Energy Transition Pathways for the 2030 Agenda

SDG 7 Roadmap for the Federated States of Micronesia

ESCAP
Economic and Social Commission for Asia and the Pacific

NEXSTEP
National Expert SDG Tool for Energy Planning

Energy Transition Pathways for the 2030 Agenda

SDG 7 Road Map for the Federated States of Micronesia

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

ESCAP
Economic and Social Commission for Asia and the Pacific

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

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Energy Transition Pathways for the 2030 Agenda
SDG 7 Road Map for the Federated States of Micronesia

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Chapter 1: freepik; Chapter 2: Traditional Meeting House in Yap Proper, Yap State; Chapter 3: Yap Renewable Energy Development Project/ ADB; Chapter 4, 5, 6, 7, 8: freepik

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Foreword: ESCAP

This SDG 7 Road Map is a joint initiative by the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) and the Department of Resources and Development of the Federated States of Micronesia. It stands as a testament to the Government's steadfast commitment to achieving the ambitious targets of SDG 7 and fulfilling the objectives of the Paris Agreement.

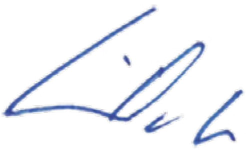
The Road Map provides a thorough assessment of existing energy policies and plans, identifies critical gaps and offers strategic recommendations for strengthening the enabling policy environment and introducing appropriate technological interventions. It also presents an in-depth analysis of potential pathways to achieve net-zero emissions by 2050.

The Federated States of Micronesia faces a complex array of energy sector challenges, including the effects of climate change and a heavy reliance on imported fossil fuels. Geopolitical tensions and volatile energy prices have further exacerbated concerns around energy security. Utilizing ESCAP's National Expert SDG Tool for Energy Planning (NEXSTEP), the Road Map highlights the urgent need to update the national policy framework in alignment with the outlined goals and targets. It emphasizes the importance of a coordinated effort between the public and private sectors to close existing gaps in electricity access, clean cooking solutions, renewable energy deployment and energy efficiency.

We are encouraged to note that the SDG 7 Road Map has served as a foundational document for the newly developed National Energy Policy 2024–2050 of the Federated States of Micronesia. Together, these documents will provide essential guidance for policymakers in navigating the energy transition toward a more sustainable, resilient and inclusive energy future.

The collaboration between ESCAP and the Department of Resources and Development underscores a shared dedication to advancing the energy-related Sustainable Development Goals. The Road Map not only charts a course toward long-term prosperity for the Federated States of Micronesia but also contributes to its recovery from the COVID-19 pandemic and offers a model for other countries striving to create sustainable energy systems.

As the Federated States of Micronesia moves forward with the implementation of the Road Map, we look forward to witnessing its progress and success in fostering a secure, sustainable and low-carbon energy future.



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

Foreword: The Federated States of Micronesia

The Federated States of Micronesia (FSM), as a Pacific island nation, is confronted with distinctive and multifaceted energy challenges. Our considerable dependence on imported fossil fuels exerts pressure on our economy and exposes us to external disruptions - ranging from geopolitical events to fluctuations in global energy prices. Coupled with this, the escalating impacts of climate change pose significant threats to our communities, underscoring the urgent necessity for a more sustainable, resilient, and self-sufficient energy framework.

In this landscape, the SDG 7 Roadmap for the Federated States of Micronesia has been a crucial instrument in guiding our journey towards universal access to affordable, reliable, sustainable, and modern energy by 2030. Through a comprehensive assessment of our current energy landscape, the roadmap has identified key gaps and outlined actionable strategies to expedite our progress towards achieving the SDG 7 targets. Significantly, it has laid the groundwork for our newly developed National Energy Policy 2024-2050, which will steer our long-term transition towards a cleaner and more sustainable energy future.

The development of this roadmap was made possible by the invaluable support and collaboration of the United Nations Economic and Social Commission of Asia and the Pacific (ESCAP). Their technical expertise and guidance have been instrumental not only in shaping this national roadmap but also in formulating four provincial energy transition roadmaps, each tailored to our unique local contexts. We express our deep appreciation for ESCAP's unwavering commitment to assisting FSM in our pursuit of energy security and sustainability.

As we progress, we remain steadfast in our commitment to the ambitious goals laid out in the SDG 7 Roadmap and our national energy policy. We eagerly anticipate continued collaboration with ESCAP and other key partners to implement sustainable energy solutions that will benefit our people, strengthen our economy, and preserve our environment for generations to come.

