Energy Transition Pathways for the 2030 Agenda

SDG7 Roadmap for Fiji

NEXSTEP
National Expert SDG Tool for Energy Planning

Acknowledgements

The preparation of this report was led by the Energy Division of the Economic and Social Commission for Asia and the Pacific (ESCAP) in collaboration with Murdoch University, Australia, Global Green Growth Institute (GGGI), Fiji, the Department of Energy, under the Ministry of Infrastructure and Meteorological Services, Fiji and the Climate Change and International Cooperation Division, Ministry of Economy, Fiji.

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The review and valuable suggestions were provided by Hongpeng Liu, Director of the Energy Division, ESCAP, Michael Williamson, Section Chief of the Energy Division, ESCAP and David Ferrari, Economic Affairs Officer, Energy Division, ESCAP.

Robert Oliver edited the manuscript. The cover and design layout were created by Xiao Dong.

Administrative and secretariat support was provided by Prachakporn Sophon, Sarinna Sunkphayung, Nawaporn Sunkpho and Thiraya Tangkawattana.

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Energy Transition Pathways for the 2030 Agenda

SDG7 Roadmap for Fiji

Foreword: Fiji

The Sustainable Development Goal (SDG) Roadmap is the path to transform Fiji's energy sector towards achieving the SDG7 targets and our commitment to the Paris Agreement by 2030. It presents a matrix of technological options and strategies for the sector. The document also identifies gaps and the support needed to achieve the intertwined objectives of the SDG7:

i. Ensure universal access to affordable, reliable and modern energy services.
ii. Increase substantially the share of renewable energy in the global energy mix.
iii. Double the global rate of improvement in energy efficiency.

Our National Development Plan (NDP) and National Determined Contribution (NDC) Roadmap, mandate that we provide all Fijians with access to modern energy services and reduce carbon emissions by 30% in 2030. While good progress has been made so far in the energy sector, more needs to be done to achieve all SDG7 targets through enabling tools and a policy framework.

Our energy transition pathway presents a complex and challenging task for policymakers. Our vulnerability to the threats of natural disaster and climate change, oil price volatility, small market size and coupled with the unprecedented impacts of the COVID-19 pandemic is a great challenge to the sector and the economy at large.

The development of the National Expert SDG Tool for Energy Planning (NEXSTEP) is a godsend and timely. It enables policymakers to make informed policy decisions supporting the achievement of the SDG7 targets as our emission reduction targets (NDCs).

I am glad to note that this document was formulated through an open, transparent, inclusive and participatory consultation process with all stakeholders.

My sincere appreciation is extended to the UNESCAP and Global Green Growth Institute (GGGI) for their technical support and the New Zealand government for its financial support in the development of this Roadmap.

I commend that the SDG Roadmap as the way forward to marshal our efforts towards transforming our power sector and achieving our sustainable development goals and target.

Honourable Jone Usamate

Minister for Infrastructure &
Meteorological Services

Foreword: ESCAP

Energy is the key enabler of development for the Asia-Pacific region, particularly for Pacific Island countries such as Fiji. The COVID-19 pandemic has reinforced the need to change the development trajectory and to build back better. In this endeavour, transitioning to a sustainable, secure and least-cost energy system can form a key part of the recovery as well as pave the way to achieve the Sustainable Development Goals.

Energy self-sufficiency is critical for Fiji to enhancing its energy security as a Pacific Island nation with limited conventional energy resources. Goal 7 provides an opportunity to diversify energy resources and reduce dependence on imported fuels. Furthermore, Fiji's endowment of renewable energy resources – solar, wind, biomass and hydropower in particular – means that the country is well-positioned to establish a sustainable clean energy future through the energy transition.

This Roadmap for achieving Goal 7 presents a detailed assessment aimed at helping the country to reach a clean and green energy future, relying largely on its indigenous resources. It details a range of technical opportunities and policy options for reducing fuel imports with the adoption of fuel-efficient vehicles and moving towards a higher share of renewables in power generation, cutting emissions, saving energy and lowering the cost of power generation. The Roadmap offers an opportunity to leverage a least-cost sustainable energy development pathway and direct the investment savings to other critical sectors – such as healthcare – in building back better from the COVID-19 pandemic.

The Roadmap also examines how Fiji can enhance its Nationally Determined Contribution targets to further contribute to the attainment of the Paris Agreement. The combination of greater transport sector energy efficiency and the phasing out of fossil fuel-based power generation will offer Fiji the opportunity to raise its emission reduction ambitions further.

The Roadmap takes a holistic approach to the energy system by using the National Expert SDG Tool for Energy Planning (NEXSTEP). It presents an energy transition pathway that reflects Fiji's development strategies and aligns with global goals and targets. It also offers different scenarios 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.

Fiji is among the first countries in the Pacific region to develop a Goal 7 Roadmap. The success of this cooperative effort is a testament to our shared ambition for Fiji and the region to deliver on the sustainable energy vision of the Sustainable Development Goals, and provides an example for other countries looking to understand how they can begin taking up sustainable energy development opportunities.

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

Ms. Armida Salsiah Alisjahbana

Under-Secretary-General of the United Nations and

Executive Secretary of the United Nations Economic and Social Commission for Asia and the Pacific

Executive Summary

Transitioning the energy sector to achieve the 2030 Agenda for Sustainable Development and the objectives of the Paris Agreement presents a complex and difficult task for policymakers. It needs to ensure sustained economic growth as well as respond to increasing energy demand, reduce emissions, and consider and capitalize on the interlinkages between Sustainable Development Goal 7 (SDG7) and other SDGs. In this connection, the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) has developed the National Expert SDG Tool for Energy Planning (NEXSTEP).[1] This tool enables policymakers to make informed policy decisions to support the achievement of the SDG7 targets as well as emission reduction targets, i.e., 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 gained 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 SDG7 roadmap[2] is to assist the Government of Fiji to develop enabling policy measures to achieve the SDG7 targets. This roadmap contains a matrix of technological options and enabling policy measures for the Government to consider. Using national data, existing energy policies and strategies as well as other development plans, the NEXSTEP tool (methodology is presented in chapter 2) has developed seven scenarios for Fiji. These are the business-as-usual (BAU) scenario, current policy scenario, SDG scenario and four ambitious scenarios that look beyond achieving SDG7.

A. Highlights of the roadmap

Fiji has been making good progress towards achieving the SDG7 targets, but more needs to be done to achieve all SDG7 targets by 2030 through a concerted effort and the establishment of an enabling policy framework. Fiji is close to achieving universal access to electricity – only 4 per cent of its population was still to be connected in 2018, and are likely to receive access by 2024.[3]

Universal access to clean cooking technology and fuel, however, remains a challenge; about half of Fiji's population was still relying on unclean cooking technology in 2018. While Fiji has been making steady progress in recent years, more efforts will be needed to achieve universal access to clean cooking by 2030 through the development and implementation of targeted policy measures.

Likewise, energy efficiency improvement needs to be boosted across different sectors in order to achieve a 2.9 per cent annual improvement, reducing energy intensity to 2.18 megajoules per US Dollar GDP (measured in constant terms at 2011 PPP) by 2030.

As an island nation, which is currently heavily reliant on imported energy resources, energy security is high on Fiji's 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 hydro) 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 2018 share of 9.4 per cent (excluding traditional biomass). Moreover, the levelized cost of electricity from renewable power technologies has experienced a steep decline in the past decade, becoming economically more competitive than the conventional fossil fuel-based technologies.

1 The NEXSTEP tool has been specially designed to perform analyses of the energy sector in the context of SDG7 and NDC with the aim that the output will provide a set of policy recommendations to achieve the SDG7 and NDC targets. No other tool has been found suitable to fit this purpose.

2 This roadmap examines the current status of the national energy sector and existing policies, compares them with the SDG7 targets, and presents different scenarios highlighting technological options and enabling policy measures for the Government to consider.

3 Projected based on the historical improvement trend between 2007 and 2018. However, the timeline may be delayed due to the impact of COVID-19 crisis and Cyclone Yasa.

This offers Fiji an economically feasible solution to transition its energy sector to a low-carbon energy future while achieving the SDG7 targets and improving energy security.

Under current policies, the country is on track to meet the unconditional emissions reduction target of 10 per cent compared to the business as usual (BAU) scenario pledged under the Paris Agreement. The policies outlined under the SDG scenario would allow Fiji to achieve an emission reduction of 21 per cent, compared to the BAU scenario. The NEXSTEP analysis shows that the emissions reduction in this scenario would be achieved mostly by increasing the shares of fuel-efficient vehicles (i.e., hybrid) and RE in the power sector.

B. Achieving Fiji's SDG7 and NDC targets by 2030

Universal access to electricity

Around 4 per cent[4] of Fiji's population lacked access to electricity in 2018, primarily in rural or maritime areas and informal settlements. Achieving universal access to electricity is a priority for the Government of Fiji. The National Development Plan (Government of Fiji, 2017) states the objective is to reach a rate of 100 per cent by 2021. However, in consideration of the adverse impacts from the COVID-19 crisis and Cyclone Yasa, the Cabinet has readjusted the 2021 objective to an open-ended timeline.

Based on a continuation of the historical improvement trend between 2007 and 2018, the NEXSTEP analysis indicates that the remaining population will receive access by 20243 under the BAU scenario. 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.

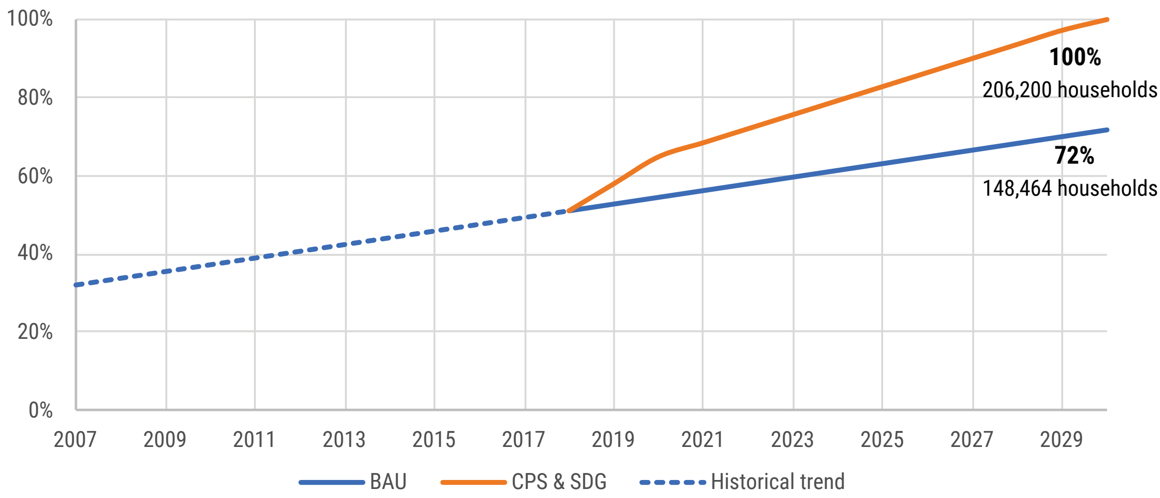
Universal access to clean cooking

In 2018, 51 per cent[4] of the population of Fiji was still reliant on unclean cooking fuel and technology, exposing them to poor indoor air quality and associated negative health impacts. A steady increase in the clean cooking access rate has been observed over the past decade, with an average addition of 1.7 per cent of the population gaining access each year. Nonetheless, based on the historical improvement trend between 2007 and 2018, it is projected that 28 per cent of Fiji's population will not have access to clean cooking by 2030.

The Government of Fiji has launched the Rocket Wood Stove Initiative, which aims to distribute cleaner, energy efficient rocket wood stoves to 60,000 households (UNFCC, 2021; and FBC News, 2020). It is expected that this initiative will bring the clean cooking access rate to 100 per cent by 2030, as modelled in the current policy scenario. Nevertheless, NEXSTEP suggests that electric cooking stoves and LPG stoves may provide the better alternatives as long-term solutions. Research has shown that improved cooking stoves (i.e., rocket wood stoves) require continual monitoring and follow-up to facilitate long-term adoption. Moreover, the low electricity tariff in Fiji also results in better affordability for electric stoves. Considering the lack of indigenous fossil fuel resources and domestic LPG production, electric cooking stoves are a better option than LPG cooking stoves for Fiji, as this reduces the reliance on imported fuels. However, considering the possible lack of sufficient power supply capacity for some households (i.e., households connected to mini-grid or solar home systems) to meet the power demand of electric stoves, LPG stoves may be the most appropriate technology for some households.

4 Based on data provided by the Department of Energy, Fiji.

Figure ES 1. Fiji's access to clean cooking under BAU, CPS and SDG model scenarios



Renewable energy

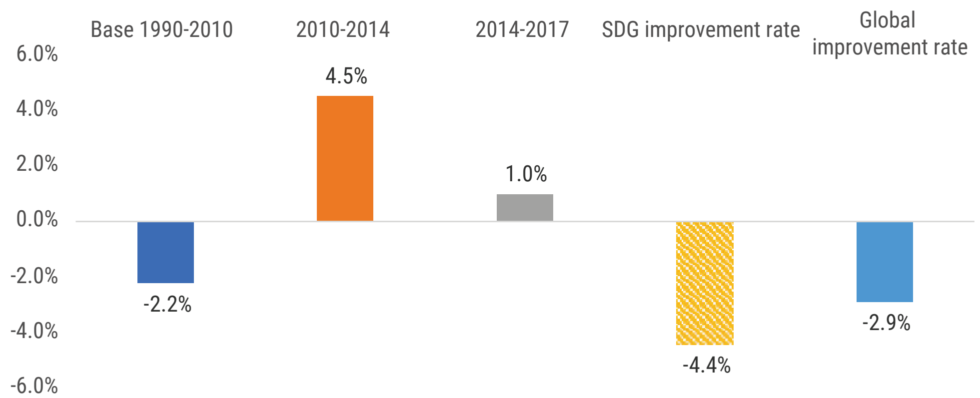
The share of renewable energy in the total final energy consumption (TFEC) was 9.4[5] per cent ("modern renewables", excluding traditional biomass) in 2018, or 11.4 per cent if traditional biomass usage is also considered. Based on the current policies, the share of renewable energy will increase to 14 per cent by 2030. The increase is due to the projected increase in the share of renewable electricity as per the current power expansion plan for 2020-2030, which is expected to increase the share of RE-based grid generation from 59 per cent of electricity in 2018 to 71 per cent in 2030. In the SDG scenario, the share of renewable energy is further improved to 14.5 per cent of TFEC in 2030. The additional 0.5 percentage point increase can be attributed to the application of several energy efficiency measures, which are projected to reduce TFEC by 56 ktoe, compared to the current policy settings.

Energy efficiency

Energy Intensity in Fiji declined at an average annual rate of 2.22 per cent between 1990 and 2010. A doubling of the 1990-2010 improvement rate is required to achieve the SDG 7.3 target, corresponding to an average annual rate of 4.44 per cent between 2018 and 2030. Consequently, the energy intensity in 2030 should be 1.80 MJ/USD_{2011}. This is an ambitious target for Fiji, which will be difficult to achieve in the short term, even with ambitious energy efficiency improvement measures. Therefore, NEXSTEP analysis suggests that Fiji's energy intensity target should be aligned with the global target of 2.9 per cent annual improvement. This corresponds to a 2030 energy intensity target of 2.18 MJ/USD_{2011}.

5 Based on author's calculation.

Figure ES 2. Fiji's energy efficiency target[6]



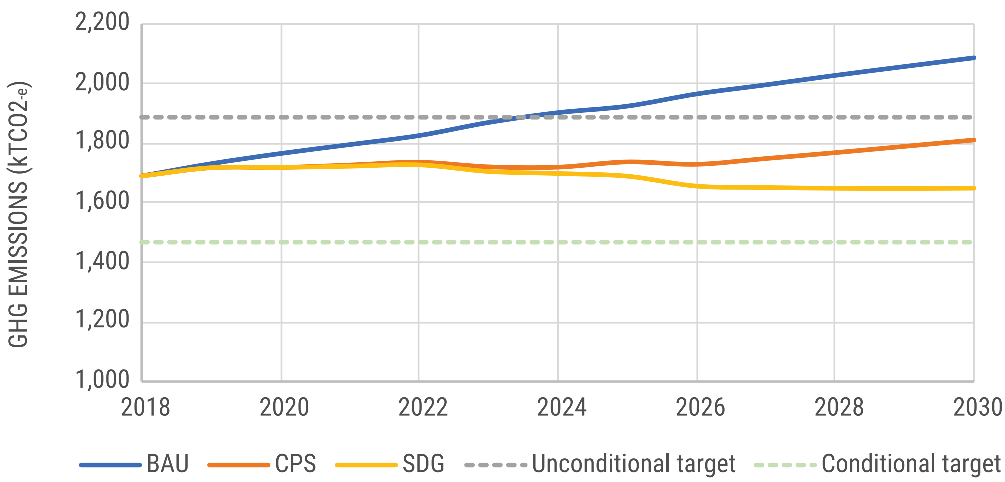
Under the current policy settings, the energy intensity is projected to drop to 2.37 MJ//USD$_{2011}$. Further effort is required to reach the proposed energy intensity target. There are ample opportunities for Fiji to achieve this target as well as implement a higher rate of improvement. These include, for example, introducing minimum energy performance standard (MEPS) for household appliances, rapid adoption of more efficient vehicles, and by energy efficiency measures in the marine transport sector. These opportunities are discussed in later sections of this report.

Nationally Determined Contribution

Fiji's Nationally Determined Contribution (NDC) document pledges an unconditional target of 10 per cent reduction and a conditional target of 30 per cent reduction (compared to the BAU scenario) by 2030. As similarly noted in the document, a 20 per cent reduction is possible through a 100 per cent renewable share in the power sector, while a further 10 per cent can be realised with economy-wide energy efficiency measures.

Under the current policy settings, Fiji is likely to meet the unconditional target of 10 per cent reduction. Emissions in the current policy scenario will reach 1,811 thousand tCO2-e (ktCO_2-e) by 2030, a 13 per cent reduction from the baseline. The SDG scenario is modelled to reach both the SDG energy intensity target and the NDC target. Correspondingly, the emissions will be 1,649 ktCO2-e in 2030, a 21 per cent reduction from the baseline. Figure ES3 shows the emission trajectories of the main scenarios.

Figure ES 3. Comparison of emissions by scenarios 2018-2030



6 Calculated based on data from the Asia Pacific Energy Portal.

C. Important policy directions

The key policy recommendations to help Fiji achieve the SDG 7 and NDC targets as well as enhance energy security include:

(a) Ramping up of renewable power capacity is cost-effective and contributes to both climate and sustainability objectives. Renewable power has become cheaper than conventional fossil fuel-based generation. Least-cost optimization analysis suggests that an early ramp-up of renewable power generation and reducing fossil-fuel-based generation to a minimum provide a larger financial benefit and pave the path towards a 100 per cent renewable power goal by 2036;

(b) Promotion of electric cooking stoves and LPG stoves as long-term solutions to achieving universal clean cooking access. NEXSTEP proposes electric cooking stoves and LPG stoves as alternative technologies to the rocket wood stove, as they require minimal follow-up and allow a substantial reduction of indoor air pollution. The choice between electric cooking stoves and LPG stoves is dependent on the household power supply capacity. Implementation of this programme will cost the Government of Fiji US$2.4 million to US$3.4 million[7] to achieve universal access to clean fuels and technologies for cooking by 2030;

(c) A multi-sectoral approach should be taken to realise energy efficiency improvement potential. Ample energy saving opportunities can be found in the residential, commercial and transport sectors. Policies such as appliance minimum energy performance standard and labelling scheme as well as building codes should be considered in order to leverage the energy reduction potential while providing positive financial gains;

(d) Transport sector energy efficiency measures are the key to achieving substantial energy savings and emissions reduction. The transport sector has the highest share of energy demand, largely relying on imported oil products. Progressive transport policies, such as minimum fuel economy standards and increasing the share of hybrid vehicles, should be considered in order to reach the SDG energy efficiency and NDC conditional targets, while enhancing energy independence.

7 Assumes full government subsidization covering the capital cost.

Contents

List of tables

List of boxes

List of figures

Abbreviations and acronyms

BAU	business-as-usual
CALGreen	California Green Construction Code
CBA	cost benefit analysis
CCGT	combined cycle gas turbine
CO2	carbon dioxide
CPS	current policy scenario
DoE	Department of Energy
EE	energy efficiency
EFL	Energy Fiji Limited
ESCAP	United Nations Economic and Social Commission for Asia and the Pacific
EV	electric vehicle
FJD	Fijian Dollar
GDP	gross domestic product
GGGI	Global Green Growth Institute
GHG	greenhouse gas
ICC	International Code Council
ICS	improved cooking stove
IEA	International Energy Agency
IER	Institute for Energy Research
IgCC	International Green Construction Code
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency
IRR	Internal Rate of Return
$ktCO_2$-e	thousand tonnes of carbon dioxide equivalent
ktoe	thousand tonnes of oil equivalent
kWh	kilowatt-hour
LCOE	Levelized Cost of Electricity
LEED	Leadership in Energy and Environment Design
LEAP	Low Emissions Analysis Platform
LPG	liquified petroleum gas
MCDA	Multi-Criteria Decision Analysis
MEPSL	minimum energy performance standard and labelling
MJ	megajoule
MoE	Ministry of Economy
MoIMS	Ministry of Infrastructure and Meteorological Services
MTF	Multi-Tier Framework
MW	megawatt
MWh	megawatt-hour
MWCPA	Ministry of Women, Children and Poverty Alleviation
NBI	New Buildings Institute
NDCs	nationally determined contributions
NDP	Five-Year and 20-Year National Development Plan 2017- 2036
NEMO	Next Energy Modelling system for Optimization
NEXSTEP	National Expert SDG Tool for Energy Planning
NREL	National Renewable Energy Laboratory
PCREEE	Pacific Centre for Renewable Energy and Energy Efficiency
PP	power plant
RE	renewable energy
SDG	Sustainable Development Goal
SIDS	Small Island Developing States
TFEC	total final energy consumption
TPES	total primary energy supply
US$	United States Dollar
WHO	World Health Organization
WorldGBC	World Green Building Council

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 Sustainable Development Goal 7 (SDG7) and other SDGs. In this connection, the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) developed the National Expert SDG Tool for Energy Planning (NEXSTEP). This tool enables policymakers to make informed policy decisions to support the achievement of the SDG7 targets as well as emission reduction targets (Nationally Determined Contributions – NDCs). The initiative was undertaken in response to the Ministerial Declaration of the Second Asian and Pacific Energy Forum (April 2018, Bangkok) and Commission Resolution 74/9, which endorsed its outcomes. NEXSTEP also gained 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 SDG7 roadmaps.

