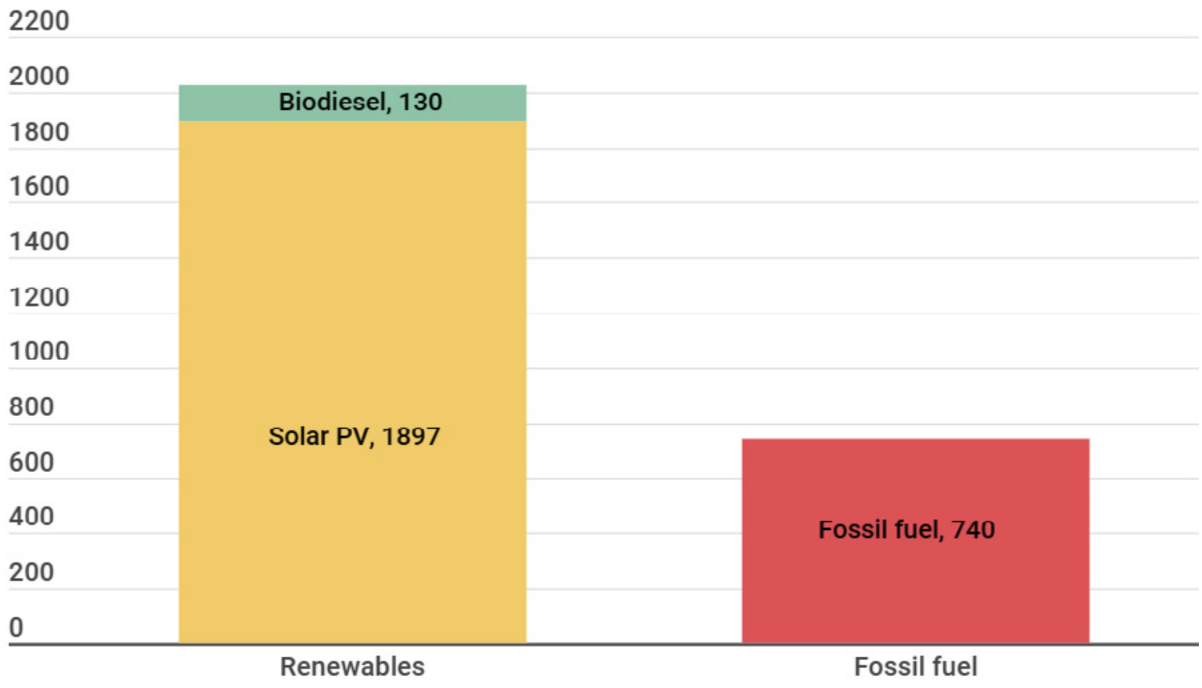
15 The Global Health Cost of PM2.5 Air Pollution (World Bank, 2022d)

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

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

Deployment of clean energy systems requires much less lead time than fossil fuel counterparts. Moreover, clean energy can create three times more jobs for the same amount spent on fossil fuel. Under the net zero scenario, an additional 83 MW solar power plant and 9.6 MW biodiesel plant are required. This will require an investment cost of around US$ 262 million for solar power plants and $17 million for biodiesel plants by 2050. The average job creation for solar PV and bioenergy generation are around 7.24 and 7.65 per million US dollars respectively (Garrett-Peletier, 2017). In contrast, Garrett-Peletier (2017) found that only 2.65 full-time equivalent jobs are created per million US dollars of spending in fossil fuels. Therefore, these renewable investments will provide employment opportunities to around 2,027 people compared with only around 740 employment opportunities generated from the same amount of investment in fossil fuel (figure 17).

Figure 17. Comparison of number of jobs created by renewable energy and fossil fuels