Elina P. Akinaga
Secretary
Department of Resources and Development
Federated States of Micronesia

Abbreviations and acronyms

BAU	business-as-usual
BESS	battery and energy storage system
CBA	cost benefit analysis
CO2	carbon dioxide
CPS	current policy scenario
DoRD	Department of Resource and Development
EE	energy efficiency
EERF	Energy Efficiency Revolving Fund
ESCAP	United Nations Economic and Social Commission for Asia and the Pacific
ESCO	energy services companies
EV	electric vehicle
GDP	gross domestic product
GHG	greenhouse gas
GW	gigawatt
ICS	improved cooking stove
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IPP	independent power producers
IRENA	International Renewable Energy Agency
ktoe	thousand tonnes of oil equivalent
kWh	kilowatt-hour
LCOE	Levelized Cost of Electricity
LEAP	Low Emissions Analysis Platform
LED	light-emitting diodes
LPG	liquified petroleum gas
MCDA	Multi-Criteria Decision Analysis
MEPS	minimum energy performance standard
MJ	megajoule
MJ/US$$_{2017}$	megajoules per US dollars measured n constant 2017 at purchasing power parity
MoE	Ministry of Energy
MTF	Multi-Tier Framework
Mtoe	million tonnes of oil equivalent
MW	megawatt
NDC	Nationally Determined Contributions
NEXSTEP	National Expert SDG Tool for Energy Planning
OECD	Organisation for Economic Co-operation and Development
PP	power plant
RE	renewable energy
SDG	Sustainable Development Goal
SPC	The Pacific Community
TFEC	total final energy consumption
TNZ	towards net zero
TPES	total primary energy supply
TWh	terawatt-hour
UNEP	United Nations Environment Programme
US$	United States dollar
WHO	World Health Organization

Executive Summary

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

The key objective of this SDG 7 Road Map[2] is to assist the Government of the Federated States of Micronesia in assessing whether the existing policies and strategies are well aligned with achieving the SDG 7 and NDCs targets by 2030 and to present a series of options to bridge these gaps. This Road Map presents three core scenarios: the business-as-usual (BAU) scenario; the current policy scenario (CPS); and the Sustainable Development Goal (SDG) scenario, that have been developed using national data, which considers existing energy policies and strategies and reflects on other development plans. The Road Map also investigates one ambitious scenario; the toward net-zero (TNZ) emissions by 2050 scenario. This scenario offers policymakers with a strategic viewpoint on how the Federated States of Micronesia could plan for a carbon-free energy sector in alignment with the global race to net-zero carbon.

A. Highlights of the Road Map

Without the presence of multiple enabling frameworks, the progress of the Federated States of Micronesia toward achieving the targets of SDG 7 and the NDCs will be challenging. In terms of access to modern energy, the Federated States of Micronesia is likely to fall short on universal access to electricity in 2030. Additionally, without concerted efforts, the Federated States of Micronesia is unlikely to achieve universal access to clean cooking technology by 2030. One option for the Federated States of Micronesia is to explore the use of highly energy efficient liquified petroleum gas (LPG) / butane gas cooking stoves. Improved cooking stoves (ICS) can be considered in areas where the distribution of the LPG/butane gas stove will be difficult.

As an island nation, which is currently heavily reliant on imported energy resources, energy security is high on the development agenda of the Federated States of Micronesia. Therefore, key aims of the country should include diversification of the power generation mix, with a focus on indigenous sources (i.e., solar), and a reduction in the reliance on imported petroleum fuel. This aligns with the SDG 7 target

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

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

for renewable energy (RE), which calls for a substantial increase in the share of RE in the total final energy consumption (TFEC) to rise from the 0.8 per cent share in 2019 (excluding traditional biomass).

In the CPS, renewable energy capacity is expected to be 57.7 per cent by 2030. This falls short from the target of 70 per cent renewable generation because a significant amount of diesel-fired generation will be required to fulfil the increasing demand for electricity. Thus, the Federated States of Micronesia needs to strengthen its energy efficiency measures. In terms of energy efficiency, energy intensity is expected to be 4.6 MJ/US$$_{2017}$ in 2030 which corresponds to an annual improvement of 1 per cent under the CPS. NEXSTEP analysis identifies that by following the SDG scenario, the Federated States of Micronesia can even lower its energy intensity to 3.5 MJ/US$2017 by 2030, which corresponds to an annual improvement of 3.4 per cent, thereby aligning with the global energy efficiency improvement rate.

In addition to a highly efficient energy system, a faster transition towards cleaner energy sources, especially renewables in electricity generation, will help the Federated States of Micronesia to reach net-zero greenhouse gas (GHG) emissions by 2050. This, however, requires an ambitious effort to switch fossil fuel-based energy systems to renewables. Electrification of existing technologies, such as the transport system and cooking stoves, will be critical. A deeper analysis indicates that phasing out diesel-fired power plants by 2050 is feasible, since the lifecycle cost of renewables-based power generation is already competitive as compared with diesel-fired generation.

B. Achieving SDG 7 and NDC targets in the Federated States of Micronesia by 2030

1. Universal access to electricity

In 2019, around 81.3 per cent of population of the Federated States of Micronesia had access to electricity leaving about 20,000 people, primarily in rural areas, with no access. Achieving universal access to electricity is a priority for the Government of the Federated States of Micronesia. However, due to the remoteness of outer islands, it is expected that the 100 per cent access rate will not be achieved by 2030 under the current policy setting. NEXSTEP analysis suggests that leveraging mini/off-grid system technologies (i.e., solar mini-grid and solar home systems) would be more appropriate to close the gap, based on their cost-effectiveness, climate resiliency and faster implementation methods.