1.2. SDG7 targets and indicators

SDG7 aims to ensure access to affordable, reliable, sustainable and modern energy for all. It has three key targets, which are outlined below.

- Target 7.1. "By 2030, ensure universal access to affordable, reliable and modern energy services." Two indicators are used to measure this target: (a) the proportion of the population with access to electricity; and (b) the proportion of the population with primary reliance on clean cooking fuels and technology.
- Target 7.2. "By 2030, increase substantially the share of renewable energy in the global energy mix". This is measured by the renewable energy share in total final energy consumption (TFEC). It is calculated by dividing the consumption of energy from all renewable sources by total energy consumption. Renewable energy consumption includes consumption of energy derived from hydropower, solid biofuels (including traditional use), wind, solar, liquid biofuels, biogas, geothermal, marine and waste. **Due to the inherent complexity of accurately estimating traditional use of biomass, NEXSTEP focuses entirely on modern renewables (excluding traditional use of biomass) for 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 gross domestic product (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 2011 PPP.

1.3. Nationally Determined Contribution

Nationally Determined Contributions (NDCs) represent pledges by each country to reduce national emissions and are the steppingstones to the implementation of the Paris Agreement. Since the energy sector is the largest contributor to GHG emissions in most countries, decarbonizing energy systems should be given a high priority. Key approaches to reducing emissions from the energy sector include increasing renewable energy in the generation mix and improving energy efficiency. In its NDC document, Fiji has pledged to reduce GHG emissions by 10 per cent (unconditional) compared to business as usual and 30 per cent (conditional) with international support compared to business as usual by 2030.

2. Overview of Fiji's Energy Sector

2.1. Current situation

Geography and climate. The Republic of Fiji (referred to as Fiji) is one of the Small Island Developing States (SIDS) located in the heart of the south-western Pacific Ocean. The total land area is around 18,000 km^2, which includes 332 islands, of which 110 are inhabited (Republic of Fiji, 2017). The archipelago is mainly made up of small volcanic islands, low-lying atolls and elevated reefs. More than 87 per cent of the land mass is concentrated in the two largest islands, Viti Levu and Vanua Levu. The capital city of Fiji, Suva, is on the south-east coast of the largest island, Viti Levu. The Fijian weather is a mild tropical climate that experiences abundant rainfall under the prevailing south-eastern trade wind from the South Pacific Convergence Zone.

Population. The majority of the Fijian population lives on Viti Levu and Vanua Levu. (Republic of Fiji, 2017) The population in 2017 was 884,887, with an annual growth rate of 0.6 per cent between 2007 and 2017. The population living in the urban areas was around 56 per cent in 2017, a 16.3 per cent increase from 50.7 per cent in 2007 (Republic of Fiji, 2017). The Fijian population may exceed 1.1 million in 2036, of which 61 per cent would live in urban areas (Government of Fiji, 2017).

Economy. Fiji's GDP in 2019 was reported as US$5.5 billion (World Bank, 2020a). The growth rate between 2010-2018 was reported to be 4.2 per cent (Republic of Fiji, 2017). A higher growth rate was initially expected but hampered by the devastating Cyclone Winston in 2016. Fiji is classified as an upper-middle income economy with a GDP per capita of US$6,176 in 2019 (World Bank, 2020b). The historically strong growth of the economy has been supported by a broad range of sectors, including the booming tourism and construction sectors as well as the rising manufacturing, finance and transportation sectors (Government of Fiji, 2017). Fiji is one of the most developed and diversified nations of the Pacific Island Countries (PICs) with a large exclusive economic zone of approximately 1.3 million square kilometres. Fiji is endowed with a range of forest, mineral and marine resources. The country is also a regional hub for trade, transport, education and technical assistance, with numerous companies, aid agencies, environmental organizations and embassies serving the region from Suva (GGGI, 2019).

Climate change risks. Due to its geography, Fiji is vulnerable to potentially catastrophic weather events and climate change risks. It is ranked as the fourteenth most exposed country towards natural hazards such as earthquakes, hurricanes, flooding, drought and sea-level rise (Bündnis Entwicklung Hilft, 2017). In 2016, Fiji experienced a catastrophic cyclone event caused by tropical cyclone Winston, which caused devastated economic losses of US$ 0.9 billion (Republic of Fiji, 2017). More recently, in December 2020, another Category 5 tropical cyclone (Yasa) hit Fiji and caused extensive damage, particularly on Vanua Levu and its nearby islands.

Energy. In many of Fiji's national policies and frameworks energy has been a focus. For example, the 5-Year and 20-Year National Development Plan 2017-2036 (NDP) stipulates several energy targets in guiding the energy sector's development in the short to medium-term. Other guiding policies include the Maritime and Land Transport Policy 2015 and Fiji's NDCs. In addition, strategic documents such as the NDC Implementation Roadmap 2017-2030 and the Fiji Low Emission Development Strategy 2018-2050 have been developed to guide Fiji on its emission reduction efforts.

2.2. National energy profile

Access to electricity in Fiji was reported as 96.3 per cent in 2018, [8] leaving 32,740 people (7,100 households) without electricity access. The majority of the unelectrified households are in the rural and maritime areas as well as in informal settlements. Of those electrified households, about 80 per cent are connected to the main Energy Fiji Limited (EFL) power grids, while the remainder are powered by distributed or off-grid technologies such as a solar home system, village-based diesel or hydropower mini-grid

8 As provided by the DoE. The 2017 national census data reported an access rate of 95.3 per cent in 2017.

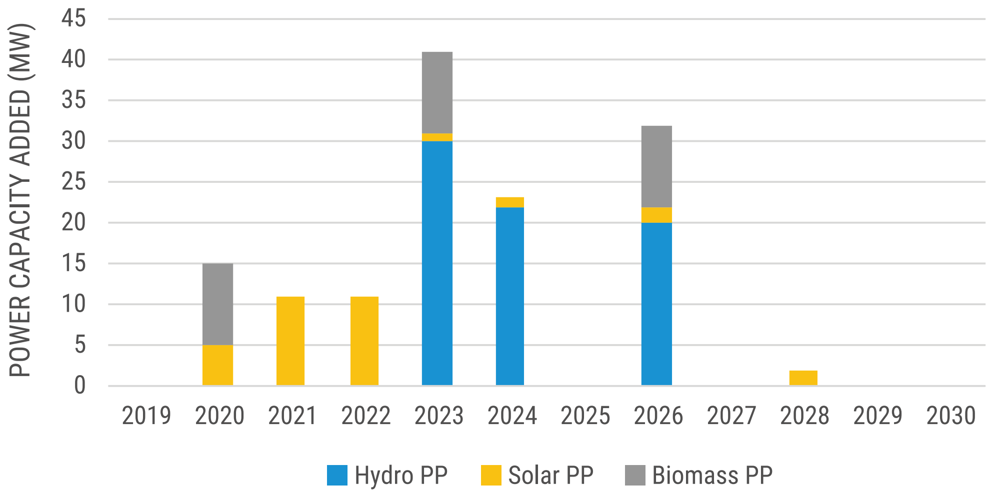
systems, or self-owned power generators.[9] One of the Government's priorities, stipulated in the Rural Electrification Policy (MoiMS, 2016) and the NDP (Government of Fiji, 2017), is to provide the population with universal access to electricity. A 100 per cent electrification access by 2021 target was originally stipulated in the NDP; however, because of the adverse impact of the COVID-19 crisis, the Cabinet readjusted the timeline for this target to be open-ended.

Access to clean cooking fuels was measured at 51 per cent in 2018.[10] The dominant clean cooking technology used by Fijian households is the liquefied petroleum gas (LPG) stove, making up around 37 per cent share of total stove usage distribution. Usage of electric stoves, mainly used by urban households, increased by around 10 percentage points from 2007 to 2017, reaching around a 15 per cent share. Fiji has progressed well in providing clean cooking access to its population during the past decade, raising the access rate from just 32.5 per cent in 2007[11] to 51 per cent in 2018. Yet, about half of its population still relies on unclean cooking technologies – mainly traditional biomass and kerosene stoves – posing risks to human health and the environment as well as contributing to climate change.

Renewable energy delivered approximately 9.4 per cent of TFEC in 2018. This excludes traditional biomass usage in residential cooking, which corresponds to an estimated amount of 10.6 ktoe. In 2018, renewable power generation makes up about 57 per cent of total generation.[12] Fiji has a high ambition in increasing its renewable energy share in power generation, with future planned capacity expansion being renewables only. Figure 1 shows the planned power capacity expansion for 2020-2030.[13]

The energy intensity in 2018 was calculated as 3.1 MJ/US$$_{2011}$.[14] A high reliance on imported petroleum is seen as a major challenge for Fiji, from the perspectives of both environmental sustainability and energy security. Various initiatives have been implemented, particularly in the transport sector, to improve energy efficiency to increase energy independence. For example, incentives have been provided to encourage the uptake of hybrid vehicles while emission standards have been tightened to indirectly attract more efficient vehicles. Other initiatives include the promotion of biomass use as transport fuel and in power generation (Government of Fiji, 2017). The NDP stipulates long-term energy intensity reduction targets (consumption of imported fuel per unit of GDP in MJ/FJD, and power consumption per unit of GDP in kWh/FJD) (Government of Fiji, 2017). Fiji also recognizes the contribution of energy efficiency improvement towards its NDC targets (Government of Fiji, 2015).

Figure 1. Planned capacity expansion, 2020-2030



9 As communicated by the DoE during the SDG 7 roadmap inception workshop.

10 As provided by the DoE.

11 Based on national census 2007.

12 Includes all forms of power generation (i.e., central grid, mini-grid and off-grid). Assumptions are made for mini-grid and off-grid generation, as output data are not readily available.

13 Information obtained through personal communication with EFL.

14 Author's calculation based on collected and assumed data for 2018.

2.3. National energy policies and targets

The development of Fiji's energy sector is guided by several national policies and frameworks. These have been used as guiding references for the NEXSTEP modelling, in order to better understand the Fijian context and to provide recommendations that adhere to the Government's overarching direction and aspiration. Where applicable, the currently implemented policies or regulations are considered in the current policy scenario,[15] to identify gaps in achieving the SDG7 and NDC targets. The policies or strategic documents consulted include:

- **The 5-Year and 20-Year National Development Plan 2017-2036** provides a forward-looking vision for Fiji in becoming a more progressive vibrant and inclusive society. It also stipulates several targets and objectives, covering the different socio-economic aspects, including the energy sector. The policies outlined in achieving a resource-efficient, cost-effective and environmentally sustainable energy sector include (Government of Fiji, 2017):
  - Access to affordable, reliable, modern and sustainable energy services for all Fijians;
  - Increase share of electricity generation from renewable energy resources;
  - Increase private sector participation in electricity supply through the reform of regulatory aspects of the electricity sector;
  - Improve energy efficiency in the electricity sector;
  - Increase the number of communities utilizing Fiji Rocket clean cooking stoves;
  - Reduce the cost of petroleum imports and develop biofuels (biodiesel and ethanol) further for electricity and transport, while ensuring safety and security of supply;
  - Long-term sustainability of renewable energy resources based on the principles of the Green Growth Framework.
- **A Green Growth Framework for Fiji**, developed in 2014, provides a guiding framework for Fiji through10 thematic areas. These include energy security, which outlines the way forward for Fiji's energy sector in the short term (up to two years), medium term (three to five years) and long term (beyond five years) (Ministry of Strategic Planning, National Development and Statistics, 2014).
- **Draft National Energy Policy, 2013-2020**, while not officially endorsed by the Government it outlines the policies and strategic actions in achieving the three main objectives (Government of Fiji, 2013) to:
  - Provide all Fijians with access to affordable and reliable modern energy services;
  - Establish environmentally sound and sustainable systems for energy production, procurement, transportation, distribution and end-use;
  - Increase the efficient use of energy and the use of indigenous energy sources to reduce the financial burden of energy imports on Fiji.
- **Maritime and Land Transport Policy, 2015** outlines the regulations and strategies for the land and maritime sectors (MoiMS, 2015):
  - **Land transport** – the policy sets out the age limit standard (under five years of age) for imported used cars, and emissions standards[16] for all newly registered vehicles. It also encourages the use of biofuels, incentivizing hybrid and electric vehicles through duty/concession;
  - **Marine transport** – the policy outlines the strategies in improving carbon and energy efficiency of the existing fleet, encourages the use of efficient/traditional vessels as well as renewable energy vessels as catalyst projects.
- **National Climate Change Policy, 2018-2030** presents a woven approach in defining Fiji's priorities in reducing present and future climate risks, and support the delivery of priorities set out in the NDP, NDC and SDGs. Targets stipulated in the National Climate Change Policy, (NCCP) include 100 per cent renewable electricity generation by 2030 and achieving carbon net zero by 2050 (MoE, 2019).

15 NEXSTEP considers only policies or directives with concrete measures that have been implemented in the current policy scenario. These are, for example, MEPSL for the domestic refrigerators and freezers as well as the Fijian Rocket Stove Initiative. Policies without concrete measures or a target-based indicator are not considered in the modelling. However, in chapter 8, "Revisiting Existing Policies", comparisons between the policy targets and NEXSTEP scenarios are offered to provide further insight. Comparisons in the SDG7 roadmap are made primarily with the NDP.

16 Euro IV-compliant in 2019. Available at https://www.fbcnews.com.fj/news/new-vehicles-imported-needs-to-be-euro-4-compliant/

- **Fiji's Nationally Determined Contributions**[17] outlines Fiji's commitment towards the Paris Agreement (Government of Fiji, 2015):
  - Unconditional target: 10 per cent reduction compared to the BAU scenario
  - Conditional target: 30 per cent reduction compared to the BAU scenario.
- **Enforcement of Minimum Energy Performance Standards and Labelling Programme (MEPSL) for household refrigerators and freezers** by the Department of Energy (DoE) stipulates that all refrigeration appliances imported into Fiji must comply with the Fiji/Australia/New Zealand Standards FS/AS/NZS 4474.1 and FS/AS/NZS 4474.2 from 2012 onwards (DoE, 2014).
- **NDC Implementation Roadmap 2017-2030** outlines an economy-wide pathway with mitigation actions in achieving the 30 per cent emission reduction compared to the BAU scenario from three aspects – (a) electricity generation and transmission, (b) demand-side energy efficiency, and (c) transportation (MoE, 2017).
- **Fiji Low Emission Development Strategy, 2018-2050** stipulates the economy-wide emission reduction pathways of various ambition levels, up to 2050. For the energy sector, recommendations are provided for (a) electricity and other energy use, (b) land transport, (c) maritime transport, and (d) domestic aviation (MoE, 2018).

2.4. National energy resource assessment

Fiji is dependent on petroleum imports to meet energy demand requirements, particularly in the transport sector. Fiji is endowed with abundant renewable energy resources (i.e., hydro, biomass, solar, wind, wave, tidal and geothermal) that are, or have yet to be tapped. According to the International Renewable Energy Agency (IRENA), a total of 220 MW of exploitable grid-connected hydropower potential is concentrated in the main islands (IRENA, 2015). Further exploitable potential may possibly be expanded as investigation is conducted at other potential sites. Hydropower is currently used as a dominant source for power generation, providing around 57 per cent of the grid electricity in 2018.

Biomass is mainly used in the residential sector by households for cooking fuel, drying of agricultural produce (copra) and, to a small extent, smoking of fish catches in the Maritime islands. A small percentage is used in co-generation by the sugar and wood industries. Fiji has rich biomass resources as it has substantial forest coverage, of which only 15 per cent of the total area is used for agricultural purposes (IRENA, 2015). The NDC Implementation Roadmap, 2017-2030, highlights the possible usage of agricultural waste for power generation (up to 28 MW), while sustainable biomass cultivation is required to supply more extensive biomass power generation (MoE, 2017). On the other hand, the National Renewable Energy Laboratory (NREL) has estimated that Fiji has a solar energy potential of 52,958 GWh per year (NREL, 2011). Prasad & Raturi (2020) suggested that a total generation of 170 GWh is possible with rooftop installations, while more can be achieved with ground installations within permissible areas with high solar irradiation.

It is noted that comprehensive wind assessment has not been conducted for Fiji. However, monthly wind speed distributions in seven locations during 1993-2005 have shown an annual average wind speed of 6.5 m/s (IRENA, 2015) . In addition, Fiji has an untapped geothermal potential of between 38 to 70 MW (IRENA, 2015). Altogether, this would allow renewable electricity generation of up to 491 GWh in a best-case scenario. Nevertheless, extensive research and investigation is needed before geothermal energy can be considered viable in Fiji.

2.5. National energy balance, 2018

The majority of the following 2018 energy data has been provided by DoE and GGGI, in consultation with various stakeholders, including the Fiji Bureau of Statistics (FBoS), Fiji Revenue and Customs Services and Energy Fiji Limited (EFL). Other publicly available resources were consulted. Transport activity data are based on data and assumptions provided by Prasad and Raturi (2018 and 2019), and MoE (2018). In the event that the required data are not available for 2018, statistical methods were applied to provide an estimation considering the activity growth. Further details are

17 The conditional target will be achieved if external funding amounting to US$500 million is available. It is noted that the NDC document outlines the possibility of achieving a 20 per cent reduction through 100 per cent power generation, while an additional 10 per cent can be achieved through further sector-wide energy efficiency improvement. However, the NEXSTEP analysis is based on the unconditional and conditional reduction targets.

Figure 2. Total primary energy supply in 2018 – 631.2 ktoe

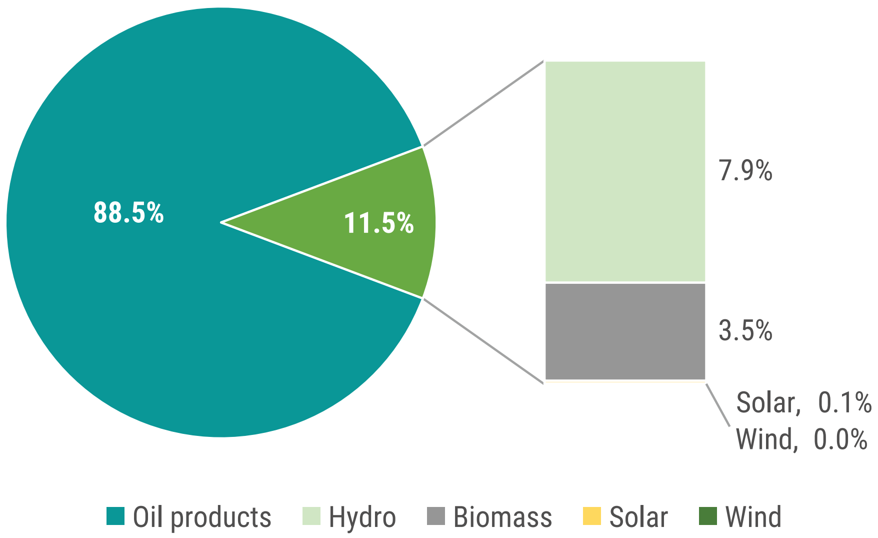
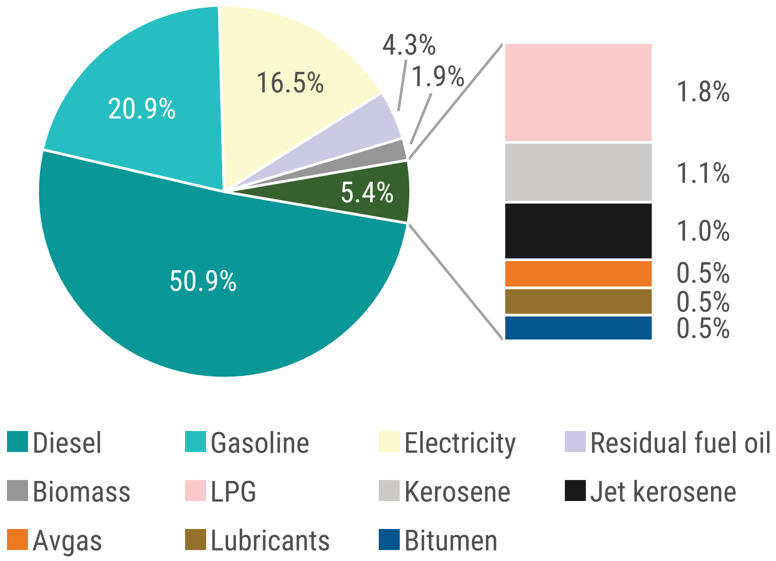


Figure 3. Total final energy consumption in 2018 – 549.6 ktoe



provided in Annex II. Figure 2 shows total primary energy supply (TPES) by sources in 2018.

Total final energy consumption in 2018 was reported to be 549.6 ktoe (figure 3). Energy use was dominated by diesel 279.9 ktoe (50.9 per cent), followed by petroleum at 115.1 ktoe (20.9 per cent), electricity at 90.6 ktoe (16.5 per cent), residual fuel oil at 23.6 ktoe (4.3 per cent) and biomass at 10.6 ktoe (1.9 per cent). The remaining 29.8 ktoe (5.4 per cent) comprised other oil products.

2.6. Energy modelling projections

The energy demand is estimated using the activity level and energy intensity in the Low Emissions Analysis Platform (LEAP) model. The demand outlook throughout the NEXSTEP analysis period is influenced by factors such as annual population growth, annual GDP growth, as well as other demand sector growth projections, as gathered from publicly available resources or governmental data. The assumptions used in the NEXSTEP modelling are further detailed in Annex II, while table 1 provides a summary on the key modelling assumptions for the three main scenarios (i.e. BAU, CPS and SDG scenarios).