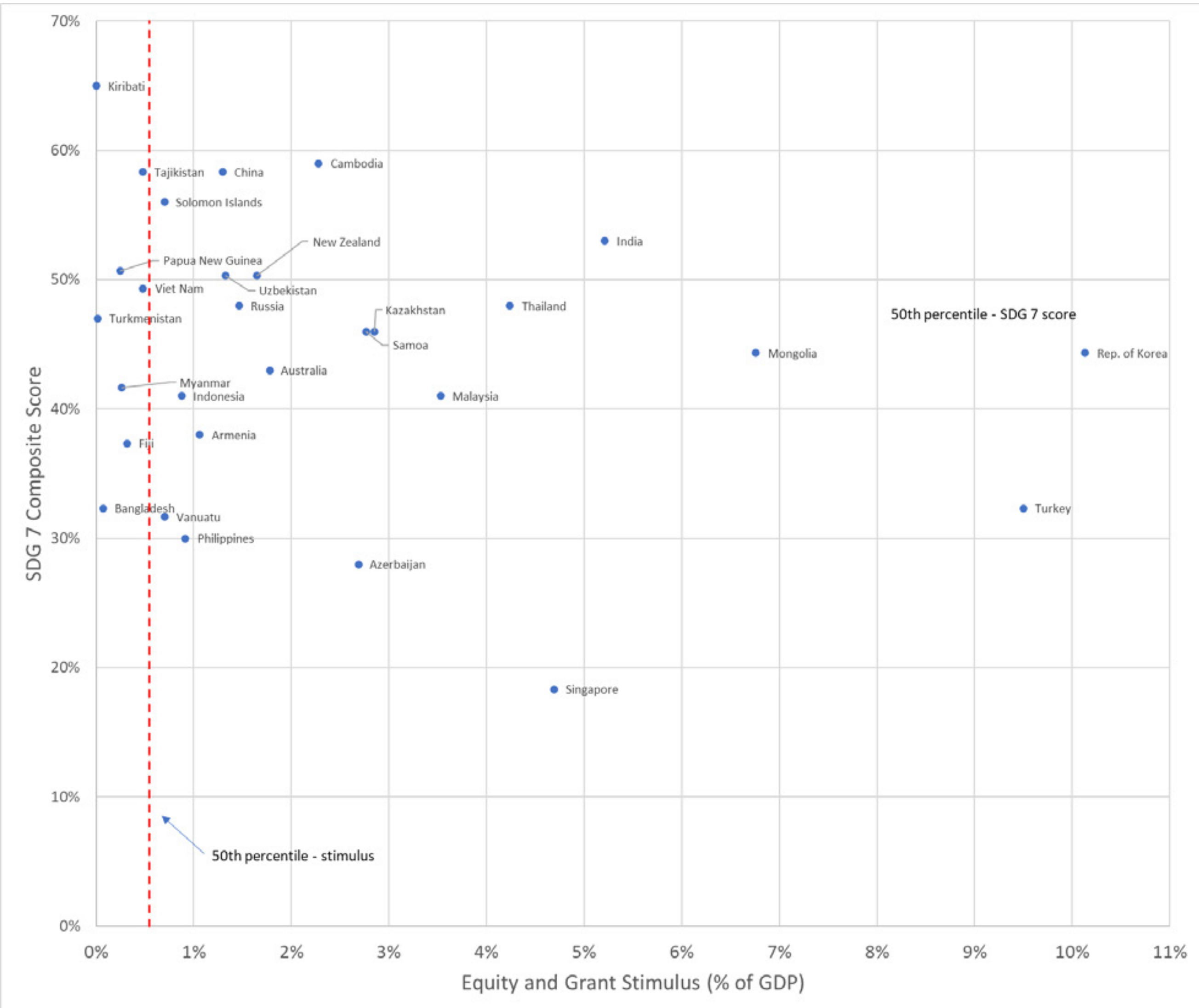
Renewable generation might also offer the opportunity to provide modern energy services to rural and underprivileged populations with decentralized systems to move people out of poverty in Kiribati. This will increase the resilience of people to the health and economic impacts of COVID-19.

8.4. COVID-19 recovery options for Kiribati

ESCAP dedicated the 2022 edition of its Economic and Social Survey of Asia and the Pacific to the issue of sustaining early recovery from COVID-19, with a focus on the challenges faced by developing countries (ESCAP, 2022b). The report advocates "spending smart and taxing fairly" to combat the fiscal shortfall. Investments in health care, social protection and education are critical for long-term sustainable development and future resilience but consume considerable resources. This should be offset by more efficient tax collection and a wider tax base. Even if these reforms were wholeheartedly accepted, they would take years to implement, and would not immediately provide the financial space needed for energy and or other investments to recover from the current crisis. Other forms of support are increasingly needed, such as debt service suspension, issuance of public bonds, debt swaps, the increased use of risk transfer instruments, and the relaxation of investment restrictions for sovereign wealth funds and pension funds (ESCAP, 2021).