2. Universal access to clean cooking technology

Under the current policy settings, access to clean cooking is projected to increase from 39.7 per cent, in 2019, to 45.9 per cent, in 2030 (figure I). This means that by 2030, 10,173 households will still rely on polluting fuel stoves, which primarily use biomass and kerosene as fuel, exposing a significant population to negative health impacts arising from indoor air pollution, including non-communicable diseases such as stroke, ischaemic heart disease, chronic obstructive pulmonary disease and lung cancer, particularly among women and children (WHO, 2022).

The Road Map suggests that gaps can be closed by transitioning to LPG/butane gas stoves as this option may provide an affordable alternative compared to electric cooking stoves, given that electricity tariffs are expensive. In areas where distribution will be difficult, ICS can be promoted. With these measures in place and under the SDG scenario, the share of LPG/butane gas cooking stoves will increase to 60.9 per cent and to 32.4 per cent for ICS. The remaining will be fulfilled by existing biogas digester and electric kitchen appliances.

Figure I. Access to clean cooking under the current policy scenario (CPS) in the Federated States of Micronesia

Source: ESCAP.

Note: Historical trend projection is based on the access rate data for 2000, provided by ESCAP (2022) as well as the access rate data for 2001 provided by SPC.

3. Renewable energy

The share of modern renewable energy (excluding traditional biomass usage in residential cooking) in TFEC (including non-energy use) was 0.8 per cent in 2019. Based on current policies, the share of renewable energy in TFEC is projected to increase to 9.2 per cent by 2030. This increase is attributed to the projected growth in renewable electricity, as per the energy master plan, along with financial support from development partners. In the SDG scenario, the share of renewable energy is projected to increase to 26.2 per cent of TFEC in 2030. The additional 17 percentage point increase can be attributed to the phasing out of traditional biomass for cooking, together with improving energy efficiency that contributes to a reduction in energy intensity.

In terms of power generation, NEXSTEP analysis projects that the Federated States of Micronesia may only reach a 57.7 per cent renewable generation, falling short from the 70 per cent target, since a significant amount of diesel generation will still be in operation to meet the increasing demand for electricity. The renewable energy share in power generation will further increase to 81.7 per cent in the SDG scenario, attributed to the suggested energy efficiency measures to reduce demand for electricity.

4. Energy efficiency

NEXSTEP analysis finds that to reach the required 2030 energy intensity under the SDG 7.3 target, the annual improvement rate between 2019 and 2030 needs to be 9.3 per cent, which is quite challenging. Therefore, NEXSTEP analysis suggests that the energy intensity target of the Federated States of Micronesia should be aligned with the global annual improvement target of 3.4 per cent (IEA and others, 2023). This corresponds to a 2030 energy intensity target of 3.5 MJ/US$$_{2017}$.