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

Parameters	Business as usual	Current policy scenario	Sustainable Development Goal
Economic growth	3.5 per cent		
Population growth	0.6 per cent		
Urbanisation rate	56.9 per cent in 2019, gradually rising to reach 59.6 per cent in 2030		
Commercial floor space	2.1 million m^2 in 2018[18], annual growth rate of 2.6 per cent		
Transport activity	Includes land transport, domestic marine transport and domestic aviation sectors. See Annex II for detailed breakdown of transport activities		
Access to electricity	2024: 100%	2024: 100%	2024: 100%
Access to clean cooking fuels	Based on historical rate of improvement	Based on historical rate of improvement and current policies[19]	100 per cent access to clean cooking technologies by 2030 based on NEXSTEP recommendation
Energy efficiency	Additional energy efficiency measures not applied	Improvement based on current policies[20]	2.9 per cent[21] annual improvement in TPES target achieved
Power plant	Based on 2018 capacity share[22]	Power expansion plan, 2020-2030[23]	Gradual capacity addition based on the current power expansion plan in balance with the rising demand

2.7. Energy demand outlook

In the current policy settings, TFEC is forecast to increase from 549.6 ktoe in 2018 to 610.5 ktoe in 2030. TFEC is forecast to be 43.9 ktoe lower than the BAU scenario in 2030. This is due to the projected energy efficiency improvement associated with the continued effort from the MEPSL scheme for refrigerators and freezers, dissemination of ICS and the increasing market penetration of hybrid vehicles.

In 2030, the transport sector will have the largest share of TFEC at 407 ktoe (66.7 per cent), followed by the industrial sector at 94 ktoe (15.3 per cent), commercial sector at 63 ktoe (10.4 per cent) and the residential sector at 40 ktoe (6.5 per cent). The sectoral overview of energy demand in the current policy scenario is discussed below and shown in figure 4.

18 Author's calculation based on electricity consumption data and energy intensity assumptions per commercial building type.

19 This refers to the distribution of ICS to 60,000 Fijian households.

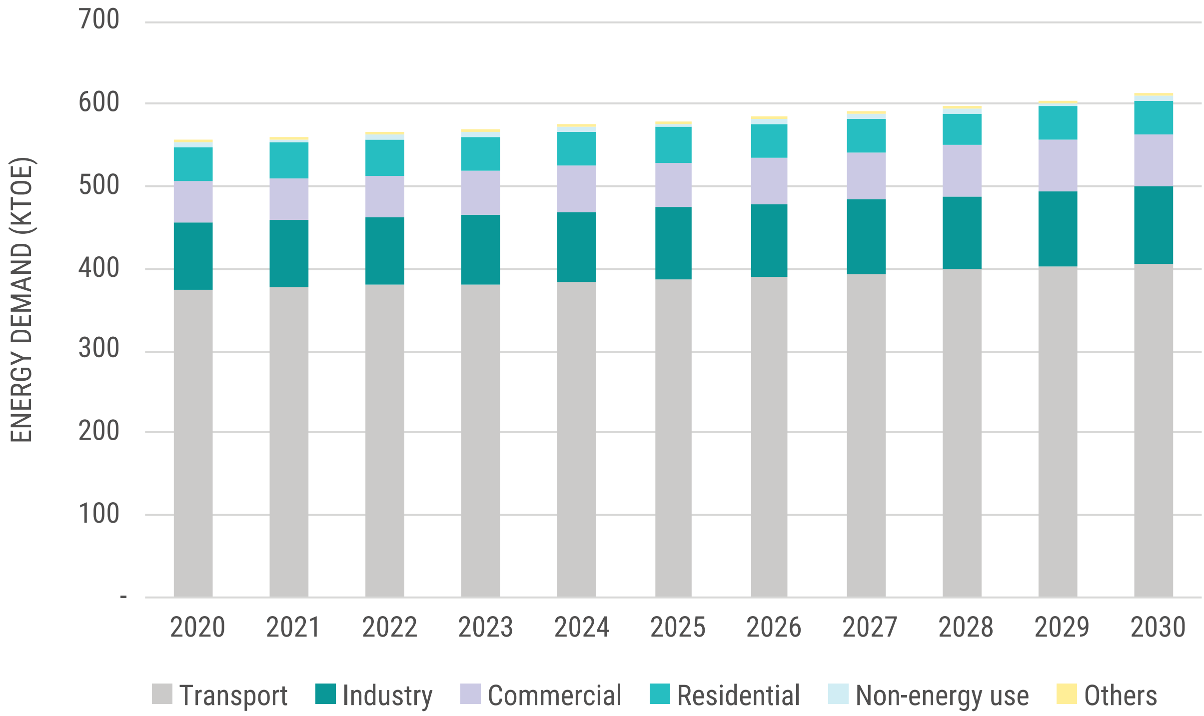
20 Energy efficiency improvement in the CP scenario as a result of ICS adoption, MEPSL for refrigeration and freezers as well as the tax incentives to promote hybrid vehicles, which have successfully raised the annual market sales to over 50 per cent. While vehicle age limit for used imported cars and EURO emissions standard have recently been enacted, the NEXSTEP analysis assumes that the average fuel economy of the vehicle fleet will remain constant without further implementation of minimum fuel economy standards.

21 In accordance with the global energy intensity reduction target.

22 Except for biomass capacity, which is being kept at 71.3 MW, assuming no expansion of the biomass co-generation plants owned by the sugar and wood industries.

23 Personal communication with Energy Fiji Limited.

Figure 4. **Fiji's energy demand outlook, CPS scenario**



(a) Transport sector

The transport sector's energy demand will continue to dominate Fiji's TFEC, and is projected to increase from 374.3 ktoe in 2018 to 407.3 ktoe in 2030. In 2030, the subsector share of transport energy demand will be: land transport at 302.8 ktoe (74.4 per cent), marine transport at 91.5 ktoe (22.5 per cent) and domestic aviation at 12.9 ktoe (3.2 per cent).

(b) Residential

Residential demand is projected to decrease to 39.9 ktoe by 2030, compared with 44.1 ktoe in 2018. In 2030, the subsector share of residential energy demand will be urban, 27.3 ktoe (68.5 per cent), and rural, 12.6 ktoe (31.5 per cent). The projected decrease in energy demand is attributable to the phasing out of unclean and inefficient cooking technologies (i.e., traditional biomass stoves and kerosene stoves). As projected in NEXSTEP, the energy demand for cooking decreases from 21.6 ktoe in 2018 to 9.1 ktoe in 2030 through the adoption of more efficient electric cooking stoves.

(c) Commercial

Commercial sector demand is projected to increase from 46.5 ktoe in 2018 to 63.3 ktoe in 2030. The sector is divided into seven subcategories, with each projected to grow annually by 2.6 per cent. The energy demand distribution is dominated by hotels, 18.7 ktoe (29.5 per cent), followed by governmental buildings, 13 ktoe (20.6 per cent). Other subcategories are private offices, 10 ktoe (15.9 per cent), hospitals, 8.9 ktoe (14 per cent), shopping malls, 7.3 ktoe (11.6 per cent), universities, 4.9 ktoe (7.8 per cent) and religious temples, 0.3 ktoe (0.5 per cent).

(d) Industry sector

Energy demand in the industry sector is expected to grow from 78.2 ktoe in 2018 to 93.5 ktoe in 2030. The share of energy demand from the 10 different industrial sectors are detailed in annex II. The energy intensity of the industrial sector is assumed to be constant, while the industrial sector GDP is projected to grow by 1.5 per cent annually.

2.8. Electricity generation outlook

In 2030 the demand for electricity in the current policy scenario will be 1,401 gigawatt-hours (GWh), an increase from 1,054 GWh in 2018. The demand will be the highest in the commercial sector at 736.5 GWh (53 per cent), followed by the residential sector at 379 GWh (27 per cent), industrial sector at 272 TWh (19 per cent) and others at 13.4 GWh (1 per cent).

Fiji's power generation comprises three categories: main grid power generation managed by EFL; mini -grid generation from diesel generators and mini/ micro-scale hydro systems; and off-grid solar home systems. This section discusses only the power generation associated with the main (EFL) power grids.

Fiji's installed electric power generation capacity in 2018 was 360.3 MW, of which 60 per cent was renewable generation capacity. In the current policy scenario, the NEXSTEP power generation analysis was conducted using planned capacity expansion data provided by EFL (figure 1). In this scenario, the total power capacity built reaches 495.3 MW by 2030. Figure 5 shows the capacity breakdown by technologies for 2018, 2025 and 2030.

In terms of power output, hydropower remains the dominating source of electricity supply, at 51.5 per cent in 2030. Power output by other renewable generation, i.e., solar, wind and biomass, increases to a total of 19.8 per cent in 2030, from just 4.2 per cent in 2018. Figure 6 shows the power generation by fuel type and renewable energy share in power generation in 2018, 2025 and 2030.

Figure 5. Installed generation capacity, CPS scenario

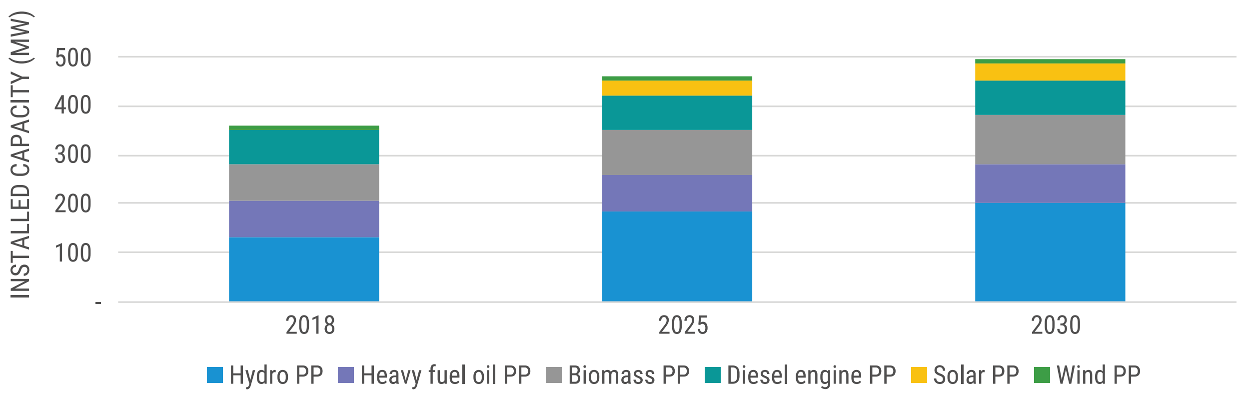
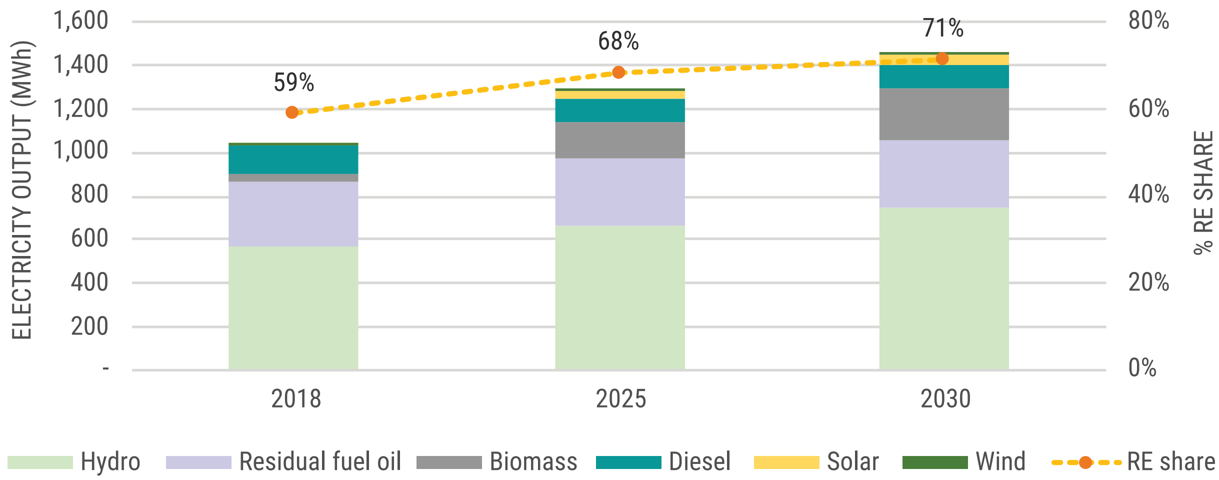


Figure 6. Electricity output by fuel type, CPS scenario



2.9. Energy supply outlook

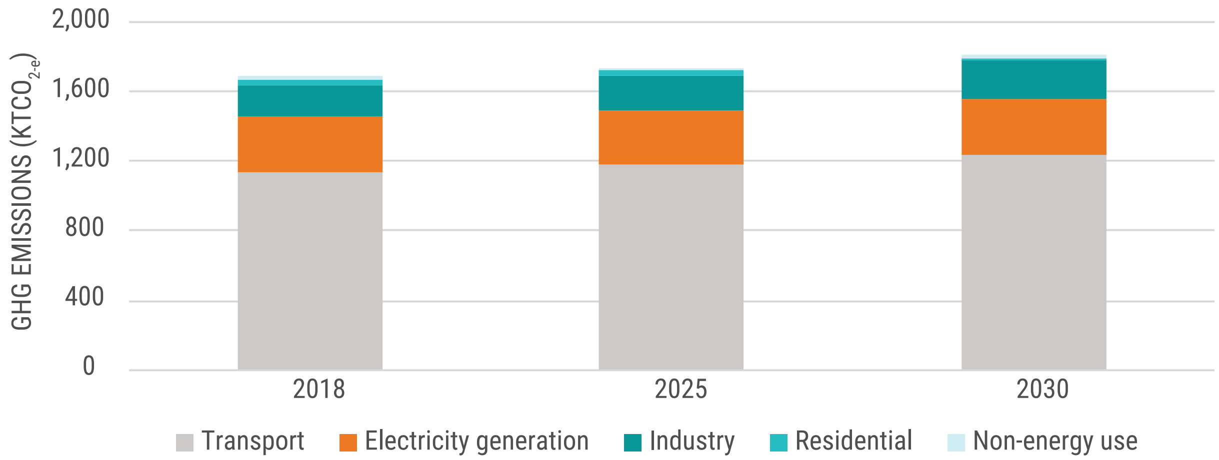
In the current policy scenario, TPES is forecast to increase from 631.2 ktoe in 2018 to 730.8 ktoe in 2030. The fuel shares in 2030 are projected to be oil products at 593.7 ktoe, biomass at 65.7 ktoe, hydro at 65 ktoe and other renewables at 6 ktoe. The share of oil products in the TPES decreases from 88 per cent in 2018 to 82 per cent in 2030. This is primarily due to the decreased use of oil products in power generation, as renewable capacity is ramped up throughout the analysis period as well as in the land transport sector with increasing uptake of hybrid vehicles and the reduced use of kerosene in residential cooking. Nevertheless, the high reliance on imported oil products in Fiji's economy may still pose a threat to its energy security, exposing Fiji to future price and supply shocks.

2.10. Energy sector emissions outlook

The energy sector greenhouse emissions are calculated in LEAP, based on IPCC Tier 1 emission factors. In accordance with the NDC document submitted to the United Nations Framework Convention on Climate Change (UNFCCC), Fiji's emission reduction targets refer to a 10 per cent unconditional reduction and a 30 per cent conditional reduction with international support, compared with the emissions in the BAU scenario in 2030.

In the current policy scenario, energy sector emissions in 2030 are projected to reach 1,811 ktCO2-e (figure 7), meeting the unconditional NDC target. This corresponds to a 13 per cent reduction from the BAU scenario.

Figure 7. Fiji energy sector emissions outlook in the current policy scenario



3. NEXSTEP methodology

The main purpose of NEXSTEP is to help design the type and mix of policies that would enable the achievement of the SDG7 targets and the emission reduction targets (under NDCs) through policy analysis. However, policy analysis cannot be done without modelling energy systems to forecast/backcast energy and emissions, and economic analysis to assess which policies or options would be economically suitable. Based on this, a three-step approach has been proposed. Each step is discussed in the following sections.

3.1. Key methodological steps

(a) Energy and emissions modelling

NEXSTEP begins with energy systems modelling to develop different scenarios in order to achieve SDG7 by identifying potential technical options for each scenario. Each scenario contains important information including the final energy (electricity and heat) requirement by 2030, possible generation/supply mix, emissions and the size of investment required. The energy and emissions modelling component use LEAP. It is a widely-used tool for energy sector modelling and for creating energy and emissions scenarios. Many countries have used LEAP to develop scenarios as a basis for their Intended NDCs. The Least Cost Optimisation method is used to calculate the optimal expansion and dispatch of the electric power system. Figure 8 shows different steps of the methodology.

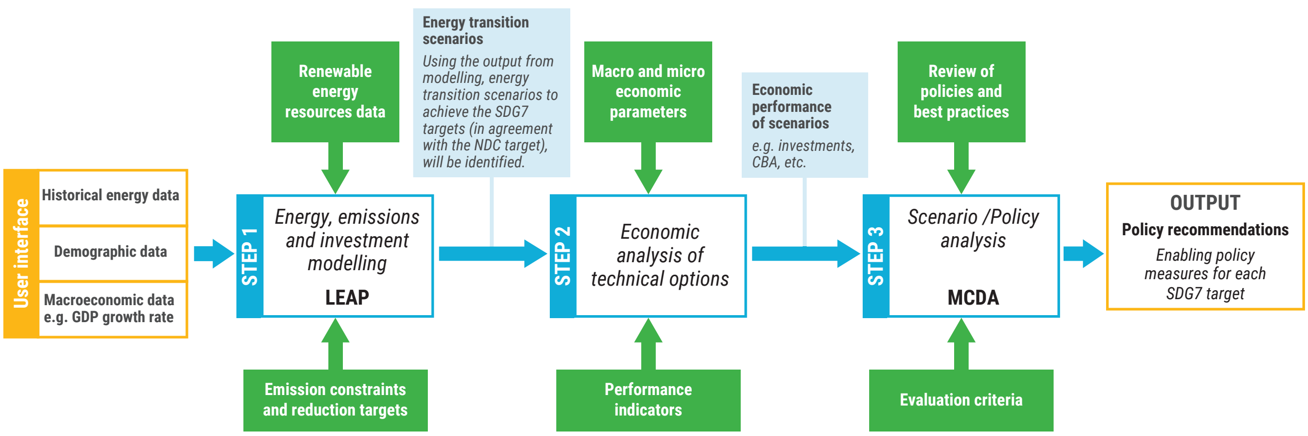
(b) Economic analysis

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

(c) Scenario and policy analysis

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

Figure 8. Different components of the NEXSTEP methodology



This tool is unique given the fact that no other tools look at developing policy measures to achieve SDG7. The key feature that makes it different is the backcasting approach for energy and emissions modelling. This is important when it comes to planning for SDG7 as the targets for the final year (2030) are already given; thus the tool needs to be able to work its way backwards to the current date and identify the best possible pathway.

3.2. Scenario definitions

The LEAP modelling system is designed for scenario analysis in order to enable energy specialists to model energy system evolution, based on current energy policies. In the NEXSTEP model for Fiji, three main scenarios have been modelled: (a) a BAU scenario; (b) Current Policy Scenario (CPS); and (c) Sustainable Development Goal (SDG) scenario. In addition, (d) several ambitious scenarios have been modelled, which look to raise Fiji's ambition beyond the SDG and the NDC targets:

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

(b) Current policies scenario. Inherited from the BAU scenario and modified, this scenario considers policies and plans currently in place. These are, for example, the Rocket Wood Stove Initiative and the minimum energy performance standard and labelling (MEPSL) scheme for refrigerators and freezers;

(c) SDG scenario. This scenario aims to achieve the SDG7 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 stove, LPG cooking stove and improved cooking stove) have been assessed, and subsequently recommended for the uptake of the most appropriate technologies. Energy intensity has been modelled to help achieve the SDG7 target. Finally, the unconditional NDC target has been used to estimate the optimum share of renewable energy in TFEC;

(d) Ambitious scenarios. Like the SDG scenario, these ambitious scenarios aim to achieve the SDG7 targets. In addition, these scenarios also look to increase the socio-economic and environmental benefits for the country from raising its ambition beyond just achieving the SDG7 targets – e.g., such as creating cost-effectiveness by further improving its energy efficiency beyond SDG7.3 target or reducing GHG emissions beyond its NDC targets through decarbonising the power sector.

3.3. Economic analysis

The economic analysis considers the project's contribution to the economic performance of the energy sector. The purpose of a Cost-Benefit Analysis (CBA) is to make better informed policy decisions. It is a tool to weigh the benefits against costs and facilitate an efficient distribution of resources in public sector investment.

3.3.1. Basics of economic analysis

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

3.3.2. Cost parameters

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

(a) Capital cost – capital infrastructure costs for technologies. These are based on country-specific data to improve the analysis. They include land, building, machinery, equipment and civil works;

(b) Operation and maintenance cost. This comprises fuel, labour and maintenance costs. Power generation facilities classify operation and maintenance costs as fixed ($/MW) and variable ($/MWh) cost;

(c) Decommissioning cost – retirement of power plant costs related to environmental remediation, regulatory frameworks and demolition costs;

(d) Sunk cost – existing infrastructure investments are not included in the economic analysis, since no additional investment is required for the project.

(e) External cost – refers to any additional externalities which place costs on society;

(f) GHG abatement – avoided cost of CO_2 generation is calculated in monetary value terms based on the carbon price. The 2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories is followed in the calculation of GHG emission for the economic analysis. The sectoral analysis is based on the Tier 1 approach, which uses fuel combustion from national statistics and default emission factors.

3.3.3. 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. The weighting for each criterion has been decided based on consolidated stakeholders' feedback gathered during the consultation workshop via an online polling platform. If deemed necessary, this step can be repeated using the NEXSTEP tool in consultation with stakeholders, where the participants may wish to change weights of each criterion, where the total weight needs to be 100 per cent. The criteria considered in the MCDA tool can include the following; however, stakeholders may wish to add/remove criteria to suit the local context:

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

4. SDG Scenario – achieving SDG7 by 2030

Access to affordable, reliable, sustainable and modern energy is essential to achieving the 2030 agenda for Sustainable Development and the Paris Agreement on climate change. This chapter provides details of the SDG scenario. It starts with the energy demand forecast and then discusses the energy sector in relation to the SDG7 targets and NDC targets.

4.1. SDG energy demand outlook

In the SDG scenario, TFEC increases slightly from 549.6 ktoe in 2018 to 554.9 ktoe in 2030. The reduction of 55.5 ktoe in TFEC in this scenario, compared to the current policy scenario, is due to the improvement in energy efficiency as per the SDG7 target. In 2030, the transport sector will have the largest share of TFEC at 356.1 ktoe (64 per cent), followed by industry sector at 93.5 ktoe (17 per cent), commercial sector at 60.4 ktoe (11 per cent), residential sector at 38.4 ktoe (7 per cent), non-energy use at 5.3 ktoe (1 per cent) and others at 1.1 ktoe (0.2 per cent). Figure 9 shows TFEC by scenarios in 2030.