Williamson (2022) mapped the Asia-Pacific countries by their SDG 7 composite values against the COVID stimulus-response (as a percentage of GDP) to propose different fiscal options for a sustainable energy-led recovery (figure 18). Kiribati is a small developing country that scores very well on SDG 7 progress but does not have the fiscal space to mount a stimulus. Its progress in SDG 7 reflects its strong renewable resource base and high levels of electricity access. However, Kiribati is below the pace of energy efficiency improvement required and has slow progress on clean cooking. The key recommendation for Kiribati is to enact measures to widen the fiscal space and focus on energy efficiency and on clean cooking, as the principal SDG 7 gaps.

Figure 18. Asia-Pacific countries mapped by equity and grant stimulus against SDG 7 composite score (Williamson, 2022)



9. Conclusion and the way forward

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

It is projected that Kiribati will achieve universal access to electricity by 2023. On the other hand, much needs to be done if Kiribati is to achieve universal access to clean cooking by 2030. Coordinated approach is therefore much desired from the private and public sectors in advancing the clean cooking gaps in order to provide clean technologies to the population. These are, for example, liquified petroleum gas stoves and improved cooking stoves, which build on current commonly used practices, while reducing fuel consumption and household indoor pollution.

The major concern of the energy sector of Kiribati is the heavy reliance on imported fossil fuel, particularly oil products. Ample opportunities exist in the residential, industrial, transport and commercial sectors to save a substantial amount of energy through the implementation of energy efficiency measures. The residential sector provides the biggest energy saving potential and should be the main focus, as this sector has the largest share of Kiribati's energy consumption, particularly via the adoption of clean cooking technologies. Kiribati has the potential to increase its ambition beyond what is needed for the SDG 7 energy efficiency target and to further reduce energy consumption in all sectors. For example, the introduction of MEPSL for household, commercial and industrial appliances is a key policy area to be considered, whereas in the transport sector the encouragement of mass transport and improvement of fuel economy will result in substantial energy savings. These measures will eventually reduce the energy sector's reliance on imported petroleum fuel.

Modern renewable energy delivered still accounts for a very small share, only 0.4 per cent of TFEC in 2021. Improvement of energy efficiency and increasing modern renewable energy share might increase the renewable energy share in TFEC to 32 per cent. The promotion of electric cooking stoves and electric vehicles in the long term will require a substantial amount of electricity in the future. Diversification of generation sources using solar PV and biodiesel might help the country to fulfil the increasing demand as well as improve energy security. The scenario analysis using the MCDA tool suggests that the Government should consider TNZ by 2050 scenario for transitioning the energy sector. In addition to achieving the SDG 7 targets, this scenario will also enable Kiribati to exploit its full potential for emission reduction in the long term. Finally, the energy transition pathway presented in this SDG 7 Road Map will support building back better after the COVID-19 pandemic. The proposed energy transition presents opportunities to reduce 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 this national Road Map is based on the results from the National Expert SDG 7 Tool for Energy Planning (NEXSTEP) project. NEXSTEP is an integrated tool for assisting policymakers in making informed policy decisions that will help in achieving SDG 7 and NDC targets by 2030. The SDG 7 and NDC targets are integrated in the LEAP energy model and back-casted from 2030, since the targets for 2030 are already defined.

Annex table 1. Targets and indicators for SDG 7

Target	Indicators	2021	2030
7.1. By 2030, ensure universal access to affordable, reliable, and modern energy services.	7.1.1. Proportion of population with access to electricity.	94%	100%
	7.1.2. Proportion of population with primary reliance on clean fuels and technology for cooking.	14.1%	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.	0.4% (excluding traditional biomass)	32%
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.	8.37 MJ/US$ (2017) PPP	5.86 MJ/US$ (2017) PPP

SDG 7.2. Renewable Energy.

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

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

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

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

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

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

Base period improvement rate for Kiribati (1990-2010): -1.46 per cent (negative sign means that the energy intensity increased during the given period).

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

II. Key assumptions for NEXSTEP energy modelling

(a) General parameters

Annex table 2. GDP, PPP and growth rate

Parameter	Value
GDP (2021)	US$ 180 million
PPP (2021, constant 2017 US dollar)	US$ 251 million
Growth rate	2.27%

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

Parameter	Value
Population (2021)	121,388
Population growth rate	1.63%
Number of households (2021)	20,679
Household size (constant throughout the analysis period)	5.87

(b) Demand-side assumptions

(i) Transportation

- Land and marine transport consumption is estimated using the vehicle statistics, load factor, annual travel mileage and estimated fuel economy as shown in annex table 4. The factors are based on vehicle statistics compiled by the local consultant and assumptions made by ESCAP and the local consultant, as local specific data is scarce.
- Land transport activities in 2021 are estimated to have been 152 million passenger-kilometres (47 million-km when considering only public transport) and 373 million tonne-kilometres. The growth in both passenger transport and freight transport activities is assumed as growing at the same rate as the population, i.e., 1.67 per cent per annum.
- Marine transport activities in 2021 are estimated to have been 22 million passenger-kilometres (11 million-km when considering only public transport) and 273 million tonne-kilometres. The growth both in passenger

transport and freight transport activities is assumed as growing at the same rate as the population, i.e., 1.67 per cent per annum.