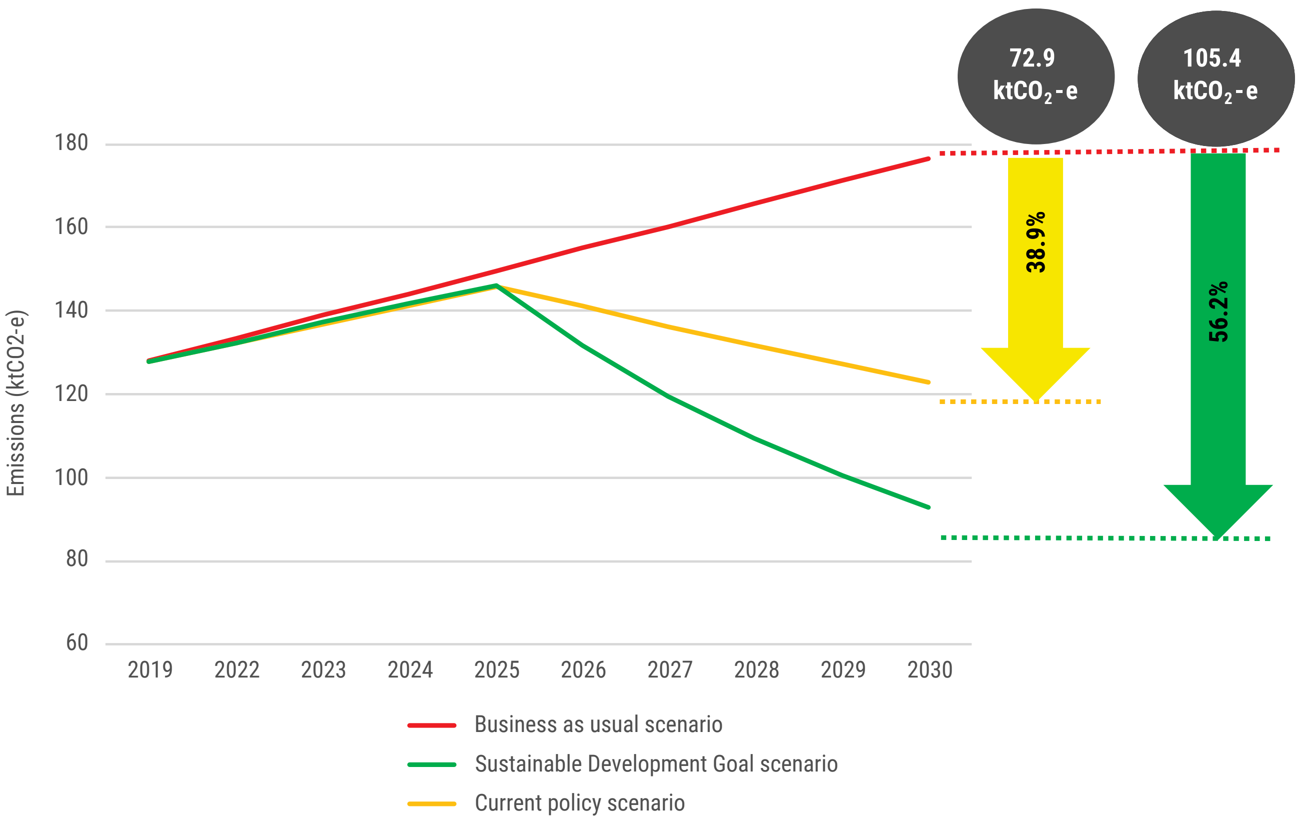
Under the CPS, the energy intensity is projected to drop to 4.6 MJ/US$$_{2017}$. This translates to a 1 per cent annual improvement rate. The Federated States of Micronesia can further reach an energy intensity of 3.5 MJ/US$$_{2017}$, aligning with the global energy efficiency improvement rate of 3.4 per cent per annum, by implementing some global best practices, such as setting minimum energy performance standards (MEPS), shifting transport modes, improving the fuel economy and implementing green building codes.

5. Nationally Determined Contributions

The updated NDCs of the Federated States of Micronesia sets a conditional mitigation target of reducing carbon dioxide emissions from electricity generation by more than 65 per cent below 2000 levels in 2030 (relative to the year 2000 inventory, electricity generation accounts for 64 $ktCO_2$-e, which means that the conditional reduction from electricity generation will be around 41.6 $ktCO_2$-e. Therefore, emissions from electricity generation must be less than 22.4 $ktCO_2$-e) (Government of the Federated States Micronesia, 2022).

Under the CPS, emissions will reach 114.6 $ktCO_2$-e in 2030, a 72.9 $ktCO_2$-e (38.9 per cent) reduction compared to the BAU scenario. The decrease in GHG emissions, relative to BAU, is due to the increase in renewable share in electricity supply as per the existing capacity expansion plan under the energy master plan of the Federated States of Micronesia. Increasing the implementation of energy-saving measures, in order to align with the global improvement target of 3.4 per cent, will further reduce emissions. In the SDG scenario, total emissions will reach 82.1 $ktCO_2$-e by 2030, corresponding to a 105.4 $ktCO_2$-e (or a 56.2 per cent) reduction compared to the BAU scenario (figure II). Despite significant emissions reduction under the CPS, emissions from the power sector will be 27.8 $ktCO_2$-e (which does not meet the NDC target). Meanwhile, emissions from the power sector will be 8.7 $ktCO_2$-e under the SDG scenario which meets the NDC target.

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



Source: ESCAP analysis.

C. Increasing ambition beyond SDG 7

This Road Map also includes a scenario that looks beyond 2030 and aims for net-zero emissions by 2050. Achievement of this target will require decarbonization of the energy sector. This will be best achieved by: (a) decarbonizing the power sector; and (b) switching all energy consumption to renewables and electricity. Fortunately, the energy system of the Federated States of Micronesia is well-positioned for an accelerated decarbonization effort since many of the required net-zero technologies, such as renewable power generation, electric cooking stoves and electric vehicles, are mature and readily available. A well-concerted effort must be undertaken to reduce electricity tariff in the future so that electrification of energy system would be possible in the long run.

D. Important policy directions

The Road Map sets out the following key policy recommendations to help the Federated States of Micronesia achieve the SDG 7 and NDC targets, together with suggestions on how to reduce reliance on imported energy sources:

(1) **Introduce strong policy measures to address the gap in clean cooking by 2030.** Achieving universal access to clean cooking fuels and technologies seems to be one of the major challenges. Adoption of LPG/butane gas cooking stoves and ICS will significantly help improve clean cooking access. The cumulative deployment cost of both technologies would require US$ 1.21 million by 2030. In the long run, the deployment of electric cooking stoves will also help the Federated States of Micronesia achieve its net-zero emissions target.