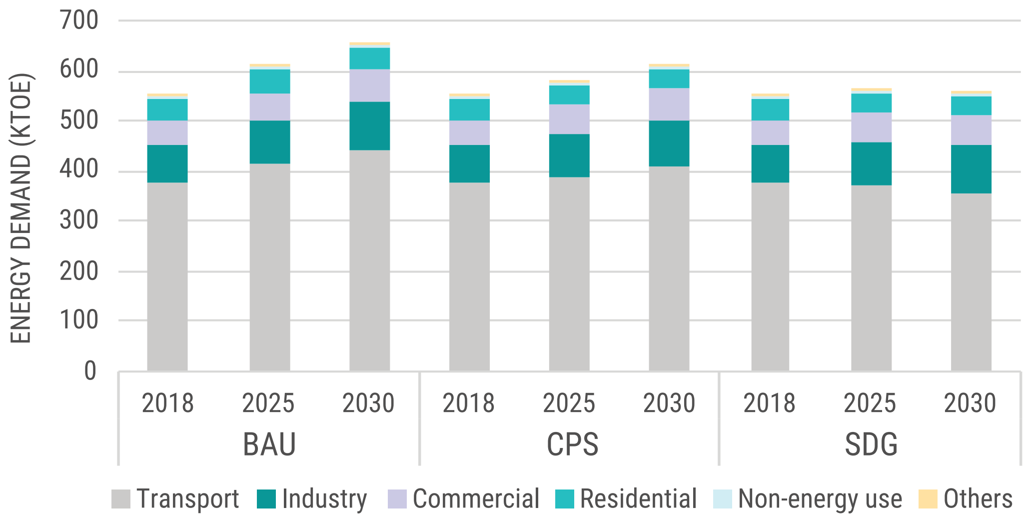
4.2. SDG7 targets

4.2.1. SDG7.1.1: Access to electricity

Fiji is on track to achieve the electricity access target within the timeline stipulated in the 2030 Agenda for Sustainable Development. The SDG scenario projects that the 100 per cent access rate[24] will be achieved by 2024, based on the historical improvement trend between 2007 and 2018. This would require continued effort to electrify the remaining 7,100 households (2018 data access rate). It is noted that the timeline may be delayed due to the impacts of the COVID-19 crisis and Cyclone Yasa. Considering the impacts from these two events, it has been decided by the Cabinet to shift the original targeted timeline (i.e., 2021) stipulated in the NDP to an open-ended timeline.

Data indicate that mini-grid solar PV systems and off-grid solar home systems may be the appropriate technologies to help accelerate the implementation process, particularly for the rural and marine settlements. Assuming that full government subsidization is given to the unconnected households, the total cost to the Government is estimated at between US$ 7.2 million and US$7.7 million.[25] Further

Figure 9. Projection of TFEC by sector, 2030, SDG scenario



24 The average energy demand per household to be electrified is estimated to be 800 KWh/HH/year, meeting Tier 3 of the Multi-tier Matrix for Measuring Household Electricity Consumption (Bhatia and Angelou, 2015).

25 The lower end assumes solar home system capital cost of US$ 1016 per household, which includes 600W solar panel, 700 VA inverter and 4kWh Lithium-ion battery storage while the higher end refers to mini grid solar system with capital cost of US$ 1080 per household (UNESCAP, 2020).

exploration of this option is included in the policy recommendations in subsection 4.4.1.

Electricity demand in the SDG scenario increases from 1,054 GWh in 2020 to 1,345 GWh in 2030. This has considered the assumed growth in different economic sectors as well as energy efficiency measures applied to achieve the SDG7 energy efficiency target (explained further in subsection 4.4.3).

4.2.2. SDG7.1.2: Access to clean fuels and technologies for cooking

Under the current policy setting, rapid advancement of clean cooking can be foreseen through the Government of Fiji's Rocket Wood Stove initiative, [26] which aims to reduce the use of traditional biomass stoves. It was recently announced that 60,000 families will benefit from the initiatives at no cost to them (FBC News, 2020; UNFCCC, 2021). With this initiative, in addition to the autonomous uptake of other clean cooking technologies (i.e., electric cooking stove and LPG stoves), based on the historical trend it is expected that the SDG7.1.2 clean cooking target[27] can be achieved, phasing out the use of kerosene and traditional biomass stoves.

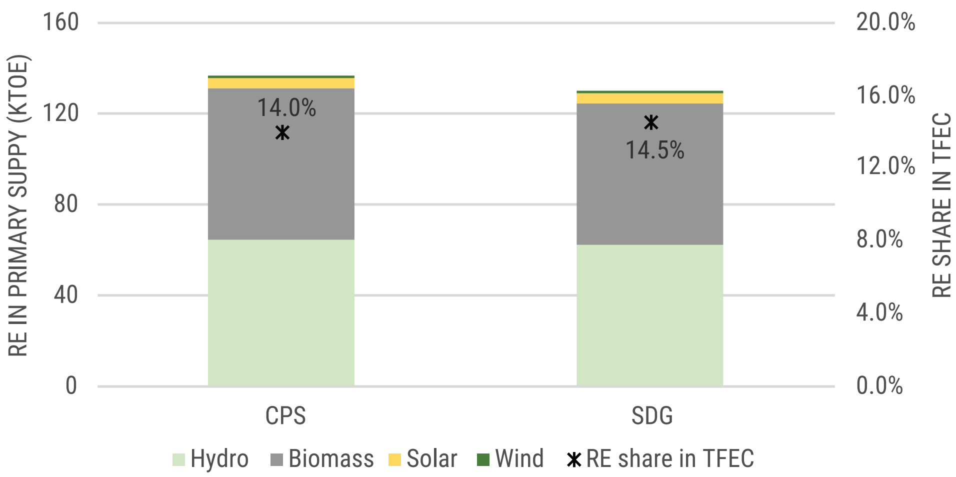
While the Rocket Wood Stove is a cost-effective means of providing clean cooking technologies to the remaining population, NEXSTEP found that electric cooking stoves and LPG stoves may be the most appropriate avenues to create a long-lasting impact. This recommendation is based on the NEXSTEP cost-benefit analysis in accordance with the Fijian context, as wells quantitative analysis based on international studies, on various options. Further qualitative and quantitative analysis results are included in subsection 4.4.2. Taking into consideration the electrification systems used in Fiji, which consist of mains grid connection, mini-grid and solar home systems, NEXSTEP stresses that uptake of electric cooking stove should be recommended to households with sufficient power supply capacity to accommodate the power demand required to run the electric stoves. On the other hand, LPG stoves may offer the best options for households connected to mini grids or isolated systems. The total cost required to distribute the clean cooking technologies (instead of ICS) will be from US$2.4 million to US$3.36 million,[28] if full subsidies are given to the 60,000 households.

4.2.3. SDG7.2: Renewable energy

SDG7.2 does not have a quantitative target, but encourages a substantial increase of renewable energy share in TFEC. The NEXSTEP methodology first estimates the net increase in energy demand in response to universal energy access (both electricity and clean cooking) and energy efficiency improvement. It then uses the unconditional NDC target for the energy sector to estimate the optimum renewable energy share in TFEC.

In the context for Fiji, the unconditional NDC target (10 per cent compared to the baseline) is readily achieved through energy efficiency measures

Figure 10. Renewable energy in TPES and TFEC, 2030



26 This initiative is launched as a Clean Development Mechanism (CDM) programme, coordinated by Korea Carbon Management Ltd in partnership with Kasabias (UNFCCC, 2021). It is noted that similar initiative has also been launched by the Ministry of Women, which has mobilized a collective PPP model approach to promote improved cooking stove (ICS) units in rural areas with development partners such as the United Nations The initiative has produced 1580 rocket wood stoves for households across 56 communities (South-South Galaxy, 2021).

27 Hereby assumes the ICS disseminated as part of the Fijian Rocket Wood Stove Initiative meets the WHO guidelines for clean cooking technologies.

28 Lower range refers to total capital cost required to distribute electric cooking stoves to 60,000 households at capital cost of US$40 per stove. Upper range refers to total capital cost required to distribute LPG stoves to 60,000 households at capital cost of US$ 56 per stove. Subsidization is for the capital cost only

expansion for the power sector as a guidance, gradually adding the power capacity to meet the growing demand. Together, these parameters set the renewable share in TFEC for the SDG scenario.

The share of renewable energy in TFEC in 2030 is 14 per cent under the current policy scenario (figure 10). This increase is largely driven by the increase in renewable energy share in power generation. In the SDG scenario, renewable energy share in TFEC is increased to 14.5 per cent. This additional 0.5 percentage increase is a result of the reduced energy demand due to energy efficiency measures.

4.2.4. SDG7.3: Energy efficiency

The primary energy intensity, a proxy for the measurement of energy efficiency improvement, is calculated as 2.37 MJ/US$$_{2011}$ in the current policy scenario, which corresponds to an improvement rate of 2.2 per cent (see box 1). Nevertheless, the required improvement in primary energy intensity to be achieved in the SDG scenario is 2.9 per cent (in accordance with the global improvement target), corresponding to a primary energy intensity of 2.18 MJ/US$$_{2011}$.

Energy savings potential can be found across the different demand-side sectors, specifically the residential, transport and commercial sectors. Figure 11 shows the energy savings potential achieved through the implementation of energy efficiency measures across the three sectors, compared with the CPS scenario. The transport sector has the largest contribution (51.1 ktoe), owing to its high share of energy demand. Opportunities can be found both through land and marine transport vehicles. The residential sector is projected to record a total savings of 1.5 ktoe through the implementation of the MEPSL scheme for several household appliances. Energy reduction can also be realised through the adoption of energy efficiency measures in the commercial sector. Further details of the energy efficiency measures and their impacts are provided in subsection 4.4.3.

Box 1. Fiji energy efficiency target explained

The calculation of the energy efficiency target for Fiji is explained below. The base period rate for calculating energy efficiency improvements is 1990-2010. ESCAP Asia-Pacific Energy Portal data for primary energy intensity are used to analyse improvements in the base period. In 1990, the primary energy intensity for Fiji was 5.33 MJ/ US$$_{2011}$, which had improved to 3.40 MJ/ US$$_{2011}$ by 2010. The compounded annual growth rate (CAGR) for primary energy intensity improvements in the base period is 2.22 per cent. The SDG target for energy efficiency requires doubling of improvement in primary energy intensity, which is 4.44 per cent per year. This is an ambitious – and likely infeasible - target to be reached by Fiji. Therefore, NEXSTEP proposes that Fiji's energy intensity target be aligned with the global target of 2.9 per cent annual improvement. This corresponds to an energy intensity target of 2.18 MJ/US$$_{2011}$.

Figure 11. Energy efficiency savings in the SDG scenario, compared to the CPS scenario

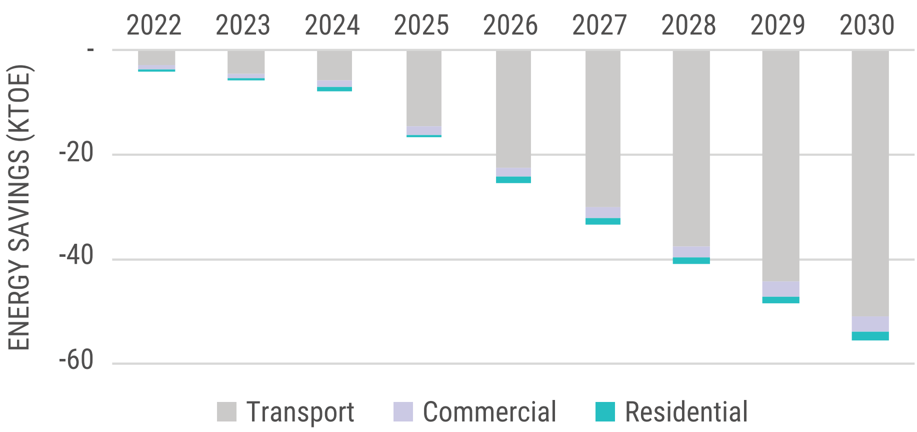
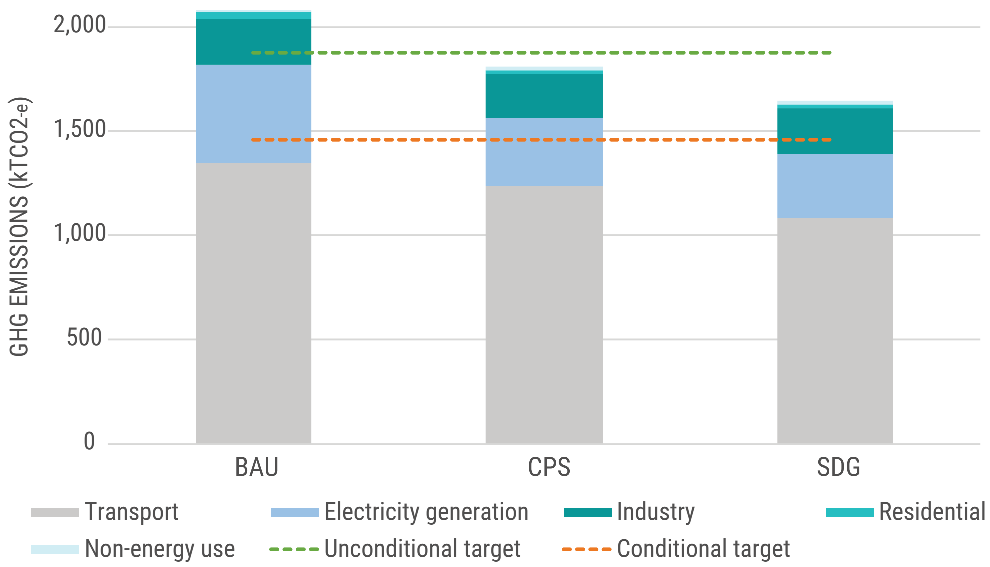


Figure 12. Emissions by scenario, 2030



4.2.5. NDC unconditional target

In the BAU scenario, emissions are projected to reach 2087 $ktCO_2$-e. Emissions in the SDG scenario are projected to be 1,649 $ktCO_2$-e in 2030. This corresponds to a 21 per cent reduction compared with the BAU scenario, which on track to achieve the unconditional NDC target. Figure 12 shows emissions in different scenarios.

4.3. Power generation in the context of SDG7

The demand for electricity in 2030 is estimated at 1,345.3 GWh in the SDG scenario, a decrease of 43 GWh compared to the CPS scenario. The electricity demand in the commercial sector is at 702.1 GWh (52 per cent), followed by the residential sector at 358 GWh (27 per cent), the industry sector at 272 GWh (20 per cent) and others at 13.4 GWh (1 per cent).

With reference to the EFL main grid power generation, the NEXSTEP power sector analysis for the SDG scenario builds on the current expansion plan for 2020-2030. It considers a gradual addition of power capacity in meeting the increased demand in accordance with the expansion plan. The estimated total installed power capacity in 2030 is 493.3 MW, with the technology breakdown shown in figure 13.

In terms of fuel mix in power generation, it is estimated that hydropower will be the dominant source (51.5 per cent) of power generation in the SDG scenario. With the ramped-up renewable power capacity, a decrease in fossil fuel power generation share is expected, which will decline from 41.1 per cent in 2018 to an estimated 28.7 per cent in 2030. The remaining is made up of other renewable-based power, which includes solar (3.1 per cent), wind (0.9 per cent) and biomass (15.8 per cent). Figure 14 shows power generation by fuel type in 2018, 2025 and 2030.

4.4. Policy actions for achieving SDG 7

4.4.1. Expediting electricity access advancement using off-grid renewable energy systems while being climate resilient

Fiji is on-track to achieve universal access to electricity by 2030. The NEXSTEP analysis recommends off-grid and distributed renewable energy systems, e.g., solar home systems or solar mini/micro-grid, depending on the remoteness of settlements, for rural electrification to improve climate resilience while facilitating rapid implementation.

Fiji's residential sector is powered with a mix of central grid electrification, mini- grid diesel/hydro generation and off-grid systems. As noted by DoE (2020), 78.9 per cent of the Fijian population is connected to the main grid managed by EFL, while 12.5 per cent utilizes an off-grid solar home system and 3.7 per cent lack electricity access; the

Figure 13. Power capacity share by technology type, 2030

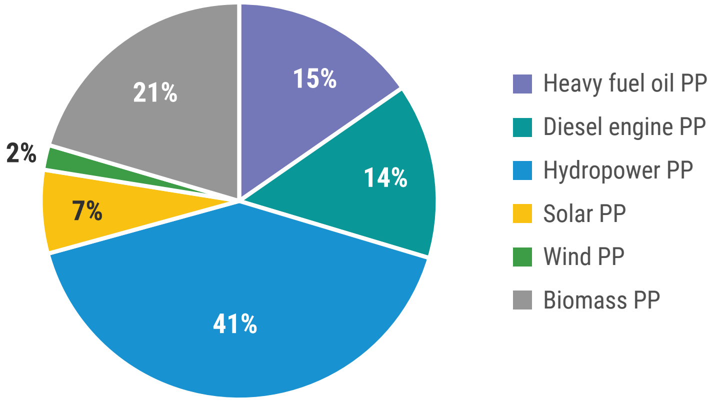
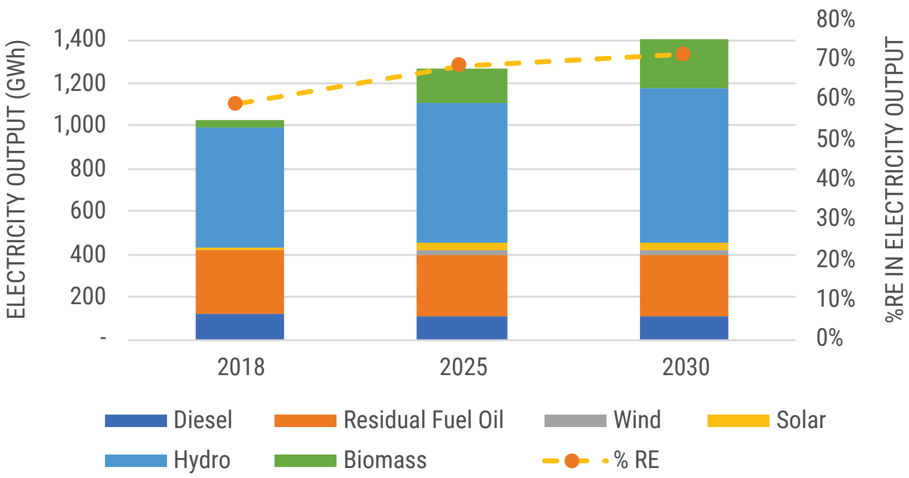


Figure 14. Power generation by fuel type, SDG scenario



remainder is powered through other means such as a village diesel mini-grid. The DoE is looking to accelerate the electrification process through a least-cost technology mix, including main grid extension, mini- grid and SHS installations.

Achieving last-mile connectivity is a major challenge in developing countries, due to remote communities and villages, complex terrain, low population densities, and levels of willingness and ability to pay by low-income households. The NEXSTEP analysis concurs the use of off-grid and distributed systems, i.e., solar home systems, particularly for settlements in rural and maritime areas, far from the central EFL grids. It is cost-effective and is resilient to climate shocks, an important factor to consider for cyclone-prone countries like Fiji. In addition, such modular installation can be implemented over a shorter period.

According to the World Bank (2017), off-grid solar home systems is a smart solution to address climate vulnerability and build resilience. For example, when Tropical Cyclone Pam caused damage to 65 km of power lines in Vanuatu, leaving 12,000 customers without power, residents with solar home systems prepared early for the storm by storing equipment inside households.

Similarly, Bangladesh is another good example of the implementation of solar home systems, where 3.95 million customers have access to electricity and resilience has been built against storm surges (World Bank, 2017). Prioritizing awareness and building resilience to extreme weather events and climate change is crucial in Fiji. From an energy security perspective, increasing off-grid renewable energy generation will reduce dependency on fuel imports and increase self-sufficiency.

4.4.2. Electric cooking stove and LPG stove as a long-term solution in achieving universal access to clean cooking

Electric cooking stoves and LPG stoves offer alternative technologies in advancing clean cooking access, serving as long-term solutions. Fiji can also capitalise on both the low electricity cost and high renewable energy share in power generation to promote electric cooking stoves in settlements connected to electrification systems with sufficient power supply capacity (i.e., EFL main grid). While still requiring imported oil products, LPG stove may be the better alternative compared to ICS in ensuring long-term adoption of clean cooking, where an electric cooking stove is not an appropriate solution.

Clean cooking technologies evaluated

(a) Electric cooking stove

Fiji has renewable electricity generation potential that can be used to promote electric cooking stoves, particularly by households with access to sufficient power supply capacity. In addition, Fiji has a comparatively low electricity tariff compared to the other Pacific Island Countries (Islam and Mamun, 2017), making the use of electric cooking stoves generally affordable at the household level. The 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. They can be generally divided into two types – solid plate and induction plate. While a solid plate cooking stove uses a heating element to transmit radiant energy to the food and reaches 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. Nonetheless, to maximise the benefits that electric cooking stoves can offer, Fiji may consider establishing a minimum energy performance standard for electric cooking stove to prevent the infiltration of poor performing products.

(b) Improved cooking stove

Studies suggest that ICS programmes often have low adoption rates due to inconvenience of use, preference for traditional cooking stoves, and the need for frequent maintenance and repairs. ICS programmes initially require strong advocacy to promote adoption, after which they require ongoing follow-up, monitoring, training, maintenance and repairs in order to facilitate continuing usage. Based on the World Health Organization (WHO) guidelines on emission rates for clean cooking, only certain types of ICS technology comply, particularly when considering that cooking stove emissions in the field are often higher than they are in laboratory settings used for testing. Based on the need for ongoing follow-up, ICS serves better as a temporary option, but is not suitable as a long-term solution.

(c) Biogas digester

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

(d) LPG cooking stove

LPG supply in Fiji is constrained due to fuel import dependency and international supply chain challenges. LPG cooking stoves generate lower indoor air pollution compared with ICS. They are classified as Level 4 in World Bank MTF[29] for cooking exposure and reduce indoor air pollution by 90 per cent compared to traditional cooking stoves. It is estimated that an LPG stove has a slightly higher annualised cost than an electric cooking stove and requires imported fuel. However, based on stakeholder's suggestions, LPG stoves may be a more appropriate technology to be promoted to households without sufficient power supply capacity (i.e., solar home systems).