Annex table 4. Passenger-km and tonne-km distribution

Land transport					
Passenger transport	**No. of vehicles**	**Annual mileage (km)**	**Load factor (pass-km/veh-km)**	**Fuel consumption**	**% share of passenger-km**
Passenger car	15,914 (gasoline)	730	2.5	12 km/l	19.1%
Motorcycle	43,592 (gasoline)	1,095	1.6	14 km/l	50.1%
Bus	10 (diesel)	14,600	40	8 km/l	3.8%
Minibus	705 (diesel)	7,300	8	8 km/l	27.0%
Freight transport	**No. of vehicles**	**Annual mileage (km)**	**Load factor (tonne-km/veh-km)**	**Fuel consumption**	**% share of tonne-km**
Freight truck	3,070 (diesel)	10,950	11	8 km/l	99.3%
Freight van	21 (diesel)	10,950	12	10 km/l	0.7%
Marine transport					
Passenger transport	**No. of vehicles**	**Annual mileage (km)**	**Load factor (pass-km/veh-km)**	**Fuel consumption**	**% share of passenger-km**
Small passenger vessel	16 (gasoline)	15,600	2.5	1.5 km/l	2.9%
Ferry	8 (gasoline)	33,800	40	0.05 km/l	50.2%
Fishing boat	5,341 (gasoline)	1,014	1.8	1.5 km/l	45.2%
Landing craft	13 (gasoline)	1,560	18	0.1 km/l	1.7%
Freight transport	**No. of vehicles**	**Annual mileage (km)**	**Load factor (tonne-km/veh-km)**	**Fuel consumption**	**% share of tonne-km**
Cargo	28 (diesel)	6,500	1,500	0.1 km/l	100%

(ii) Residential

- The residential sector is further divided into urban and rural households. Urban households have achieved a 100 per cent electricity access rate, while rural households have achieved an 86 per cent electricity access rate; the overall clean cooking rate was 14.1 per cent in 2021. The breakdown is shown in annex table 5.

Annex table 5. Cooking distribution in urban and rural households[16]

Stove type	Energy intensity (GJ/household)	Urban	Rural
LPG stove	2.95	15.2%	3.0%
Electric stove	1.93	7.0%	0.5%
Biomass stove*	78.38	27.4%	80.8%
Kerosene stove*	7.05	50.4%	15.7%

* *This is assumed as unclean fuel/technology.*

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

Annex table 6. esidential appliance baseline assumptions

Appliance	Electricity intensity (kWh/HH/year)	Ownership – urban	Electricity intensity (kWh/HH/year)	Ownership – rural
Lighting	262.8	100%	262.8	100%
Refrigerator	1,095.0	39%	1,095.0	4%
Electric kettle	438.0	16%	438.0	1%
Rice cooker	219.0	13%	219.0	1%
Washing machine	103.5	25%	103.5	3%
Sewing machine	18.0	12%	18.0	25%
Electric fan	98.6	60%	98.6	13%
Television and video	251.9	18%	251.9	5%
Stereo	164.3	31%	164.3	31%
Computer	91.3	33%	91.3	8%

(iii) Industry

- The industry sector is differentiated into seven subcategories. The fuel consumption by industry subcategories is as detailed in annex table 7.

16 The clean cooking access rate is indicated as 49.3 per cent (with uncertainty range from 33.6 per cent to 65.1 per cent) in (World Health Organization, 2022). The energy intensity is based on assumptions provided by the local consultant.