(2) **Enhance efficiency of energy use in all economic sectors.** The Federated States of Micronesia needs to enhance and strengthen its energy-saving measures to align with the 3.4 per cent global energy efficiency improvement pathway. This can be achieved by implementing best practices, such as setting MEPS, building energy codes, shifting transport modes, and improving the fuel economy, in the years leading up to 2030.

(3) **Implement fuel switching strategies, including electrification.** Such strategies are needed to accelerate progress toward achieving SDG 7 and provide multifold benefits in the long run. The electrification of end uses would be critical to decarbonize the entire economy by 2050. Since electrical equipment is more efficient compared to fossil fuel-based equipment, this will significantly reduce demand for fossil fuel. Rapid adoption of electric vehicles in the Federated States of Micronesia, for instance, will reduce the demand for oil products, hence reducing the reliance on imported petroleum fuels. The Government should start setting ambitious electric vehicle and electric cooking stove targets from 2031 to 2050. Switching over to electric appliances must be supported by investment in clean energy systems. The need for additional investment in clean energy systems can be limited by an increased adoption of energy efficient measures.

(4) **Decarbonize the power sector to provide the highest potential in GHG emissions reduction as well as improve energy security.** In the ambitious TNZ emissions by 2050 scenario, the projected decrease in grid emissions can realize a substantial overall national GHG emissions reduction. Investments in diesel-fired power are no longer cost-effective compared with renewables and should be discontinued to avoid emissions lock-in. NEXSTEP analysis suggests that lifecycle costs of renewables, such as hydropower, solar and wind, are cheaper than diesel-fired technologies. The underlying financial risks of investment in diesel-fired power plants should not be ignored. Fulfilling the required capacities for the net-zero emissions scenario could be challenging technically and economically, yet these investments will help improve energy security through the utilization of indigenous resources.

1. Introduction

1.1. Background

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

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

1.2. SDG 7 targets and indicators

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

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

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

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

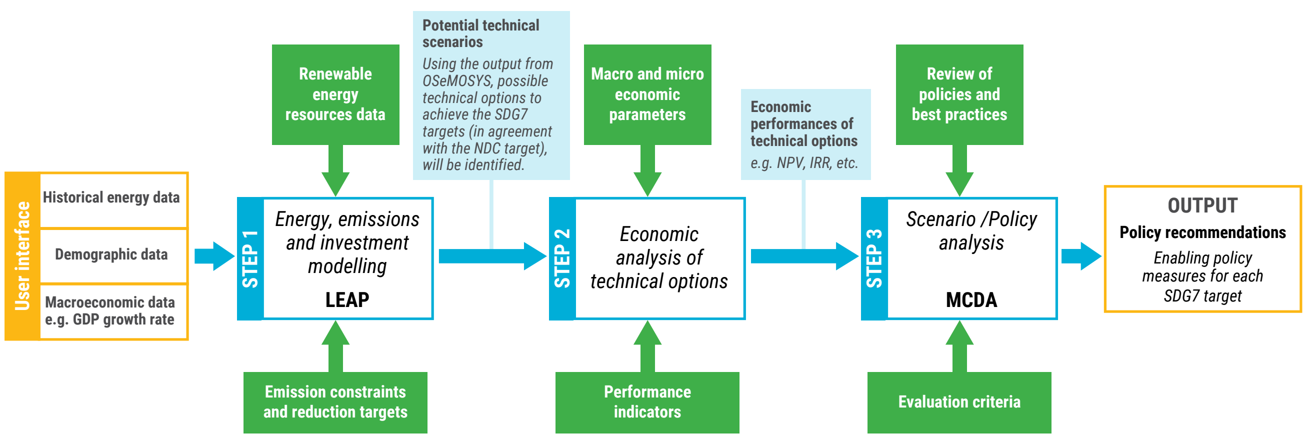
1.3. Nationally Determined Contributions (NDCs)

Nationally Determined Contributions represent pledges by each country to reduce national emissions and are the stepping-stones to the implementation of the Paris Agreement. Since the energy sector is the largest contributor to GHG emissions in most countries, decarbonizing energy systems should be given a high priority. Key approaches to reduce emissions from the energy sector include increasing renewable energy in the generation mix and improving energy efficiency. In its NDC document (Government of the Federated States of Micronesia, 2022), the Federated States of Micronesia sets a conditional mitigation target of increasing access to electricity to 100 per cent nationwide, increasing electricity generation from renewable energy to more than 70 per cent of total generation, and reducing carbon dioxide emissions from electricity generation by more than 65 per cent below 2000 levels (relative to the year 2000 inventory, electricity generation accounts for 64 ktCO2-e meaning the conditional reduction from electricity generation will be around 41.6 ktCO_2-e).