29 Available at http://documents.worldbank.org/curated/en/937711468320944879/pdf/88699-REVISED-LW16-Fin-Logo-OKR.pdf

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

Technology	Annualized cost
ICS	US$34
LPG stove	US$240
Biogas digester	US$ 31
Electric stove	US$229

Table 2 summarizes the estimated annualized cost of different cooking technologies in the context of Fiji. Annex IV summarizes the cost and technical assumptions used in the economic analysis.

4.4.3. Multi-sectoral approach to achieve SDG energy efficiency target, while allowing cost savings and enhancing energy security

Energy efficiency policies across sectors can help to achieve substantial energy savings. At the same time, reducing grid infrastructure and reliance on imported fuels, shields Fiji from future price and supply shocks. Policymakers should improve Fiji's energy efficiency strategy by including the appropriate technological options, targets, implementation timelines and enforcement.

Achievement of the recommended SDG7 target of 2.18 MJ/US$$_{2011}$ by 2030 will require a 2.9 per cent reduction in energy intensity per year up to 2030. NEXSTEP analysis identified the following measures to support this reduction across different sectors. Annexes V to VII provide a detailed explanation of the energy efficiency measures and the modelling assumptions applied.

(a) Residential sector – estimated total savings: 2.8 ktoe

(i) MEPSL for new lights sold from 2022 onwards – estimated energy savings in 2030: 1.2 ktoe.

(ii) MEPSL for all new televisions from 2022 onwards – estimated energy savings in 2030: 1.0 ktoe.

(iii) MEPSL for all new air-conditioners from 2022 onwards – estimated energy savings in 2030: 0.55 ktoe.

It should be noted that MEPSL has already been implemented for refrigerators and freezers since 2012 and is modelled in the CPS scenario. In the NEXSTEP analysis, the introduction of additional MEPSL schemes has been modelled from 2022 onwards to provide policymakers time to prime the market participants.

(b) Land transport sector – estimated total savings: 34.3 ktoe

(i) From 2025 onwards, 75 per cent market sales share[30] for hybrid private passenger vehicles– estimated energy savings in 2030: 11.1 ktoe.

(ii) From 2025 onwards, 75 per cent sales market sales share for hybrid public passenger[31] vehicles– estimated energy savings in 2030: 3.4 ktoe.

(iii) 75 per cent market sales share for hybrid buses from 2025 onwards – estimated energy savings in 2030: 10.0 ktoe.

(iv) Introduction of minimum vehicle fuel economy standard for diesel freight trucks from 2025 onwards – estimated energy savings in 2030: 9.8 ktoe.

In the NEXSTEP analysis, new policy measures for land transport are assumed to be effective from 2025 onwards.

(c) Marine transport sector – estimated total savings: 16.9 ktoe

(i) Gradual adoption of operational efficiency measures (i.e., hull coating and cleaning, and propeller polishing) for vessels more than 15 metres, reaching a 100 per cent adoption rate by 2030 – estimated energy savings in 2030: 10.6 ktoe.

30 It is noted that the implemented tax incentives have successfully raised the market sales of passenger and public hybrid vehicles to more than 50 per cent, as already modelled in the CPS scenario.The SDG scenario builds on the 50 per cent market sales in the CPs scenario, and proposes raising it to 75 per cent from 2025 onwards.

31 This refers to taxis and rental cars

(ii) Gradual replacement of two-stroke outboard motors to efficient four-stroke outboard motors to reach a 60 per cent share by 2030 – estimated energy savings in 2030: 6.3 ktoe.

(d) Commercial sector – estimated total savings: 2.96 ktoe

(i) Adoption of green building measures in 50 per cent of all government buildings by 2030 – estimated energy savings in 2030: 1.96 ktoe.

(ii) Adoption of green building measures in all newly constructed hotel buildings – estimated energy savings in 2030: 1.0 ktoe.

It is considered that the implementation of the above energy efficiency measures will enable the achievement of SDG7.3 energy efficiency by 2030. It should be noted that these are not the only energy efficiency measures applicable to Fiji, but other opportunities can also be sought to enhance energy savings further. For example, other household appliances (i.e., electric heaters) may be considered as part of the MEPSL scheme in the future.

Energy saving measures for the transport sector have multi-fold benefits. Reduced fuel use in the transport sector will allow a significant reduction of carbon emissions, while at the same time enhancing Fiji's energy security, as an estimated 68 per cent of imported oil products were consumed by the transport sector in 2018. Fiji recently stepped up its regulations for land transport with the aim of indirectly improving the fuel economy of the vehicle fleet and reducing pollutant emissions. New regulations will limit the age of imported used cars and require newly imported cars to be EURO IV-compliant.[32] In addition, Fiji has successfully raised the market sales of hybrid vehicles to more than 50 per cent since the introduction of tax incentives.

NEXSTEP further shows that hybrid sales can be raised to 75 per cent, while the introduction of minimum vehicle fuel economy standards can be implemented for freight trucks in order to realise additional energy savings to meet the SDG target. Minimum vehicle fuel economy standards are widely adopted by other countries, including Japan which is a major car exporter to Fiji. In the European Union's bid to become climate neutral by 2050, the European Commission has also further strengthened its mandatory emission targets for new cars and vans, calling for a 37.5 per cent and 31 per cent reduction from 2030 onwards, respectively, using 2021 as the starting point (European Commission, 2020a). On the other hand, in the marine transport sector, substantial fuel savings can be realised through the adoption of regular hull and propeller maintenance. Incentives should also be given to accelerate the transition from two-stroke to four-stroke outboard motors. In terms of contribution towards the NDC, it is estimated that applied road and marine transport measures will lead to a reduction of 155.5 ktCO_2-e in 2030.

The adoption of green building measures in the commercial sector (see box 2 for more information) can be encouraged through setting/updating the national building codes. Some groundwork has been done in investigating the potential of incorporating energy efficiency into the national building code (New Buildings Institute, 2014). Energy reduction, as modelled in the SDG scenario, are limited to government buildings and hotel buildings, with a total estimated energy reduction of around 3 ktoe. While not explored in the NEXSTEP analysis, significant potential savings can also be found in other commercial subsectors, e.g., private offices, shopping malls etc. Hence, adoption of green building measures should be enacted across all building types, allowing further energy/electricity reduction. Indirectly, the reduction of electricity demand will allow reduced power infrastructure needs.

32 Euro IV-compliant in 2019: See https://www.fbcnews.com.fj/news/new-vehicles-imported-needs-to-be-euro-4-compliant/

Box 2. Policy options for a more sustainable building sector

The building sector contributes significantly to global energy consumption and GHG emissions. This calls for adoption of green building measures and designs in new and existing building stocks to allow energy savings and rapid GHG emissions reduction in order to meet the Paris Agreement. A 'green' building can be defined as "a building that, in its design, construction or operation, reduces or eliminates negative impacts, and can create positive impacts, on our climate and natural environment" (WorldGBC, 2021). Green building adoption can be made obligatory through the implementation of building codes or promoted with certification/rating systems.

The building code is a comprehensive set of mandatory minimum building standards. One example is the 2018 International Green Construction Code (IgCC), developed to aid government jurisdictions in administering minimum requirements covering the design, construction and operation of buildings (International Code Council, 2021).

Another implemented green building code by state jurisdiction is the California Green Building Standards Code (CALGreen) (State of California, 2021). Certification systems or rating tools, which provides third-party assessment and confirmation that a building meets certain green requirements or standards, are also widely used. Examples are the LEED (Leadership in Energy and Environmental Design) rating system and Australia's Green Star Buildings rating tool. For example, the Green Star certification has been given to almost 3,000 buildings with an average reduction of 56 per cent (Green Building Council of Australia, 2020).

Box 3. National biofuel policy of Fiji

The drafting of the National Biofuel Policy (NBP) of Fiji and the corresponding National Biofuel Strategic Action Plan is underway and are expected to commerce in 2021. The NBP echoes the Government's commitment to decarbonise the energy sector with biomass, paving the way towards a carbon net-zero economy by 2050. It also draws its rationale from strategies and goals stipulated in various governmental policies and frameworks (i.e., NCCP, NDP, LEDS). The strategic action plan stipulates the actions, areas and actionable items during 2021-2045. The primary objective of the documents is to reduce the GHG emissions by 37 kton per annum by 2030, as envisioned in the NDC Implementation Roadmap 2017.

A biofuel-based approach brings in financial and environmental benefits, while at the same time strengthening Fiji's energy security. Nonetheless, a comprehensive policy is required to address several issues, such as feedstock supply chain and encouraging market uptake. The NBP serves to provide a framework in addressing the following four key areas:

1. Create a conducive environment for a market-based advance biofuel industry in the country;
2. Influence biofuel usage;
3. Establish a biofuel feedstock supply chain;
4. Develop an environmentally sustainable biofuel industry.

The Government of Fiji is targeting a blending mandate of 7 per cent by 2030, for both petroleum and diesel (except for re-exported fuels). The fuel usage[33] in 2030 in the SDG scenario is estimated to be 342.4 million litres of diesel and 133.4 million litres of petroleum. The GHG emission reduction from a 7 per cent blending mandate corresponds to 35.4 kTCO2-eq.[34] The 37 kTCO2-eq may not be met, not because of the insufficient blending, but from lower-than-expected fuel consumption due the various energy efficiency measures applied. The energy efficiency measures are expected to substantially lower the GHG emissions compared to the BAU scenario.

33 Including consumption in the transport, industry and power sectors.

34 Calculated based on the formula *Net avoided CO2eq = Energy content of biofuel (TJ) * Emission factor of fossil diesel or gasoline*$\left(\frac{TCO2}{TJ}\right)$** Biofuel CO2 Lifecycle avoidance factor(%).* The assumed avoidance factor is 45 per cent.

5. Energy transition pathways with increased ambitions

Several ambitious scenarios have been further analysed to identify the best way forward for Fiji to transition its energy sector to 2030. This analysis shows that there are socio-economic and environmental benefits for Fiji in raising its ambition beyond just achieving the SDG7 targets, such as creating cost-effectiveness through increasing renewable electricity generation as well as increasing energy independence through reduced use of oil products in the energy system.

The SDG scenario is further expanded with different ambitious scenarios to analyse and compare costs and benefits, and to identify a scenario that is most suited to Fiji. Like the SDG scenario, these ambitious scenarios, at a minimum, aim to achieve the SDG7 targets and the unconditional NDC target. The scenarios are:

(a) Sustainable transport scenario. This scenario builds on the SDG scenario with a special focus on the transport sector. It explores the impact of increased use of public transport as well as the potential for enhancing energy efficiency improvement and energy independence through the promotion of electric vehicles;

(b) Decarbonization of the power sector scenario. This scenario is similar to the SDG scenario in terms of the demand-side assumptions (i.e., demand growth and energy efficiency measures applied). On the power generation front, this scenario utilizes the Next Energy Modelling system for Optimization-based (NEMO) least cost optimization module to determine the least-cost power generation mix for Fiji;

(c) Enhancing NDC with power and transport sector strategies scenario. This scenario is the most ambitious one, combining the attributes from scenarios (a) and (b) above. As such, it considers the more ambitious transport energy efficiency measures and utilizes the NEMO model in suggesting the least-cost power generation mix focusing on decarbonization of power sector.

The following section presents details of the key results of the ambitious scenarios. A summary of key results is also included in Annex VIII.

In addition, an exploratory scenario has been modelled to see how Fiji may fulfil the ambition of 100 per cent renewable power target by 2036.

5.1. Ambitious scenario 1: Sustainable transport scenario

The energy efficiency measures modelled in the SDG scenario have substantially reduced the energy demand from the transport sector as well as the associated carbon emissions. Nonetheless, it still leads the share of energy demand and contribution significantly towards carbon emissions. In particular, fuel usage by land transport constitutes around half the imported oil products.

This scenario looks at the transport strategies alternative to the SDG scenario, namely the promotion of electric vehicle adoption, as well as increases the energy efficiency ambition. In addition, it explores the impact of increased use of sustainable public transport, as a means to reduce both fuel consumption and traffic congestion. The following sections summarize the measures applied and the key results.

5.1.1. Energy efficiency improvements

This section details the energy efficiency measures and the corresponding energy savings.

Land transport – estimated total additional savings of 19.9 ktoe (compared to SDG scenario):

(a) Increase public bus usage from 68.2 per cent in 2018 to 73.2 per cent by 2030 (as a share of total passenger-km travelled);

(b) Introduce a 25 per cent electric vehicle market sales share[35] for private passenger vehicles from 2025 onwards;

(c) Introduce a 25 per cent electric vehicle market sales share[36] for public passenger vehicles[36] from 2025 onwards;

35 This builds on the 50 per cent market sales of hybrid vehicles currently achieved in the CP scenario. The sustainable transport scenario considers an additional 25 per cent of market sales of electric vehicles from 2025 onwards.

36 This refers to taxis and rental cars.

(d) All buses sold from 2025 onwards should be hybrid buses.

Measures (b) and (c) replace the sales share set for hybrid vehicles as modelled in the SDG scenario with electric vehicles, while measure (d) enhances energy savings effort stipulated in the SDG scenario. Minimum vehicle fuel economy standards for cars and trucks are similarly applied in this scenario. Annex VI provides further explanation on the measures and assumptions used.

Applying the above measures allows an estimated total energy savings of 19.9 ktoe (compared to the SDG scenario). While a public bus requires an additional demand of 1.3 ktoe, the reduction realised from private cars is 14.4 ktoe and from public cars it is 6.8 ktoe. Increased public bus usage, which reduces the use of private and public passenger cars, allows an estimated reduction of 6.8 ktoe compared to the BAU scenario, assuming other energy efficiency measures are not applied for the other land transport types. However, if more fuel-efficient private and public passenger cars are adopted, the energy savings gained from increased use of public buses will be reduced. Nonetheless, increased use of bus usage is an effective means of reducing traffic congestion. Similarly, the energy savings associated with private cars and public cars is a function of both reduced vehicle usage and adoption of electric and fuel-efficient vehicles.

Marine Transport – estimated additional savings of 4.17 ktoe (compared to the SDG scenario):

Gradual replacement of two-stroke with four-stroke outboard motors to reach 100 per cent by 2030. The measure above enhances energy savings effort stipulated in the SDG scenario. The maritime operational efficiency measures (i.e., hull coating, cleaning and propeller polishing) are similarly applied in this scenario.

5.1.2. Fuel import dependency

The transport sector is the main consumer for oil products. The adoption of fuel-efficient vehicles and alternative technologies (i.e., electric cars and four-stroke outboard transition) allows reduced reliance on fuel imports, making Fiji less susceptible to future price and supply shocks. The additional measures applied in this scenario further reduce the fuel dependency in the transport sector by an estimated 26.9 ktoe, compared to the SDG scenario. Relative to the CPS scenario, this corresponds to an estimated 78 ktoe reduction.

5.1.3. Electricity demand and the power sector

Adoption of electric cars is an effective measure to reduce fuel consumption, and may provide opportunities for optimization of the grid management system and integration of variable renewable energy generation; however, it also increases overall electricity demand. The increased electricity demand due to the measures applied is an estimated 32.8 GWh in 2030 or a 2.4 per cent increase from the SDG scenario. Correspondingly, slight additional power infrastructure is required to fulfil the additional demand. The NEXSTEP power analysis for the sustainable transport scenario is based on the SDG scenario, while the required additional power capacity is fulfilled by solar PV. The total estimated installed power capacity is 505.3 MW in 2030. Figures 15 and 16 show the installed power capacity and output share by fuel type between 2020 and 2030.

5.1.4. GHG emissions reduction

The emissions reduction through the enhanced and alternative transport strategies are substantial, totalling up to an estimated 79.7 ktCO$_2$-e, compared to the SDG scenario. The road transport emissions are reduced by an estimated 67.2 ktCO$_2$-e, while the total phasing out of two-stroke outboard motors in small vessels leads to an additional 12.5 ktCO$_2$-e.

The emissions reduction due to the adoption of electric vehicles will not be realized without a similar decarbonization effort in power generation. In the sustainable transport scenario, the power generation will reach a high share of renewable generation, allowing such measures to have a negligible impact on the carbon emissions from the power sector.

Figure 15. Installed power capacity, 2020-2030, sustainable transport scenario

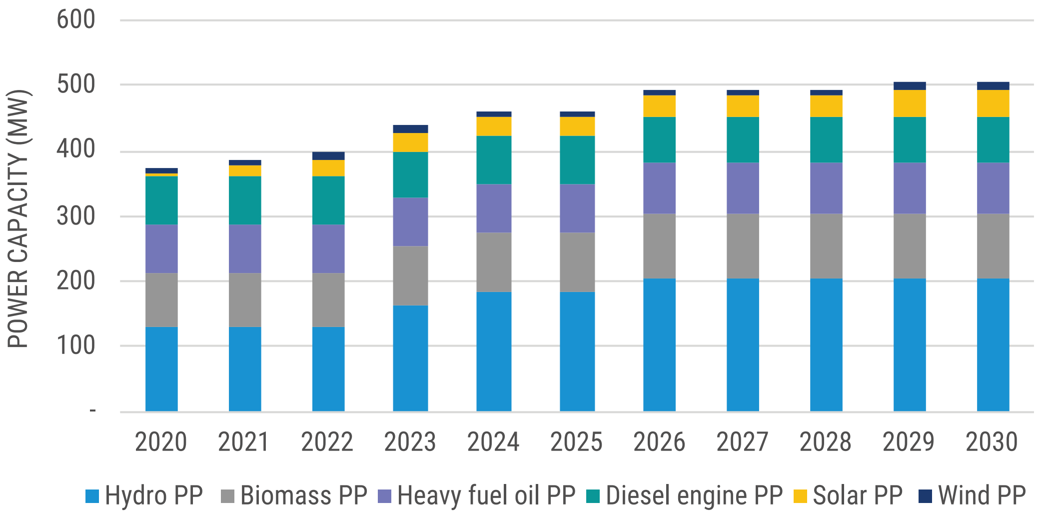
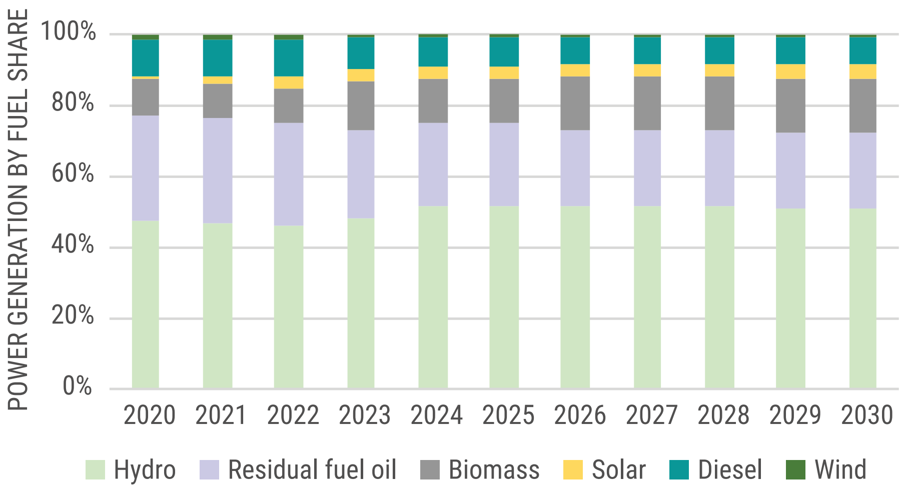


Figure 16. Electricity output share by fuel type, 2020-2030, sustainable transport scenario



5.2. Ambitious scenario 2: Decarbonization of the power sector scenario

The decarbonization of the power sector scenario inherits the demand-side assumptions from the SDG scenario (see subsection 4.4.3), while exploring a least-cost power generation mix for the main grid generation. This is facilitated by the NEMO-based least cost optimization module using the cost data listed in Annex X.[37] On the contrary, the SDG scenario power capacity addition is based on EFL's power capacity expansion plan, 2020-2030. This aims to provide an alternative suggestion for Fiji on future capacity expansion. The key results for this scenario ae given below.

5.2.1. Power capacity and generation mix

As suggested by the NEMO-based least cost optimization modelling, power capacity increases from 360.3 MW in 2018 to an estimated 731.3 MW in 2030. A notable increase is observed for the solar PV capacity, from around just 1 MW in 2018 to 304.8 MW in 2030. Figure 17 shows the capacity built from 2020 to 2030.

37 Capacity constraint is applied to hydropower capacity (220 MW) (based on IRENA, 2015). Biomass capacity is capped at 30 MW. This follows the suggestion gathered from stakeholders, on considering the resource constraint of sustainable biomass feedstock.