- The industrial GDP is assumed to grow at an annual rate of 2.27 per cent, similar to the national GDP growth rate. The energy intensity is assumed constant throughout the analysis period in the absence of energy efficiency interventions

Annex table 7. Fuel consumption by industry subcategories in 2021

Industry	Fuel consumption (ktoe)					
	Coal	Natural gas	Oil products	Electricity	Biomass	Total
Kiribati Fishing Limited	-	-	-	146.94	-	**146.94**
Kiribati Copra Mill	-	-	79.19	115.61	-	**194.80**
Betio Shipyard	-	-	-	10.28	-	**10.28**
Plant Vehicle Unit	-	-	-	6.87	-	**6.87**
Cenpac Producer Limited	-	-	-	26.38	-	**26.38**
Air Kiribati Limited	-	-	-	18.85	-	**18.85**
Kiribati Oil Company	-	-	-	9.32	-	**9.32**
Total	**-**	**-**	**79.19**	**334.24**	**-**	**413.44**

(iv) Commercial sector

- The total annual energy consumption in the commercial sector was 2,098 ktoe in 2021. It is projected to grow at an annual rate of 2.27 per cent, similar to the national GDP growth rate in the BAU scenario. Energy savings are, however, expected in the current policy scenario through the obligatory building standards.
- The commercial sector is further differentiated into four categories, and the energy consumption by categories are as shown in annex table 8.

Annex table 8. Commercial sector fuel consumption in 2021

Category	Floor space (million m^2)	Fuel consumption (ktoe)				
		Kerosene	Natural gas	LPG	Electricity	Total
Community service	61,198	210.35	-	119.59	104.47	434.41
Government building	77,613	261.76	-	37.80	225.14	524.71
Private business	78,803	203.74	-	207.87	402.89	814.50
Hotel	18,568	2.08	-	84.69	94.34	181.11
Educational institution	68,827	1.74	-	9.31	49.58	60.63
Worship centre	78,496	9.00	-	13.34	60.46	82.80
Total	**383,505**	**688.67**	**-**	**472.61**	**936.88**	**2,098.16**

(v) Other sectors

- The remaining demand is used for non-energy use. The consumption growth is projected to grow at an annual rate of 2.27 per cent, the same as the national GDP growth rate.

Annex table 9. **Consumption by other sectors in 2021**

Category	Fuel consumption (ktoe)					
	Coal	Natural gas	Oil products	Electricity	Biomass	Total
Non-energy use	-	-	160	-	-	160

III. Power technologies cost and key assumptions

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

Annex table 10. **Power technologies key assumptions**

Efficiency	Maximum availability	Investment cost (US$/kW)	Fixed O&M (US$/ kW-year)	Variable O&M (US$/MWh)
32.5	47.8%	1,800	37.7	6.4
-	20.1%	3,155	80	-
-	16.0%	6,175	130	-

IV. Economic analysis data for clean cooking technologies

The NEXSTEP economic model utilizes the technological and cost parameters to estimate the. annualised cost of clean cooking technologies (annex table 11). The calculation assumes an annual cooking thermal energy requirement of 1,623 MJ per household. In addition, a discount rate of 5.37 per cent is assumed.

Annex table 11. **Technology and cost data for clean cooking technologies**

Technologies	Efficiency[17] (%)	Lifetime[18] (years)	Stove cost (US$)	Variable O&M[19] (US$/year)	Fuel cost (US$)
ICS	30	4	25	10	0.22 per kg
LPG stove	65	7	30	10	3.23 per kg
Electric stove	84	15	37	10	0.40 per kWh

17 Sourced from: ICS – own estimation, LPG stove efficiency ranges – (World Bank, 2014), electric cookstove (induction stove) – (IEA, 2012).

18 Sourced from: ICS – own estimation, LPG stove – (Clean Cooking Alliance, 2021), electric stove – (IEA, 2012).

19 Variable O&M is based on own assumptions

V. Summary results for the scenarios

	BAU scenario	CPS scenario	SDG scenario	TNZ scenario
Universal access to electricity in 2030	100%	100%	100%	100%
Universal access to clean cooking in 2030	22.1%	65.5%	100%, via LPG stoves and ICS	100%, via LPG stove and ICS
Energy efficiency in 2030	8.06 MJ/US$	6.86 MJ/US$	5.86 MJ/US$	5.42 MJ/US$
Renewable energy share in TFEC in 2030	0.5%	9.6%	32%	36.1%
GHG emissions in 2030	125.7 $MTCO_{2\text{-}e}$	105.2 $MTCO_{2\text{-}e}$	97.5 $MTCO_{2\text{-}e}$	58 $MTCO_{2\text{-}e}$
Power sector optimization	Percent share	STREP	STREP	LEAP's Least Cost Optimisation
Renewable energy share in power generation in 2030	7%	28%	28%	100%
Net benefits from the power sector	US$ 169 million	US$ 142 million	US$ 142 million	US$ 146 million
Total investment for the power sector up to 2030	US$ 10.1 million	US$ 15.8 million	US$ 15.8 million	US$ 32.7 million