1.4. NEXSTEP methodology

The main purpose of NEXSTEP is to help design the type and mix of policies that would enable the achievement of the SDG 7 targets and the emissions reduction target (under NDCs) through policy analysis. The tool helps modelling energy, emissions and economics to analyse a range of policies and options for their suitability (figure 1). This tool is unique as no other tools focus on developing policy measures that are specifically aimed at achieving SDG 7. One key feature of this tool is its back-casting approach to energy and emissions modelling. This method is important for planning toward SDG 7, as it involves developing a trajectory by working backwards from the (known) 2030 targets to the present day, thereby ensuring a clear path for achieving the goals.

Figure 1. Components of the NEXSTEP methodology



Source: ESCAP.

1.4.1. Energy and emissions modelling

NEXSTEP analysis begins by developing a model of the energy system for each scenario, defining the technical options in terms of the final energy (electricity and heat) requirement for 2030, possible generation/supply mix, emissions and the size of investment required. The energy and emissions modelling component uses the Low Emissions Analysis Platform (LEAP) tool (Heaps, 2022). This proprietary software is widely used by many countries to develop scenarios for the energy sector, conduct policy analysis and establish NDC targets.

1.4.2. Economic analysis

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

1.4.3. Scenario analysis

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

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

This step is performed using the NEXSTEP online portal, as a means to suggest the best way forward for the countries by prioritizing the scenarios (ESCAP, 2024). Stakeholders can update this scenario ranking using various criteria and their weights. The top-ranked scenario from the MCDA process is used to inform the Government on the best possible energy transition pathway for the country.

1.5. Data sources

The primary source of data collection has been from government databases and reports. Some data have been collected directly from government agencies through request from the Pacific Community (SPC). In a few instances where government data was unavailable, such as resource potential data, research papers and analyses have been consulted. The final dataset has been presented to and approved by Department of Resources and Development.

2. Country overview

2.1. Demographic and macroeconomic profile

The Federated States of Micronesia is located in the western part of the Pacific Ocean, 1,645 kilometres south-east of Guam and 4,023 kilometres south-west of Hawaii. The country covers around 3 million km² of sea surface and a total of 702 km² of land area. The Federated States of Micronesia have a tropical rainforest climate, where the temperature lies between 22°C and 32°C with an average annual rainfall between 2,500 mm and 5,000 mm. Communities in the Federated States of Micronesia are experiencing rising sea levels and temperatures because of climate change.

The Federated States of Micronesia comprises four states, namely Kosrae, Pohnpei, Chuuk and Yap, which spread across 607 islands. The State of Pohnpei is one of the four federal states of the country where the capital is located. Chuuk is the most populous state, where most people live in the Chuuk lagoon. Weno island, Chuuk's state capital and the country's biggest city, is situated in this lagoon. The state of Kosrae is the eastern-most state of the Federated States of Micronesia, and the state of Yap is the western-most state comprising four main islands and 134 smaller islands.

In 2019, the country had a population of 104,358 people, with an estimated 17,015 households which amounted to an average of 6.1 persons per household.[3] Around 47 per cent of the population is living in Chuuk, 35 per cent in Pohnpei, 11 per cent in Yap and 7 per cent in Kosrae. The annual population growth rate was around 0.4 per cent between 2018 and 2019. The urbanization rate in 2019 was around 22.8 per cent (ESCAP, 2023).

The GDP of the Federated States of Micronesia was estimated at $332 million (constant 2015 US$) in 2019. The annual GDP growth rate was around 1.2 per cent between 2018 and 2019. However, GDP growth has been heavily affected by the COVID-19 pandemic, resulting in a contraction of 1.8 per cent in 2020, 3.2 per cent in 2021, and 0.6 per cent in 2022 (World Bank, 2023a).

2.2. Energy sector overview

2.2.1. National energy profile in the baseline year 2019

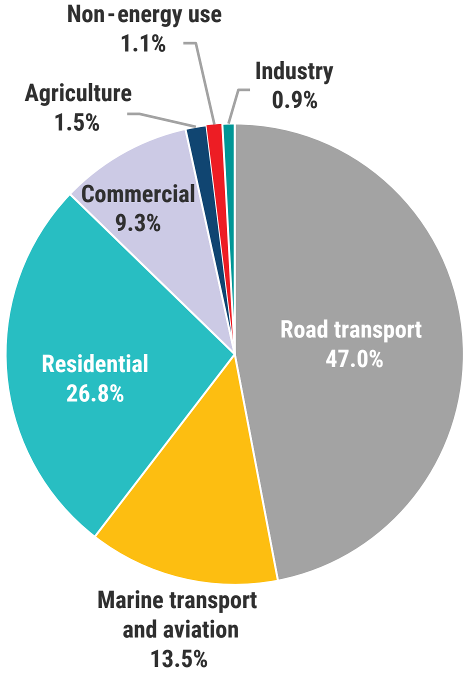
The following details describe the estimated national energy consumption using data collected with a bottom-up approach, such as activity level and energy intensity for different sectors. The bottom-up estimation is generally in agreement with the national energy statistics in terms of total energy supply and total final energy consumption by fuel type. The baseline year of 2019 has been chosen based on the latest year for which all data points are available.