Figure 17. **Power capacity, 2020-2030, decarbonization of the power sector scenario**

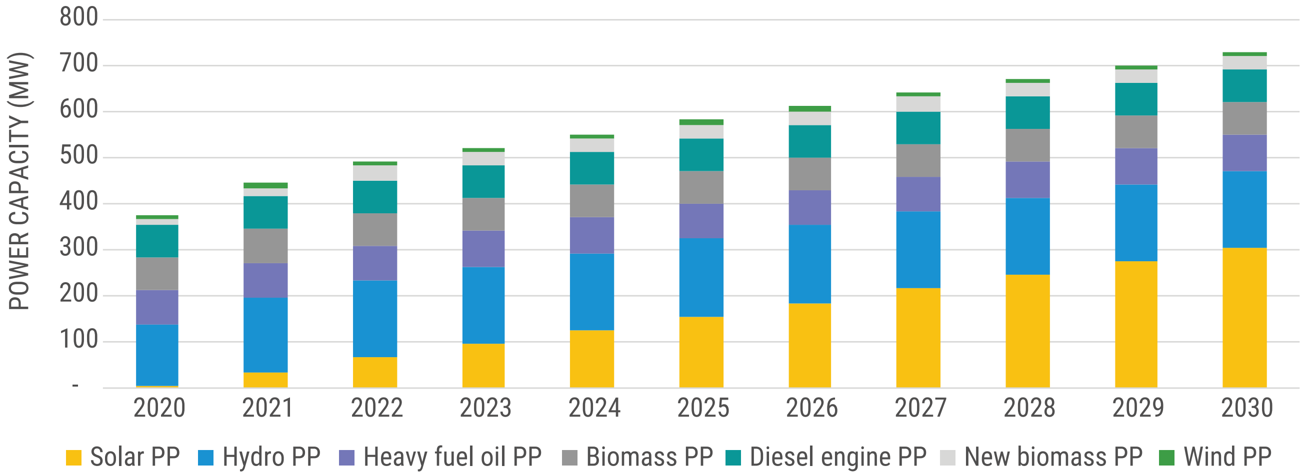
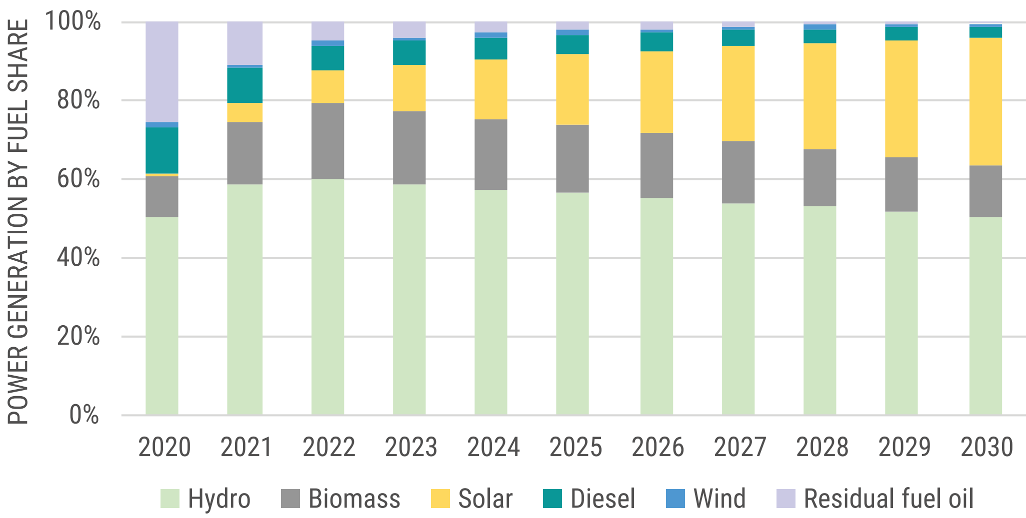


Figure 18. **Power generation by fuel share, 2020-2030, decarbonization of the power sector scenario**



In terms of the power generation mix, a rapid decrease in fossil fuel-based generation is suggested. This is due to the high cost of oil products (i.e., diesel and residual fuel oil). The percentage share of fossil fuel-based generation stood at 41 per cent in 2018. This decreases to just an estimated 2.9 per cent in 2030. Hydropower still dominates the generation share, with a projected 50.8 per cent in 2030. Other fuel mix includes biomass (12.9 per cent), solar (32.3 per cent) and wind (1.1 per cent). Figure 18 shows the power generation fuel mix throughout 2020-2030.

5.2.2. Investment cost[38] and net benefits of the power sector

The total investment cost incurred throughout the analysis period is projected to be US$ 585 million. More than half (67.6 per cent) of that investment will be to increase the solar PV capacity, while remaining amount will be for the installation of new hydropower (23.7 per cent) and new biomass (8.7 per cent) capacities. The investment cost is US$223.7 million higher than the SDG scenario, as more new renewable capacity is built in the decarbonization of power sector scenario.

38 Considering only the investment costs for new power plants.

Nevertheless, the net benefits gained from the decarbonization of the power sector are substantially higher than the SDG scenario. The total net benefits throughout analysis period are estimated to be US$1.39 billion, while for the SDG scenario the amount is US$0.43 billion. This is due to the high fuel cost associated with fossil fuel-based generation in the SDG scenario.

5.2.3. GHG emissions

The low share of fossil fuel-based generation also corresponds to a substantial projected GHG emissions reduction from the power sector. The GHG emissions from power generation amounts to only 30.8 ktCO_2-e, while the emissions from the SDG scenario total 286.1 ktCO_2-e, a 255 ktCO_2-e reduction.

5.3. Ambitious scenario 3: Enhancing NDC with power sector and transport strategies scenario

This scenario explores the extent of GHG emissions reduction that can be achieved through ambitious energy efficiency measures in the transport sector, and a drastic change in the power generation mix based on least-cost optimisation. The demand side assumptions are similar to the sustainable transport scenario, which assumes the implementation of electrification strategies and enhanced energy efficiency measures, both in land and marine transport. On the power generation front, it utilizes the NEMO-based least cost optimisation module to suggest the least cost power generation mix as well as power capacity required in response to the increased electricity demand from transport electrification. The key results are described below.

5.3.1. Power capacity and generation mix

As proposed by the NEMO-based least cost optimization modelling, the power capacity increases from 360.3 MW in 2018 to an estimated 733.9 MW in 2030. Similar to the decarbonization of the power sector scenario, a substantial increase of solar capacity is proposed, totalling 305.7 MW in 2030. The total investment cost for the power sector is projected to be US$592 million throughout the analysis period.

A rapid phase-out of fossil fuel-based generation is suggested, due to the high import cost of oil products. Figure 19 shows the capacity built between 2020 and 2030, while figure 20 shows the power generation fuel mix between 2020 and 2030.

5.3.2. GHG emissions

The combination of enhanced transport energy efficiency measures and the phasing out of fossil fuel-based power generation sees the GHG emissions drop to an estimated 1,324.4 ktCO_2-e. This corresponds to a 36.5 per cent reduction compared to the BAU scenario, or a 26.7 per cent reduction compared to the CPS scenario. This shows that there is much room for Fiji to contribute towards the Paris Agreement via more ambitious measures, while benefiting from an enhanced energy independence from reduced use of oil products.

Figure 19. Power capacity, 2020-2030, enhancing NDC via the power sector and transport strategies scenario

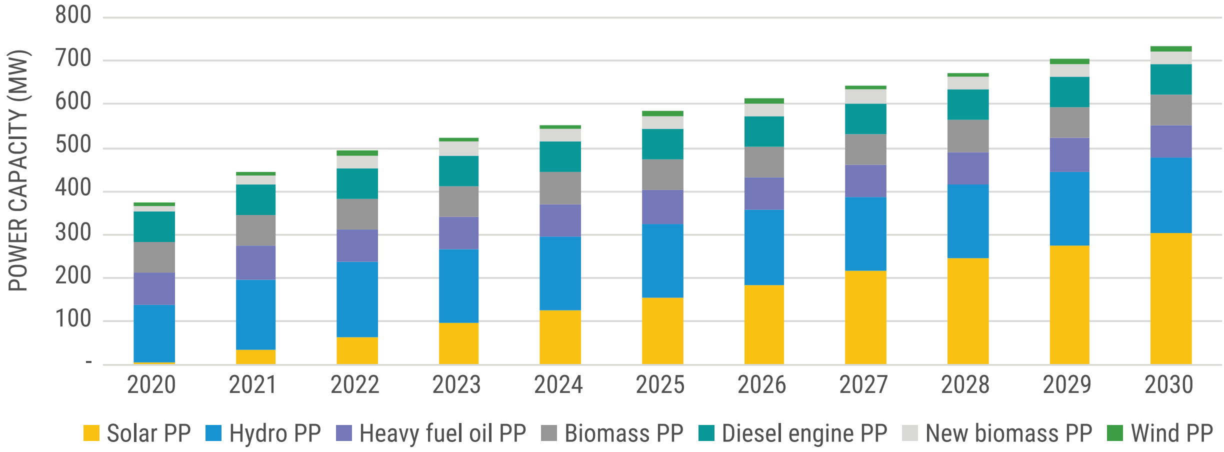
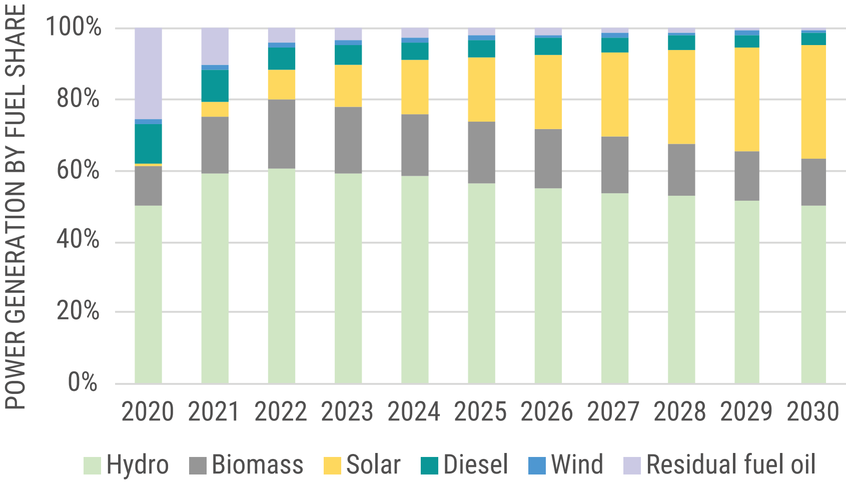


Figure 20. Power generation by fuel share 2020-2030, enhancing NDC via the power sector and transport strategies scenario



5.4. Exploratory scenario: 100 per cent renewable power in 2036

This scenario is modelled with the aim of exploring how the power sector may evolve while meeting a 100 per cent renewable power target[39] in 2036, a target stipulated in the NDP. This inherits from the SDG scenario, meaning that all SDG and NDC targets have been met in 2030, while energy efficiency policies continue to apply until 2036. The power sector trajectory is as proposed by the NEMO-based least cost optimization modelling, in meeting the 100 per cent renewable power target in 2036.

Figure 21 shows the projected power capacity installed during 2018-2036. To reach a 100 per cent renewable power target requires the ramping-up of renewable capacity by a substantial amount. The total estimated renewable installed capacity for 2036 is 926.1 MW, which comprises solar – 485.7 MW, hydro – 182.3MW, new biomass – 30 MW, existing biomass – 71.3 MW and wind – 10.7 MW. This sends a strong signal that an early effort to increase renewable capacity would be required to raise the renewable power capacity from just 213.5 MW in 2018, to reach a 100 per cent renewable power target within a relatively short time frame. In terms of power generation, hydropower remains the dominating fuel at 46.7 per cent, while solar increases to 45.9 per cent (figure 22).

However, NEXSTEP has not analysed the impact of a 100 per cent renewable share on grid management. Further in-depth analysis must be performed in order to better understand the possible technical challenges and interventions required (e.g., storage and demand-side management) to improve grid flexibility and enable integration of high penetrations of variable renewable energy generation.

The projected total investment throughout the analysis period up until 2036 would be US$872 million. This comprises solar – US$630.5 million, hydro – US$190.5 million and biomass – US$51 million. The reduced reliance on imported oil products allows a high net benefit to be gained, totalling up to US$2.29 billion.

39 This considers EFL main grids only. Based on stakeholders' feedback, a 100 per cent renewable power target including off-grid systems may not be feasible. Currently, there is a small percentage of households dependent on village-based diesel-fuelled grids.

Figure 21. **Installed power capacity, 2020-2036**

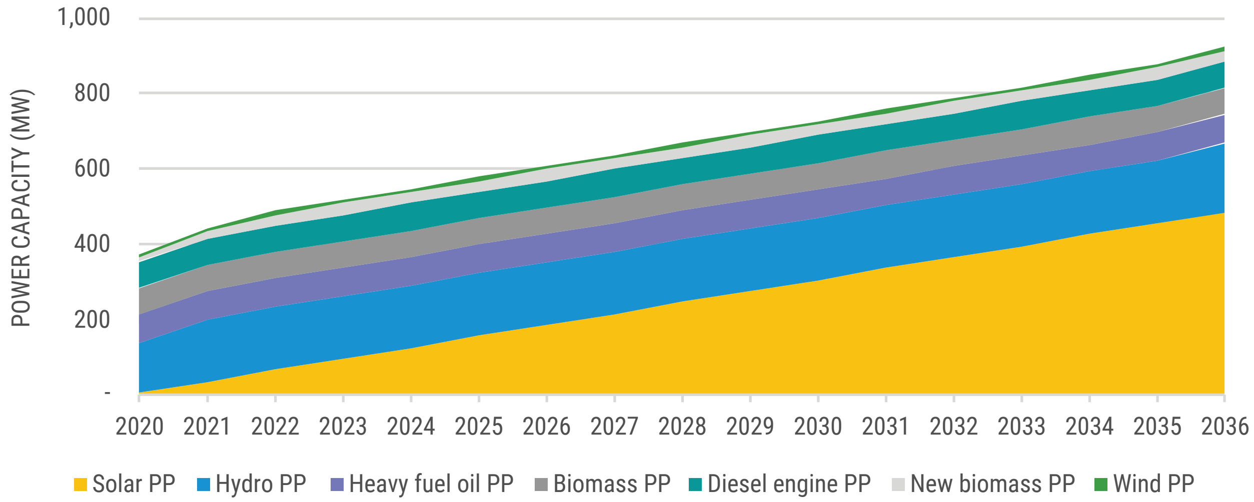
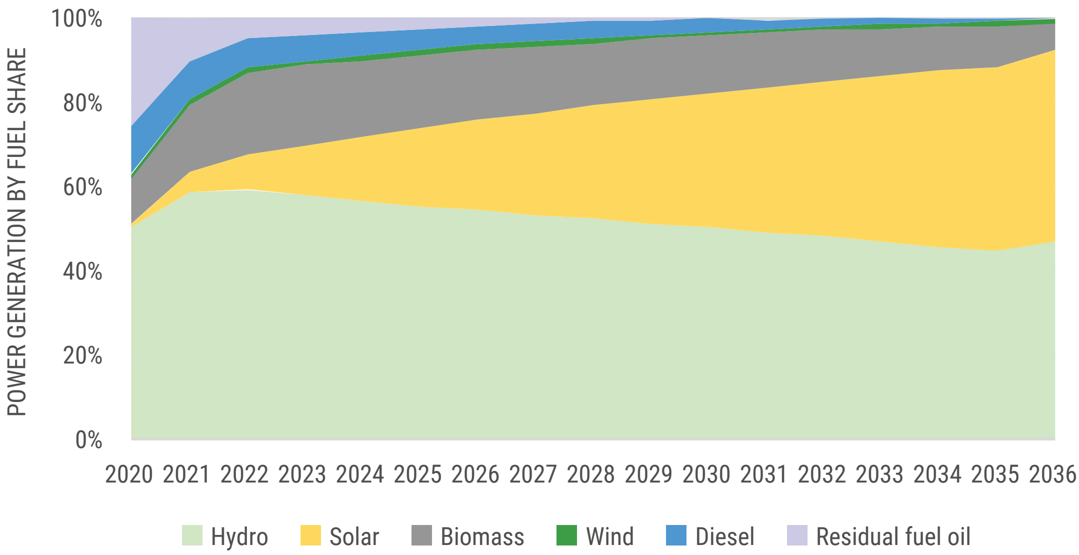


Figure 22. **Power generation share by fuel type, 2020-2036**



6. Policy recommendations for raising ambitions

6.1. Scenario ranking

The current policy, SDG and the ambitious scenarios have been evaluated and ranked, using the Multi- Criteria Decision Analysis (MCDA) tool, with a set of 11 criteria and weights assigned to each criterion (table 3). The weighting for each criterion has been decided based on consolidated stakeholders' feedback gathered during the consultation workshop via an online polling platform. If deemed necessary, this step can be repeated using the NEXSTEP tool to determine a new ranking based on an updated set of weightages. 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;

(g) When applicable, carbon pricing should be introduced to encourage investments in clean energy.

Table 3. Criteria with assigned weights for MCDA

Criterion	Weight (%)
Access to clean cooking fuel	11
Energy efficiency	16
Share of renewable energy	10
Emissions in 2030	12
Fossil fuel phase-out	11
Cost of access to electricity	10
Cost of access to clean cooking fuel	6
Investment cost (power sector)[40]	15
Net benefit from the power sector	8

40 Considering only the investment costs for new power plants.

Table 4. Scenario ranking based on MCDA

Scenario	Weighted score	Rank
Enhancing NDC with power sector and transport strategies	69.0	1
Decarbonization of the power sector	65.4	2
Sustainable transport	55.8	3
SDG scenario	52.0	4
Current Policy scenario	47.6	5

Table 4 shows the summary of results obtained through this evaluation process. The scenario recommendation suggests that the ambitious scenario, *Enhancing NDC with power sector and transport strategies scenario,* is the highest-ranked energy transition pathway for Fiji.

The following subsections present several policy recommendations to aid Fiji in raising its ambitions beyond the SDG and NDC targets. The policy recommendations are not only valid for the Enhancing NDC with power sector and transport strategies scenario, but also offer cross-cutting suggestions for the other ambitious scenarios.

6.2. Sustainable transport strategies offer multi-fold benefits

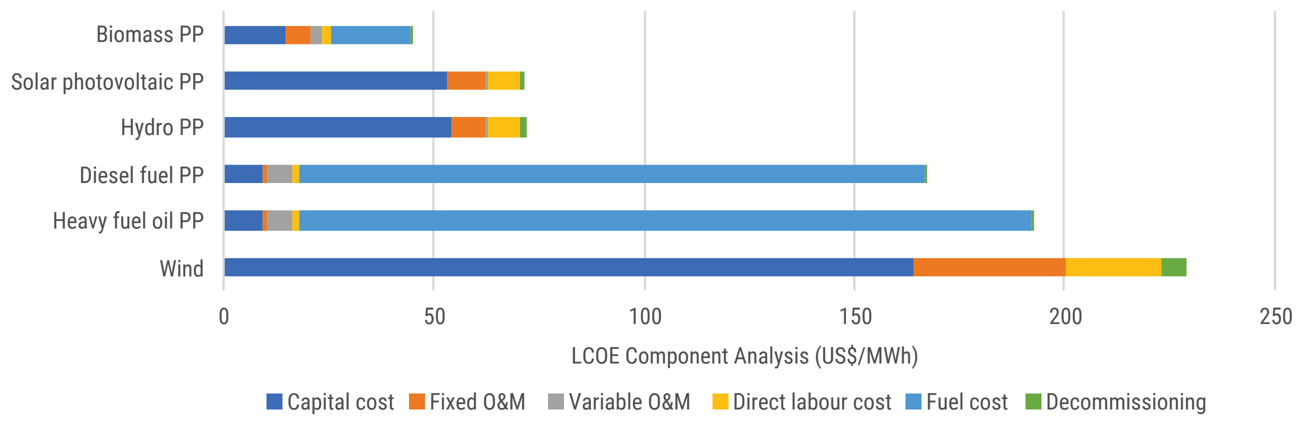
Ambitious policy actions for the land transport sector are critical for Fiji to achieve the SDG7 energy efficiency target and to contribute towards climate mitigation. For example, in the SDG scenario NEXSTEP proposes a more rapid adoption of hybrid vehicles and the introduction of minimum fuel economy standards for freight transport to allow substantial energy savings by 2030. Alternative strategies such as the use of electric vehicles and increasing share of public transport usage can be considered to raise Fiji's ambition towards energy savings, while offering multi-fold benefits.

Promoting the use of public transport, and specifically buses, can effectively reduce fuel consumption by the transport sector. While the fuel savings through increased public transport will be dampened by other energy-efficiency initiatives promoted in the other land transport subsectors (i.e., electric vehicles and minimum fuel economy standards), it is a means of reducing traffic congestion – a major problem in cities. With the urbanization rate expected to rise over the years, traffic congestion is likely to worsen without intervention. In addition, air pollution can be substantially decreased by taking cars off the road.

Electric vehicles have garnered great interest globally, growing exponentially during the past decade. Electric car sales passed 2 million globally in 2019, with a projected compound annual growth rate of 29 per cent through to 2030 (Deloitte, 2020). Various governmental policies have been introduced, directly or indirectly promoting the adoption of electric vehicles as a means to achieve environmental and climate objectives. Seventeen countries have stated their ambitions to phase out internal combustion engines before 2050, while the European Union's stringent CO_2 emissions standard have accelerated electric vehicle adoption, according to the International Energy Agency (IEA, 2020). . With Fiji's renewable power share expected to grow, electric vehicles can substantially help to reduce overall GHG emissions. Other positive impacts include reducing pollutants due to zero-tailpipe emissions. However, the roll-out of EVs should be accompanied with carefully thought-out plans for retired batteries (both for EV and hybrid vehicles) to avoid adverse environmental impacts caused by battery disposal. For example, retired car batteries can be provided with a second life as home energy storage or recycling (IER, 2019).

For the marine transport sector, NEXSTEP analysed the fuel savings and carbon reduction associated with operational efficiency measures (i.e., hull cleaning and propeller polishing) and outboard motor transition. Decarbonization opportunities are not limited to these aspects; alternative measures can be considered or new technologies can be pioneered. As an example, the use of sail-powered or other low-carbon

Figure 23. Levelized cost of electricity for the power technologies[41]



vessels can be similarly encouraged. The Ministry of Economy (MoE, 2018) has also proposed the pioneering of large low-carbon vessels by the Government, as a proof of concept.

6.3. Pursuance of high renewable power share provides cost-effectiveness and enhances fuel independence

Renewable energy capacity has increased significantly throughout the world amid climate change concerns. Fiji recognises the contribution of a higher renewable power share towards its NDC targets. For example, the ELF current expansion plan for 2020-2030 comprises solely renewable technologies of 135 MW. While increasing renewable power is an imperative measure to achieve the Paris Agreement, many renewable technologies have also reached grid parity with conventional fossil fuel-based technologies, even if not cheaper.

Figure 23 shows the estimated Levelized Cost of Electricity (LCOE) for the power technologies applicable for Fiji. LCOE is a widely-used metric in the energy industry for comparing the cost-competitiveness of different electricity generation technologies. It calculates the unit cost of electricity (US$/MWh) over the lifetime of a project, including capital, operating and financing costs.

The quantitative analysis shows that renewable technologies such as biomass, solar PV and hydropower are comparably cheaper than fossil fuel technologies.

While a biomass power plant is the cheapest technology, the expansion of biomass power plants should be done with caution, taking into consideration the sustainability of the biomass feedstock supply chain as well as feedstock availability. Sustainability criteria should be enacted to ensure that the biomass for power generation has not only met the GHG reduction expectation, but causes no other direct and indirect adverse impacts (i.e., land-use change).

Two of the ambitious scenarios utilizing the least cost optimisation modelling have proposed an accelerated action in ramping up renewable power capacity, specifically solar PV. At the same time, phasing out fossil fuel-based generation has been suggested due to the high import costs of oil products. While this also means early retirement of existing fossil fuel-based power plants, the net benefits gained are substantially higher with the reduced use of oil products in the power sector – around a 50 per cent increase. Another benefit would be the enhanced energy security, where Fiji can become less reliant on imports for its essential service.