Energy demand: In 2019, the total final energy consumption (TFEC[4]) was around 37.1 ktoe (figure 2). Most of the demand came from the transport sector (60.5 per cent), followed by the residential sector (26.8 per cent). The third largest consumption was in the commercial sector, estimated at 9.3 per cent or 3.5 ktoe. The industrial sector consumed 0.9 per cent and the agriculture sector consumed 1.5 per cent energy. The remaining 1.1 per cent was for non-energy use (lubricants for lubricating engines).

3 Based on the data provided by the Pacific Community (SPC).

4 This includes residential, commercial, industry, transport, agriculture and non-energy use sectors.

Figure 2. Total final energy consumption by sector in 2019



Source: ESCAP analysis.

In terms of fuel usage in TFEC, oil products contributed the highest amount (68.4 per cent). The transport sector, which operated predominantly with internal combustion engine vehicles, was the main consuming sector for oil products. Traditional biomass use was around 16.5 per cent and was consumed mainly in the residential sector. Electricity accounted for 15.1 per cent of energy demand.

In the transport sector, 77.7 per cent of energy or 17.4 ktoe was consumed by road transport. The remaining was consumed by the marine transport (4.9 ktoe) and aviation (0.1 ktoe) subsectors. In the road transport category, 47.7 per cent was used for passenger cars and 44.1 per cent of energy was used by freight trucks. Buses and minibuses accounted for 1.1 per cent while freight vans accounted for 3.9 per cent of energy demand. The remaining 3.2 per cent was for motorcycles, taxis and other vehicles. In the marine transport sector, 75 per cent of energy demand was for both small fishing boats and large fishing vessels. Around 16 per cent was used for passenger boat and the remaining 9 per cent was used for cargo vessels.

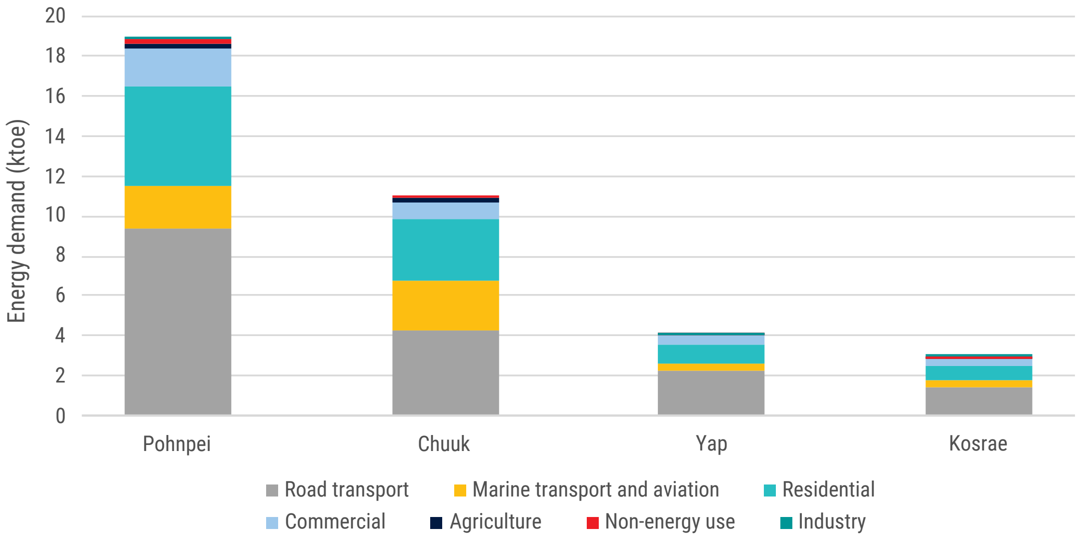
In the residential sector, around 78 per cent of energy was consumed for cooking purposes, which was supplied by kerosene and inefficient traditional biomass stoves. In terms of electricity, around 2.3 ktoe was utilized to power household appliances. Of this, refrigeration consumed 32.1 per cent, lighting 23.3 per cent, televisions 16.3 per cent, electric fans 10 per cent and the remaining 18.3 per cent was used for air conditioners, water heaters, washing machines, irons and other appliances.

In the commercial sector, supermarkets and shops accounted for 25.3 per cent of the energy demand, followed by government buildings at 20.2 per cent.[5] Hotels and restaurants consumed 13.7 per cent of commercial energy demand. Educational institutions and healthcare facilities accounted for 16.5 per cent and 13.7 per cent of energy demand, respectively. Around 9.7 per cent was consumed by private offices and the remaining 1 per cent was consumed by worship centres.

By state, Pohnpei accounted for 51 per cent of energy demand followed by Chuuk at 30 per cent. Yap and Kosrae accounted for 11 per cent and 8 per cent, respectively. All states showed a similar pattern where the transport sector had the highest demand followed by the residential sector (figure 3).