41 Based on author's calculations. Refer to Annex III for the parameters used.

6.4. Marginal abatement cost curve

The marginal abatement cost (MAC) curve of energy efficiency measures proposed for Fiji is shown in figures 24 and 25. The figures offer powerful insights and a strong message for policymakers to prioritize energy efficiency measures based on their potential to reduce energy intensity and GHG emissions, while providing long-term financial gains. The BAU scenario is used as the reference for the MAC curve. Annex VIII summarises the assumptions used in the calculations.

Many of the proposed energy efficiency measures provide net financial gains. While the initial capital investment may put off the implementation of such measures, policymakers and consumers should instead take note of the long-term financial benefits in their decision-making process. Transport sector measures not only provide high GHG emission reduction potential, but also financial savings. This is particularly so because of the high import costs for oil products in Fiji. For the commercial and residential sectors, the transition towards a more energy efficient, greener

Figure 24. Marginal abatement cost curve of energy efficiency measures in the residential and commercial sectors[42]

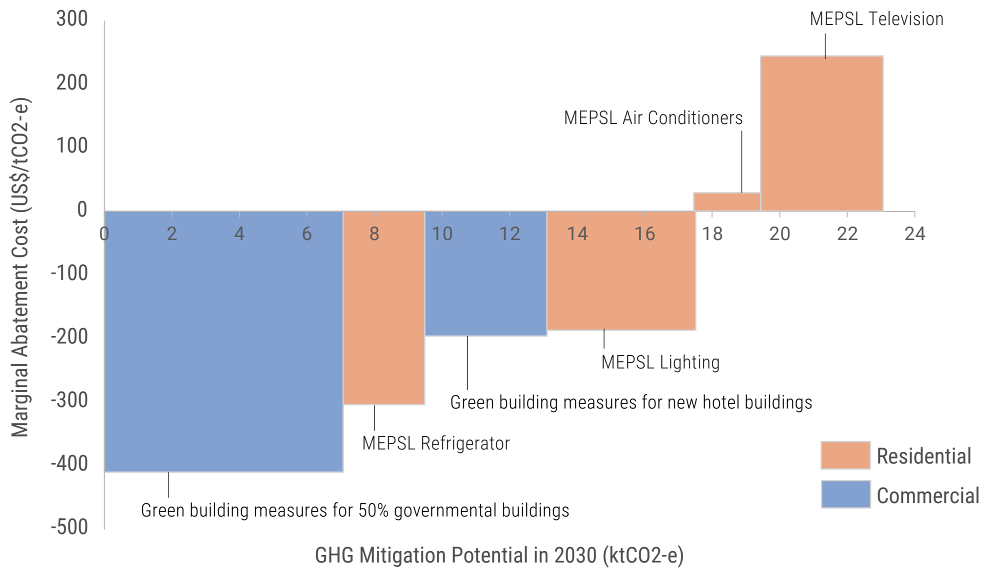
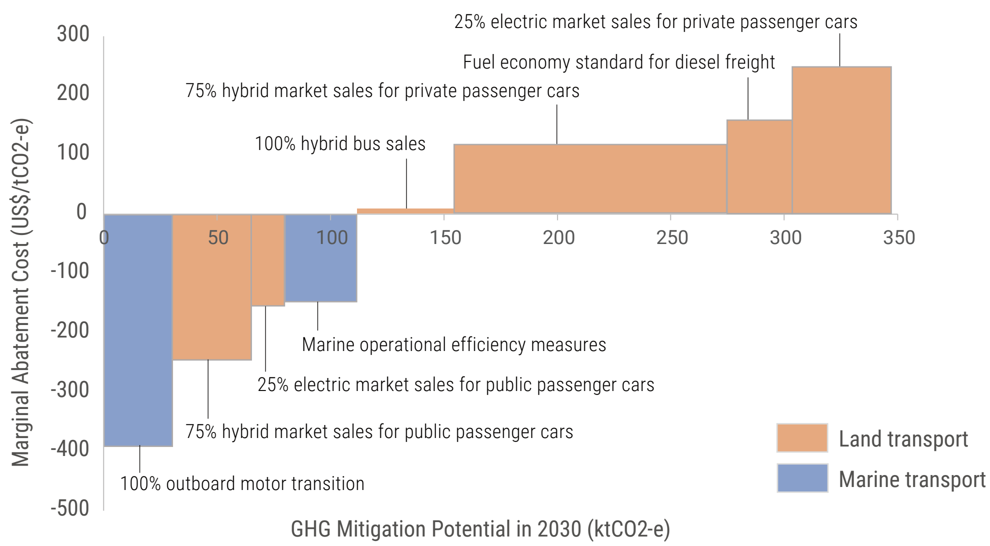


Figure 25. Marginal abatement cost curve of energy efficiency measures in the transport sector[43]



42 The emission reduction potential of the energy efficiency measures in the residential and the commercial sectors is dependent on the grid emissions. The reduction potential can be expected to decrease as the zero carbon renewable power generation share increases.

43 Reduction potential calculations for private and public passenger cars and hybrid buses, assuming the stipulated market sales are achieved from 2025 onwards. The fuel economy standard for diesel freight is assumed to be effective from 2025 onwards.

working and living environment similarly provides a positive return while raising the standard of living.

6.5. Green financing

Sustainable green transition in the energy sector often offers financial benefits in the long term. For example, a high renewable power share provides a greater net benefit over the years due to its low or zero fuel costs. However, high capital costs are generally involved in creating new renewable power capacities. For the other sectors, this could entail financial incentives to promote efficient vehicles or efficient household appliances. Therefore, accelerating green financing is critical to achieving the 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.

Green bonds mobilize resources from domestic and international capital markets to finance climate solutions. In 2017, Fiji successfully raised US$40 million through issuing its first green bonds. The proceeds are expected to be used to fund climate resilient projects, with the focus area including the transport sector, according to the Pacific Centre for Renewable Energy and Energy Efficiency (PCREEE, 2018). Similar initiatives can be also be considered for financing renewable energy technologies.

Renewable energy technologies have relatively high financing costs in developing countries, which causes their unattractive risk/return profile. This is because of their long-term horizon, high initial capital costs, illiquid equipment and project risks. Policymakers can reduce high financing costs using two methods – de-risking and direct incentives. De-risking has two basic forms – policy de-risking instruments that reduce risk, and financial de-risking instruments that transfer risk. For example, the Sustainable Energy Financing Project (SEFP) in partnership with the World Bank incentivises small-scale private investments in renewable energy and energy efficiency equipment in Fiji through a loan scheme, with the World Bank providing partial loan guarantee (DoE, 2021). Direct incentives are direct finance transfers or subsidies to low carbon investments. The United Nations Development Programme's (UNDP) "De-risking Renewable Energy Investment"[44] is an important guide for policymakers in developing strategies to reduce risks in renewable energy investment.

44 See https://www.undp.org/content/undp/en/home/librarypage/environment-energy/low_emission_climateresilientdevelopment/derisking-renewable-energy-investment.html.

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

The COVID-19 pandemic has not caused a health-care crisis in Fiji, with a total of just 53 recorded cases (as of 6 January 2021). However, Fiji's economy, which depends heavily on the tourism industry, has suffered. The tourism industry accounts for around 34 per cent of Fiji's GDP and employs approximately 150,000 people directly or indirectly (Gounder, 2020; Xinhua, 2020). The border closure has caused visitor arrivals to fall by 74 per cent. As a result, the Fijian economy is estimated to have contracted by 19.8 per cent in 2020 and may only have a minimal recovery of 1 per cent in 2021, considering the possibility of restarting tourism activities in the second half of the year (ADB, 2020). While grappling with the devastation caused by this global health crisis, Fiji should not lose sight of its progress and ambitions towards achieving the SDG and NDC targets. On the contrary, Fiji should build back better from this crisis, to become more resilient in facing future challenges, i.e., climate change impacts.

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 in the recovery to build back better. The SDG7 roadmap has identified several key areas that will assist policymakers in strengthening policy measures to help recover from the COVID-19 impacts, while maintaining the momentum to achieving the 2030 Agenda for Sustainable Development and the Paris Agreement.

7. Building back better with the SDG7 roadmap in the recovery from COVID-19

7.1. Accelerating access to clean and modern energy services

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

In 2018, Fiji had about 434,000 people without access to clean cooking fuel. Access to clean cooking technologies is a development challenge that is often forgotten. One medium-term impact of COVID-19 could be decreased investment in energy access, as national budgets come under strain and priorities shift. WHO has warned about the severity of health impacts arising from the exposure to traditional use of biomass for cooking, and is encouraging policymakers to adopt measures to address this challenge. Moreover, scientists are already investigating links between air pollution and higher levels of coronavirus mortality, with preliminary results showing a probable correlation between the two (Aarhus University, 2020)).

The SDG7 roadmap has analysed and identified technical options for connecting the remaining population to cleaner fuel for cooking and has estimated the cost of the measure. The benefits resulting from this measure, in the form of reduced mortality and health impact, will exceed the needed investment of US$2.4 million to advance the clean cooking rate to 100 per cent.

7.2. Savings from the energy sector will help in building up other sectors

The NEXSTEP analysis shows that there are ample opportunities for Fiji to save energy by improving energy efficiency beyond the current practices. As highlighted in the previous chapters of this report, several cost-effective energy efficiency measures can be implemented in the residential, transport and commercial sectors that will result in net financial gain. Savings from this improvement can help investment in other sectors, such as health, social protection and stimulus, which are critical in responding to, and recovering from the COVID-19 pandemic.

An example of low- to no-cost measures is the introduction of minimum energy efficiency standards (MEPS) in producing appliances, e.g., air conditioners, televisions and lights, all of which have zero or negative costs. There is also potential for implementing energy efficiency in the transport sector, for example by introducing vehicle fuel economy standards and by promoting electric vehicles. This has multiple additional related benefits (in addition to energy saving), including the reduction of expenditure on importing petroleum products and reducing local air pollution. Increasing the renewable power share could also increase the net benefits as fuel costs associated with fossil fuel-generation are reduced. Such measures are very important in solidifying the pathway to recovery from COVID-19 and rebuilding better.

7.3. 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 used this unfortunate situation to "reset" their economy. For example, the World Economic Forum has launched the Great Reset initiative, to encourage economic transformation and build a better society as we recover from this 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, 2020b).

The Fijian government has announced a FJ$3.7 billion stimulus budget (US$1.8 billion), in a bid to shield the impact of COVID-19 crisis from its society and economy. A World Bank analysis has pinpointed top interventions for stimulus to build resilience and support sustainable growth, emphasizing both short term and long term (World Bank, 2020c). The list includes several energy-related measures, such as improving resilience of rural mini-grids and solar home systems as well as diversifying its renewable energy generation and expanding solar generation. This further concurs that a well-planned energy transition pathway that aligns with the sustainable agenda is not a hindrance to economic recovery, but a means of building back better.

8. Revisiting existing policies

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

8.1. Universal access to electricity

Existing policy	NEXSTEP analysis – gaps and recommendations
The 5-Year and 20-Year National Development Plan 2017- 2036 (NDP) The NDP stipulates the ambition to achieve 100 per cent electricity access by 2021. Electrification projects will be expedited, whereby decentralised renewable systems will be installed on the rural and outer islands to electrify the unelectrified rural and maritime settlements. *Considering the impacts from COVID-19 crisis and Cyclone Yasa, the Cabinet recently announced its decision to readjust the 2021 timeline to an open-ended timeline.*	**SDG and ambitious scenarios** NEXSTEP analysis suggests off-grid systems, i.e., solar home systems or mini/micro-grid, depending on the remoteness of the settlement, may be the most appropriate technology for rapid implementation while ensuring climate resiliency. This needs to be supported by appropriate financing mechanisms (e.g., village-based co-operatives or similar) to cater for operational and maintenance costs, as well as 'recovery' after natural disasters.

8.2. Universal access to clean cooking

Existing policy	NEXSTEP analysis – gaps and and recommendations
Fiji Rocket Woodstove initiative The initiative aims to distribute Rocket Wood Stoves to 60,000 households, at no cost to them.	**SDG and ambitious scenarios** Universal access to clean cooking is expected to be achieved through the Rocket Wood initiative, but maintenance of the technology may present some challenges. The NEXSTEP analysis proposes both electric cooking stoves and LPG stoves as the alternative technologies to the Rocket Wood stove to support long-term sustainability. Fiji's low electricity cost also offers higher affordability of electric cooking stoves compared to other Pacific countries. Nonetheless, electric cooking stoves may have limited application in households connected to less sufficient power supply capacity (i.e., the solar home system). In considering that constraint, LPG stoves may be the most appropriate option for some households.

8.3. Renewable energy

Existing policy	NEXSTEP analysis – gaps and recommendations
EFL power expansion plan, 2020-2030 The power expansion plan includes 135 MW of new renewable power capacity. **The 5-Year and 20-Year National Development Plan, 2017- 2036 (NDP)** The targets stipulated in the NDP are: • Renewable share in power generation – 90 per cent in 2026, 100 per cent in 2036; • Renewable share in total energy consumption – 25 per cent in 2031.	The projection based on the current expansion plan is a 71 per cent share of renewable power generation (EFL grids only) in 2026 and 2030. The renewable share in TFEC is projected to be 14 per cent. **SDG scenario** As the NEXSTEP analysis is based on meeting the SDG7 and NDC targets, NDP renewable targets were not considered in the SDG scenario. SDG7 has no quantitative goal for renewable energy share in TFEC, hence the NEXSTEP analysis determines the renewable energy share based on the fulfilment of both energy efficiency and the NDC target. The renewable energy share in power generation (EFL grids only) is projected to be 71 per cent in 2026 and 2030, while the renewable share in TFEC is projected to be 14.5 per cent in 2030. **Ambitious scenarios** Least cost optimisation for the power sector (EFL grids only) has proposed a 94.1 per cent share of renewable power generation in 2026 and a 97.1 per cent share in 2030.The renewable energy share in TFEC is projected to be 20.9 per cent in 2030 in the most ambitious scenario. **Exploratory scenario** 100% renewable power in 2036 (EFL grids only) can be achieved by early ramping up of renewable power capacity.

8.4. Energy efficiency

Existing policy	NEXSTEP analysis – gaps and recommendations
General **The 5-Year and 20-Year National Development Plan 2017- 2036 (NDP) stipulates two targets:** - Consumption of imported fuel per unit of GDP in 2031: 2.73 MJ/FJD; - Power consumption per unit of GDP in in 2030: 0.209 kWh/FJD. **Appliances** MEPSL for refrigerators and freezers as implemented since 2012. **Transport** Regulations introduced include: - Age limit for imported cars; - Emission standards for newly registered cars. **The transport and maritime policy** proposes various decarbonization strategies.	The current MEPSL scheme and the transport regulations will not lead to achievement of the SDG7 target. **SDG scenario and ambitious scenarios** The NEXSTEP analysis shows that expansion of MEPSL schemes, green building measures and more vigorous transport policies are required to achieve the global annual improvement rate of 2.9 per cent. Achieving the SDG target also allows the energy efficiency targets stipulated in the NDP to be met. The consumption of imported fuel per unit of GDP is 1.32 MJ/FJD [45], while power consumption per unit of GDP is 0.078 kWh/FJD in 2030. The ambitious scenarios show that further energy intensity improvement can be achieved through enhanced energy efficiency measures as well as the increased use of renewable power technologies.

8.5. Nationally determined contributions

Existing policy	NEXSTEP analysis – gaps and recommendations
Several strategic documents have been published since the adoption of NDC targets. These are the Fiji Low Emission Development Strategy 2018-2050 and the NDC implementation roadmap.	The strategic documents developed provide sound strategies and recommendations towards achieving the NDC targets. **SDG scenario and ambitious scenarios** The NEXSTEP analysis similarly explores the strategies required to achieve the NDC targets (unconditional) in conjunction with the SDG targets, while the most ambitious scenario allows a 36.5 per cent reduction compared to the BAU scenario.

45 Calculated based on GDP in 2018 at current US dollar rate and a projected growth of 3.5 per cent. (Exchange rate of US$1 to FJ$2.04).

9. Conclusion

The 2030 Agenda for Sustainable Development and Paris Agreement provide a common goal for all countries to achieve sustainability and climate objectives. Achieving the SDG7 and NDC targets is not an easy feat, but it will help to create a more sustainable and resilient society. This roadmap 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. Some scenarios have looked beyond just achieving SDG7 targets; they have explored the full potential of the country in relation to improving energy security by shielding the energy sector from supply and price shocks as well as to enhancing the climate resilience of the energy sector. The multi-criteria decision, analysis-based scenario analysis suggests that Fiji should not only achieve the SDG7 targets; it also recommends decarbonization of the power sector and a dive deep into energy efficiency measures.

Fiji is on track to achieve the 100 per cent electrification target, while achieving universal access to clean cooking fuel is far from the target. If fully implemented, the Government's plan to offer improved cooking stoves to the remaining half of the population will help Fiji achieve this target. However, improved cooking stoves are a temporary solution and the success rate of such a large-scale improved cooking stove programme is very low as continuous monitoring and follow-ups are required to ensure long-term adoption. Fiji should consider the promotion of electric cooking stoves and LPG stoves to support long-term sustainability and the substantial reduction of household air pollution.

Much work has to be done to reduce Fiji's energy intensity in accordance with the global improvement rate of 2.9 per cent. Ample opportunities exist in the residential, commercial and transport sectors. The transport sector provides the biggest energy-saving potential and should be the main focus, as this sector represents 69 per cent Fiji's energy consumption that is fully imported. Fiji has the potential to increase its ambition beyond what is needed for the SDG7 energy efficiency target and further reduce energy consumption in the transport sector. For example, the promotion of electric vehicles allows additional fuel savings while reducing urban air pollution. Reduction in petroleum fuel use through implementing energy saving measures in the transport sector (both land and marine vehicles), as outlined in this roadmap, will enhance Fiji's energy security.

Under EFL's current power capacity expansion plan, renewable power share will increase to 71 per cent in 2030 (14 per cent RE share in TFEC). The Government also has a plan for decarbonization of the power sector by 2036. This roadmap has shown that this target is both technically and economically feasible and has outlined how to achieve this ambition. This requires ramping up its renewable power capacity more rapidly than EFL's current expansion plan. A significant increase in solar photovoltaic-based electricity generation will be required. Full decarbonization of the power sector and a comprehensive implementation of energy efficiency measures, as presented in this roadmap, will allow Fiji to achieve beyond its conditional NDC target of 30 per cent reduction. Such a strategy not only allows further carbon reduction, it reduces Fiji's reliance on imported fuels, while allowing a higher financial return.

Finally, the energy transition pathway presented in this SDG7 roadmap will support rebuilding better after the COVID-19 pandemic. The proposed energy transition presents opportunities for reducing economic risks, both for public and private investment, and identifies areas for financial savings in the energy sector that can support the recovery of other critical sectors, such as the health sector.

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Annexes

I. National Expert SDG7 Tool for Energy Planning Methodology

The analysis presented in the national roadmap is based on the results from the National Expert SDG7 Tool for Energy Planning (NEXSTEP) project. NEXSTEP is an integrated tool for assisting policymakers formulate informed policy decisions that would help in achieving SDG7 and NDC targets by 2030. The SDG7 and NDC targets are integrated in the LEAP energy model and backcasted from 2030, since the targets for 2030 are already defined.

Table 5. Targets and indicators for SDG7

Target	Indicators	2018	2030
7.1. By 2030, ensure universal access to affordable, reliable, and modern energy services.	7.1.1. Proportion of population with access to electricity.	96.3%	100%
	7.1.2. Proportion of population with primary reliance on clean fuels and technology for cooking.	51%	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.	9.4% (excluding traditional biomass)	14.5%
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.	3.10 MJ/US$ (2011) PPP	2.18 MJ/US$ (2011) PPP
7. A. By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency, and advanced and cleaner fossil fuel technology as well as promote investment in energy infrastructure and clean energy technology.	7.A.1. International financial flows to developing countries in support of clean energy research and development, and renewable energy production, including in hybrid systems.	n.a.	n.a.

SDG7.3. Energy Efficiency. "By 2030, double the global rate of improvement in energy efficiency", as measured by the energy intensity of the economy. This is the ratio of the total primary energy supply (TPES) and GDP. Energy intensity is an indication of how much energy is used to produce one unit of economic output. As defined by the IEA, TPES is made up of production plus net imports minus international marine and aviation bunkers plus stock changes. For comparison purposes, GDP is measured in constant terms at 2011 PPP.

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

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

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

Base period improvement rate for Fiji (1990 – 2010): 2.22 per cent

SDG7.3 improvement rate for Fiji (doubling of base period improvement rate): 4.44 per cent

SDG7.3 improvement rate for Fiji (in accordance with global improvement rate): 2.9 per cent

SDG7.2. Renewable energy

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

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

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

II. Key assumptions for NEXSTEP energy modelling

(a) General parameters

Table 6. GDP and GDP growth rate

Parameter	Value
PPP (2018, constant 2011 US dollar)[46]	US$8.53 billion
growth rate	3.6%

Table 7. Population, population growth rate and household size

Parameter	Value
Population (2018)	884,887
Population growth rate	0.6%
Number of households (2018)	191,911
Household size (constant throughout the analysis period)	4.61

(b) Demand-side assumptions

Industry:

The industrial GDP is estimated to be 14.03 per cent of the total GDP in 2018. It is assumed that the industry sector will grow moderately with an annual increment rate of 1.5 per cent. The industrial sector is further split into 10 different subsectors with estimated baseline energy consumption as provided in table 8. The energy intensity is projected to remain constant in all scenarios. No energy efficiency measure has been applied due to the lack of

46 https://wits.worldbank.org/CountryProfile/en/Country/FJI/StartYear/2014/EndYear/2018/Indicator/NY-GDP-MKTP-PP-KD

finer consumption details.

Table 8. Consumption in 2018 [47]

Subsector	Share of total industrial demand (%)	Consumption in 2018 (ktoe)			
		Electricity	Diesel fuel and heavy fuel oil	Kerosene	LPG
Food and beverages	30.4	14.44	9.27	-	0.12
Chemical and synthetic products	0.5	0.03	0.18	-	0.16
Glass, cement and non-metals	0.6	0.27	0.20	-	0.02
Iron and steel	3.8	2.82	0.16	-	0.01
Pulp and paper	1.0	0.49	0.17	0.10	-
Textiles and leather	0.3	0.13	0.07	0.03	-
Machinery and transportation equipment	0.0	0.01	0.02	0.01	-
Wood and other products	0.6	0.33	0.15	-	-
Mining Industries	61.3	-	47.97	-	-
Other processing industry	1.4	1.07	0.03	0.03	0.01

Transportation:

Land transport

Land transport activity is primarily based on Prasad and Raturi (2018), with assumed annual growth of 1.3 per cent for passenger transport and 1 per cent for freight transport. (table 9). Following shows the land transport activity for the different vehicle types, in absolute values and in percentage shares, in 2018.

Table 9. Land transport

Passenger transport	Billion passenger-km 2018	Share of vehicle activity in 2018 (%)
Private cars	3.06	17
Public cars [48]	1.84	10.24
Mini vans (mini buses)	0.46	2.56
Buses	12.3	68.2
Carriers	0.36	2
Freight transport	**Billion tonne-km in 2018**	**Share of vehicle activity in 2018 (%)**
Goods vehicles	2.81	100

Marine transport

Marine transport activity references based on Prasad and Raturi (2019) with assumed annual growth of 2 per cent for passenger transport and 0.5 per cent for freight transport. Table 10 shows the land transport activity for the different vehicle types, in absolute values and percentage shares, in 2018:

47 Fuel consumption (except for electricity) is estimated and extrapolated based on fuel consumption data for 2014 provided by FBoS. Electricity data provided by EFL.
48 This refers to taxis and rental cars

Table 10. Marine transport

Passenger transport	Million passenger-km in 2018	Share of vehicle activity in 2018 (%)
Roll-on Roll off	49.8	6.2
Passengers	268.7	33.3
Fishing	73.6	9.1
Tourists	412.0	51.0
Tugs	2.6	0.3
Police	0.03	0.0004
Other sea vessels	0.2	0.03
Freight transport	**Billion tonne-km in 2018**	**Share of vehicle activity in 2018 (%)**
Barge + cargos	2.81	100

Domestic aviation transport

Modelling for the aviation transport has been based on fuel consumption of aviation petroleum and jet fuel (table 11). The assumed annual growth rate is 3.5 per cent (similar to the GDP growth rate).

Table 11. Domestic aviation transport

Fuel type	Consumption (ktoe)
Aviation gasoline	2.81
Jet fuel	5.74[49]

Residential:

Residential urbanization

Table 12. Residential urbanization [50]

	2018	2030	2036
Rural	43.1%	40.4%	39%
Urban	56.9%	59.6%	61%

Household appliances ownership (as a percentage of all households)

Household appliances ownership (table 12) for 2018 is based on data provided by GGGI. The 2030 ownership assumption for refrigerators, air- conditioners and televisions is based on assumptions used in George Wilkenfeld and Associates (2014), while projections towards 2036 are based on assumptions by ESCAP (2020).

Ownership projections for electric fans, electric heaters, washing machines and irons are not readily available. Hence, a 0.6% growth in appliance saturation is assumed, similar to the population growth.

49 Extrapolated based on 2014 fuel consumption assumed by MoE (2018) and assumed annual growth rate of 3.5 per cent.

50 Urbanization rates for 2030 and 2040 are linearly interpolated based on the rate in 2018 (56.9%) and suggested rate (Government of Fiji, 2017) for 2036 (61%).

Table 13. Household appliances ownership (as a percentage of all households, unless otherwise stated)

	2018	2030	2036
Refrigerators	80%	90%	96%
Air-conditioners	8%	20%	26%
Televisions	83%	95%	98%
Electric fans and electric heaters	39%	43%	45%
Washing machines	58%	64%	67%
Irons	73%	82%	85%
Water pumps	40% of rural households		
Others	100%		

Commercial:

This subsection provides the assumed data for the commercial sector. The baseline electricity consumption (kWh/m^2) has been compiled from various sources, while the floor space is estimated based on the electricity consumption assumption and the measured demand data from EFL.

It is assumed that the commercial sector will grow at an annual growth rate of 2.6 per cent. [51]

Table 14. Commercial floor space

Space type	Baseline electricity consumption (kWh/m^2)	Floor space (million m^2) in 2018
Private office	176	0.489
Government building	176	0.63
Shopping mall	451	0.14
Hotel	482	0.33
Hospital	300	0.26
University	180.4	0.24
Religious temple	180.4	0.02

III. Economic analysis data for power technologies

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

Table 15. Economic analysis parameters

Economic parameters	
Nominal discount rate	8.00%
Inflation rate	2.50%
Standard Conversion Factor (SCF)	0.90
Skilled workforce	80%
Shadow Wage Rate Factor (SWRF)	0.75
Decommissioning cost	5% of CAPEX

51 Based on the electricity demand growth rate assumed by MoE (2018).

Table 16. Fuel price for power plant technologies

Fuel Price	
Diesel and residual fuel oil	700 US$/ton [52]
Biomass	30 US$/ton [53]

Table 17. Fiji technology capacity factor/efficiency and cost data

Technologies	Capacity factor (%)	Efficiency (%)	CAPEX/MW (US$/MW)	Fixed O&M (US$/MW)	Variable O&M (US$/MWH)
Diesel PP	80	39.7	1,100,000	8,000	6.4
Heavy fuel oil PP	80	37	1,100,000	8,000	6.4
Hydro PP	48	-	3,750,000	37,700	0.7
Solar photovoltaic PP	17	-	1,300,000	15,000	0.0
Offshore wind	17	-	4,000,000	60,000	0.0
Biomass PP	80	31	1,700,000	47,600	3.0

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. The calculation assumes an annual cooking thermal energy requirement of 3,840 MJ per household (Putti and others, 2015). In addition, a discount rate of 5.37 per cent is assumed.

Table 18. Technology and cost data for clean cooking technologies

Technologies	Efficiency [54] (%)	Lifetime [55] (years)	Stove cost [56] (US$)	Variable O&M [57] (US$/year)	Fuel cost [58] (US$)
ICS	35	4	20	10	0.03 per kg
LPG stoves	56	7	56	10	1.40 per kg
Biogas digesters	50	20	950	50	-
Electric stoves	84	15	40	10	0.16 er kWh

V. Energy efficiency measures in the residential sector

This annex provides further explanation of the energy efficiency measures applied in the residential sector, across the SDG and the ambitious scenarios.

MEPSL refrigeration (including freezers) (also applied in the CPS scenario)

Refrigerator ownership in 2018 was 80 per cent. This is projected to increase to 90 per cent in 2030 (George Wilkenfeld and Associates, 2014). MEPSL was introduced in 2012 by the Government of Fiji, whereby the share of efficient refrigerators stood at 51.2 per cent in 2018.[59] It is expected that the implemented policy will increase the share of efficient refrigerators to 85.7 per cent in 2030, as old and inefficient refrigerators are replaced gradually.

52 Based on diesel wholesale price stipulated in the 2018 Pacific Fuel Price Monitor (PCREEE, 2018).
53 Biomass price indicated in (IRENA, 2012) ranges between US$15 and US$60.
54 Sourced from: ICS - (MWCPA, n.d.), LPG stove and biogas digester efficiency ranges - (World Bank, 2014), electric cookstove (induction stove) - (IEA, 2012)
55 Sourced from: ICS – (MWCPA, n.d.), LPG stove – (Clean Cooking Alliance, 2021), biogas digester (Wang and Zhang, 2012), electric stove - (IEA, 2012).
56 Sourced from: ICS - (MWCPA, n.d.), LPG stove and biogas digester – (IRENA, 2017), electric cookstove cost range (Putti and others, 2015).
57 Variable O&M is based on own assumptions, with the exception of biogas digester (IRENA, 2017).
58 Wood cost is assumed opportunity cost related to wood collecting activities, LPG price refers to retail prices announced in 30 December 2020 (available at https://fccc.gov.fj/wp-content/uploads/2020/12/FCCC-New-Fuel-LPG-Price.pdf), electricity cost is based on domestic rate.
59 Based on ESCAP stock-turnover analysis.

MEPSL lighting

MEPSL lighting is applied to all households, except those that are electrified by solar home systems (SHS). Households relying on SHS are assumed to have a lighting electricity demand of 50 kWh/household/year (MoE, 2018). NEXSTEP analysis assumes a total of 31 thousand households will be connected via SHS, based on 2017 statistics and the assumption that the remaining 7,100 unelectrified households will be connected via SHS. The lighting demand of all other households is expected to increase from 301 to 429 kWh/household/year in 2030, under the BAU scenario. It is modelled that the introduction of MEPSL for lighting shall reduce the lighting demand to 348 kWh/household/year in 2030 (George Wilkenfeld and Associates (GWA), 2014).

MEPSL air- conditioners

Household ownership of air-conditioners in Fiji was 8 per cent in 2018 and is projected to increase to 20 per cent by 2030 (George Wilkenfeld and Associates, 2014). It is assumed that all appliances are inefficient, with an average consumption of 1,500 kWh/owning household/year. The introduction of MEPSL from 2022 onwards will increase the share of efficient appliances to 77.4 per cent, [60] which are expected to have an estimated consumption of 1,300 kWh (George Wilkenfeld and Associates, 2014)..

MEPSL televisions

Ownership of a television in Fiji households was 83 per cent in 2018 and is projected to increase to 95 per cent by 2030 (George Wilkenfeld and Associates, 2014). It is assumed that all appliances are inefficient appliances, with an average consumption of 240 kWh/owning household/year.[61] .The introduction of MEPSL from 2022 onwards will increase the share of efficient appliances to 67 per cent, with an estimated consumption of 150 kWh (MoE, 2018).

VI. Energy efficiency measures in the transport sector

This annex provides further explanation of the energy efficiency measures applied in the transport sector, across the SDG and the ambitious scenarios. Stock turnover analysis is used in calculating the share of different vehicle types for the land transport sector, in response to the policy measures proposed.

Land transport

CP scenario:

50 per cent market sales share for hybrid private and public passenger vehicles

The estimated share of hybrid private passenger vehicles was 6.4 per cent in 2018 [62]. In the CPS scenario, it is assumed that hybrid passenger and public vehicles will continue to have a market sales share of 50 per cent throughout the analysis period. This corresponds to a 39.5 per cent share of hybrid private passenger vehicles, and a 40.6 per cent share of hybrid public passenger vehicles in 2030.

SDG scenario and decarbonization of the power sector scenario:

75 per cent market sales share for hybrid private and public passenger vehicles from 2025 onwards

Building on the CPS scenario, NEXSTEP proposes the ramping up of hybrid vehicles sales share from the current 50 per cent to 75 per cent, from 2025 onwards. This corresponds to a 52.2 per cent share of hybrid private passenger vehicles, and a 63 per cent share of hybrid public passenger vehicles in 2030.

75 per cent market sales share for hybrid buses from 2025 onwards

There are no existing hybrid buses in 2018. NEXSTEP analysis proposes targeting a 75 per cent market sales share of hybrid buses from 2025 onwards. This corresponds to a 33.8 per cent share of hybrid public passenger vehicles in 2030. Hybrid buses are assumed to have a fuel economy of 3.89 km per litre of fuel (Volvo, 2012).

60 Ibid.

61 Ibid.

62 Estimated share references 2016 share provided in Prasad and Raturi, 2018.

Introduction of minimum vehicle fuel economy standard for diesel freight truck from 2025 onwards

The share of diesel trucks is an estimated 94.4 per cent in 2018,[63] with the remaining being petroleum and LPG trucks. The NEXSTEP analysis proposes the implementation of a minimum vehicle fuel economy standard for newly imported diesel trucks, in adherence to the 2015 Japanese fuel economy standards (TransportPolicy.Net, 2018). A weighted average fuel economy of 10 km per litre of fuel is assumed in the NEXSTEP modelling, covering both light and heavy trucks.

Sustainable transport scenario and Enhancing NDC with power sector and transport strategies scenario:

25 per cent market sales share of for electric private passenger vehicles from 2025 onwards

The estimated share of electric private and public passenger vehicles in 2018 is zero per cent. Building on the CPS scenario, the NEXSTEP analysis proposes targeting a 25 per cent market sales share for electric vehicles from 2025 onwards, on top of the existing 50 per cent market sales share of hybrid vehicles. This corresponds to a 11.4 per cent share of electric private passenger vehicles and 37.2 per cent of hybrid electric private cars. On the other hand, electric and hybrid public vehicles will reach 11.3 per cent and 38.3 per cent shares, respectively, in 2030.

100 per cent sales quota for hybrid buses from 2025 onwards

There were no existing hybrid buses in 2018. The NEXSTEP analysis proposes targeting a 100 per cent market sales share for hybrid buses from 2025 onwards. This corresponds to a 47 per cent share of hybrid public passenger vehicles in 2030. Hybrid buses are assumed to have a fuel economy of 3.89 km per litre of fuel (Volvo, 2012).

Introduction of minimum vehicle fuel economy standard for diesel freight trucks

The same as already applied in the SDG scenario (see above)

Land transport – marine transport

Gradual replacement of two-stroke outboard motors with efficient four-stroke outboard motors

The NEXSTEP analysis proposes a gradual replacement of two-stroke outboard motors to efficient four-stroke outboard motors, reaching a 60 per cent share by 2030 in the SDG and the decarbonization of the power sector scenario. The share is increased to 100 per cent for sustainable transport and enhancing NDC through decarbonization of the power sector and sustainable transport.

This measure is applied to commercial vessels of less than 15 metres, assuming all small vessels are powered by outboard motors. Four-stroke outboard motors are assumed to be 50 per cent more efficient than two-stroke outboard motors (Johnson, 2018).

Gradual adoption of operational efficiency measures (i.e., hull coating and cleaning, and propeller polishing) for vessels of more than 15 metres

The NEXSTEP analysis proposes the gradual adoption of operational efficiency measures for all commercial vessels of more than 15 metres, reaching a 100 per cent adoption rate by 2030. Specifically, this refers to the adoption of regular hull coating and cleaning, and propeller polishing.. A 15 per cent energy reduction is assumed to be achieved through these strategies (Prasad and Raturi, 2019).

63 Ibid.

VII. Energy efficiency measures in the commercial sector

Adoption of green building measures in 50 per cent of all government buildings by 2030

The energy reduction enabled by the adoption of green building measures is assumed to be 30 per cent from the baseline. The NEXSTEP analysis assumes that energy efficiency measures will be adopted by all newly-built governmental buildings (27 per cent of all governmental building space) as well as 30 per cent of the existing buildings (23 per cent of all governmental building space) through retrofitting.

Adoption of green building measures in all newly-constructed hotel buildings

The energy reduction enabled by the adoption of green building measures is assumed to be 20 per cent[64] from baseline. NEXSTEP analysis assumes that energy efficiency measures will be adopted by all newly-built hotel buildings (27 per cent of all hotel building space, assuming an annual growth rate of 2.6 per cent).

VIII. Marginal abatement cost curve assumptions

This annex summarises the assumptions used in constructing the MAC curve for the different energy efficiency measures. The electricity grid emission factor assumed for the MEPSL schemes and the commercial sector are based on the BAU scenario of 85.7 kg/GJ. The grid emission factor for electric vehicles is 56.0 kg/GJ based on the sustainable transport scenario, assuming that the measures will only be implemented when there is a substantial penetration of renewables (around 70 per cent).

Measures	Assumptions
Green building measures for 50 per cent of governmental buildings	Incremental cost of US$19.4 per square metre.
MEPSL refrigerator	US$1,007 USD for efficient version, US$982 for conventional version. Assumed lifetime of 12 years.
Green building measures for new hotel buildings	Incremental cost of US$108 per square metre. This assumes a building cost of US$2,150 per square metre and a green building premium of 5 per cent.
MEPSL lighting	US$4.4 for one LED Bulb (lifetime of three years), US$31 for seven LED bulbs. A conventional light bulb is US$0.50 per bulb (lifetime of 1 year) – US$3.50 for seven bulbs.
MEPSL air-conditioners	1228 USD for efficient version (lifetime:15 years) and 736 USD for conventional version (lifetime:10 years)
MEPSL television	Assumption of US$500 for efficient version (lifetime:15 years), 250 USD for conventional version (lifetime:10 years).
100 per cent outboard motor transition by 2030	US$6,000 for a four-stroke motor and US$3,300 for a two-stroke motor, lifetime of 8 years.
75 per cent hybrid market sales for public passenger cars from 2025 onwards	Incremental cost of US$10,000, average lifetime of 10 years.
25 per cent electric market sales for public passenger cars from 2025 onwards	Incremental cost of US$15,000, average lifetime of 10 years.
100 per cent adoption of marine operational efficiency measures by 2030[65]	Annual operational cost of US$16,500 – hull coating US$7,500 (annualised cost), hull cleaning US$5,000 USD and propeller polishing US$ 4,000.

64 Author's estimation of the reduction potential. (Prasad, 2016) indicates potential savings of 16.1 per cent and 19.6 per cent for two hotels in Fiji.

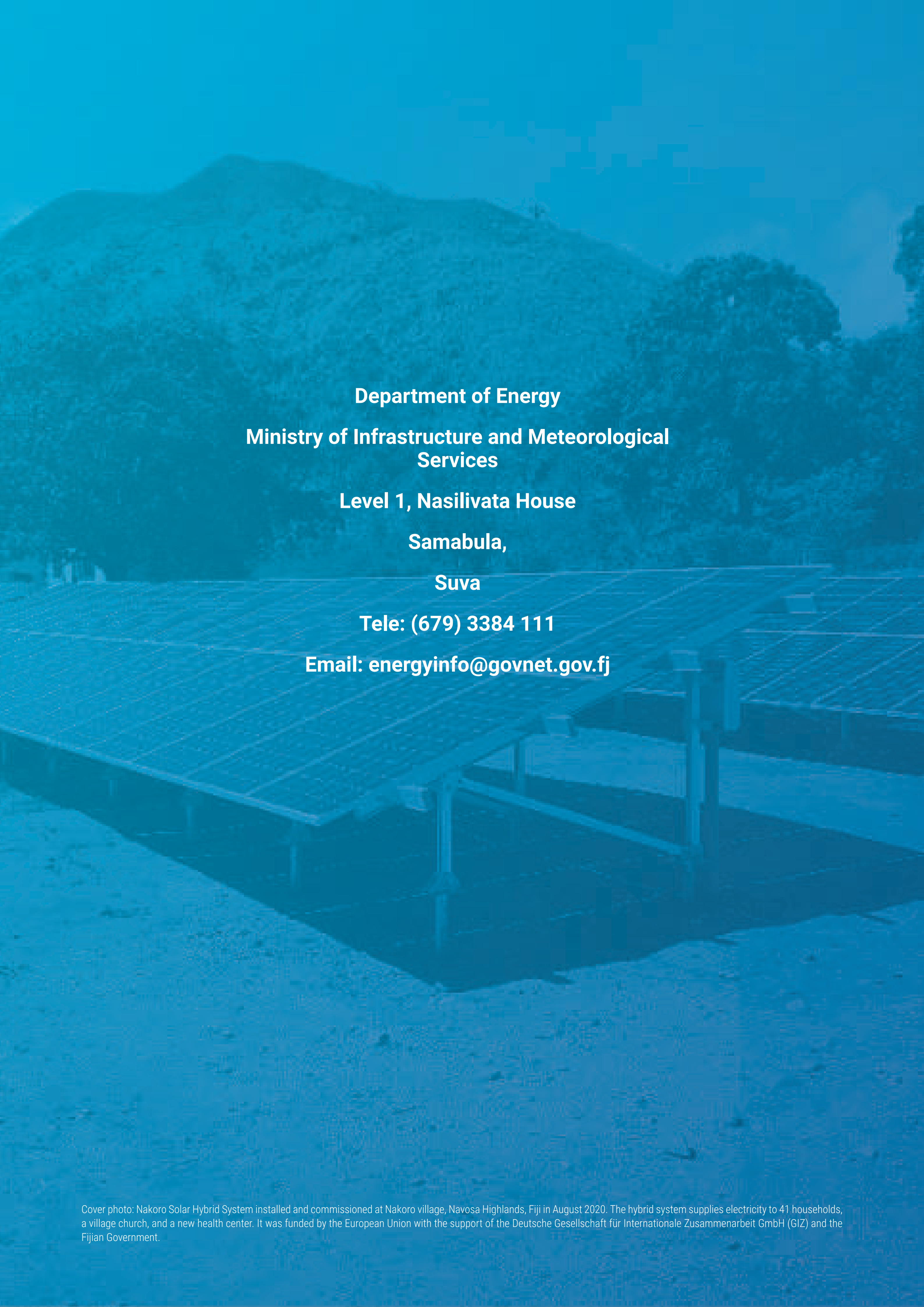
65 For vessels of more than 15 metres.

100 per cent hybrid bus sales from 2025 onwards	Incremental cost of 135,000 for hybrid buses, lifetime of 12 years.
Fuel economy standard for diesel freight from 2025 onwards	Incremental cost of US$15,000, average lifetime of 15 years.
75 per cent hybrid market sales for private passenger cars from 2025 onwards	Incremental cost of US$10,000, average lifetime of 10 years.
25 per cent electric sales for private passenger cars from 2025 onwards	Incremental cost of US$15,000, average lifetime of 10 years.

IX. Summary results for the scenarios

	CPS Scenario	SDG Scenario	Sustainable transport	Decarbonization of the power sector	Enhancing NDC via power sector and transport strategies
Universal access to electricity in 2030	100%	100%	100%	100%	100%
Universal access to clean cooking in 2030	100%, via ICS	100%, via electric cooking stove and LPG stove	100%, via electric cooking stove and LPG stove	100%, via electric cooking stove and LPG stove	100%, via electric cooking stove and LPG stove
Energy efficiency in 2030	2.50 MJ/US$	2.18 MJ/US$	2.11 MJ/US$	1.98 MJ/US$	1.92 MJ/US$
Renewable energy share in TFEC in 2030	14.0%	14.5%	15.8%	19.7%	20.9%
GHG emissions in 2030	1810.9 ktCO_2-e	1649.7 ktCO_2-e	1574.1 ktCO_2-e	1394.4 ktCO_2-e	1324.4 ktCO_2-e
Power generation optimization	Current expansion plan	Current expansion plan	Current expansion plan	Least-cost	Least-cost
RE share in power generation in 2030	71%	71%	72%	97%	96%
Net benefits from the power sector	US$ 991.4 million	US$ 958.1 million	US$ 970.4 million	US$ 1394.3 million	US$ 1403.3 million
Total investment for the power sector[66]	US$ 363.9 million	US$ 361.3 million	US$ 376.9 million	US$ 584.7 million	US$ 592.0 million

66 Considering only the investment costs for new power plants



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Cover photo: Nakoro Solar Hybrid System installed and commissioned at Nakoro village, Navosa Highlands, Fiji in August 2020. The hybrid system supplies electricity to 41 households, a village church, and a new health center. It was funded by the European Union with the support of the Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ) and the Fijian Government.