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

Figure 3. Total final energy consumption by state in 2019

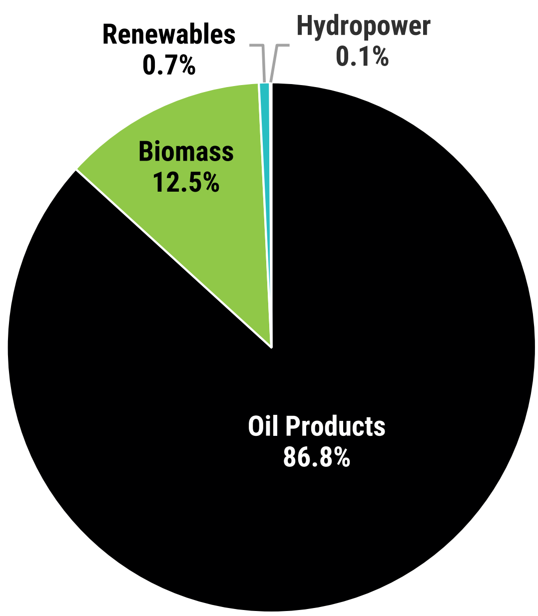


Source: ESCAP analysis.

Primary energy supply: The total primary energy supply (TPES) in 2019 was around 48.8 ktoe (figure 4). The energy supply mix was as follows: oil products, 86.8 per cent; biomass, 12.5 per cent; renewables, 0.7 per cent; and hydropower, 0.1 per cent. Therefore, the energy production from indigenous sources was around 13.3 per cent.

Electricity generation: Total installed power generation capacity in 2019 was 38.1 MW. In terms of capacity mix, diesel accounted for 84.7 per cent of the capacity. Renewables accounted for 15.3 per cent of capacity of which solar was 11.2 per cent, wind was 2.2 per cent and hydropower was 1.9 per cent. Total electricity generation in 2019 was 80.1 GWh. Thermal power plants accounted for 94.6 per cent of power generation while the remainder 5.4 per cent came from renewable energy.

Figure 4. Total primary energy supply by sector in 2019



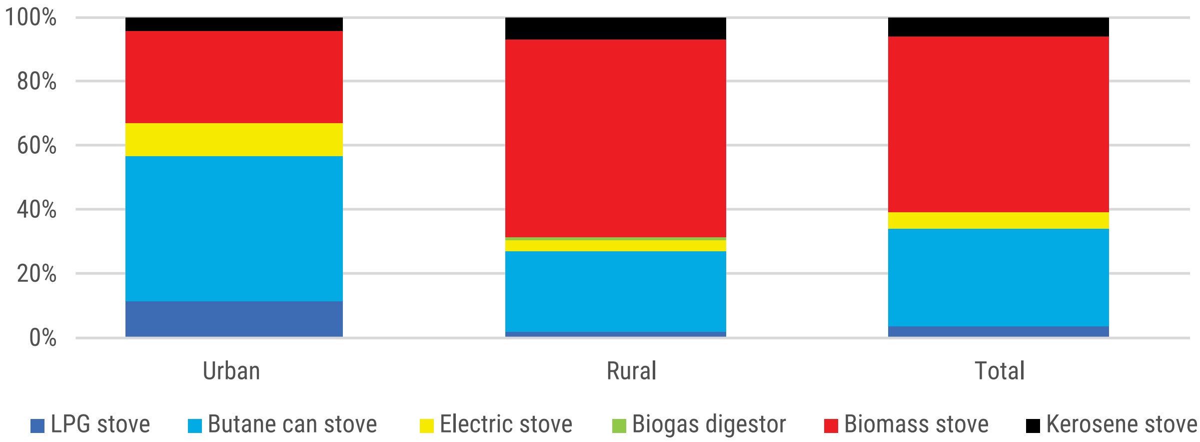
Source: ESCAP analysis.

2.2.2. Status of SDG 7 targets in the baseline year 2019

Access to modern energy: The rate of electrification in the Federated States of Micronesia was 81.3 per cent in 2019. Chuuk had the lowest electrification rate at 42.8 per cent. In contrast, the electrification rate in Pohnpei, Kosrae and Yap was around 96.7 per cent, 96 per cent, and 85 per cent, respectively.

Access to clean cooking technologies was measured at 39.7 per cent, in 2019. The remaining 60.3 per cent of the population, which corresponds to 10,260 households, still relied on polluting kerosene and biomass stoves as their primary cooking technologies. In households with clean cooking technologies, LPG/butane gas stoves were the most dominant primary clean cooking technology, with an estimated share of 33.8 per cent, followed by a small proportion of electric cooking stoves and biogas stoves. Figure 5 shows the distribution of different cooking fuels and technologies in 2019. By state, Pohnpei had the largest clean cooking access share at 64 per cent, while Chuuk had the lowest share at 19.9 per cent. Yap and Kosrae had 47.7 per cent and 45.4 per cent of clean cooking access shares, respectively.

Figure 5. Shares of cooking access by technologies



Source: ESCAP analysis.

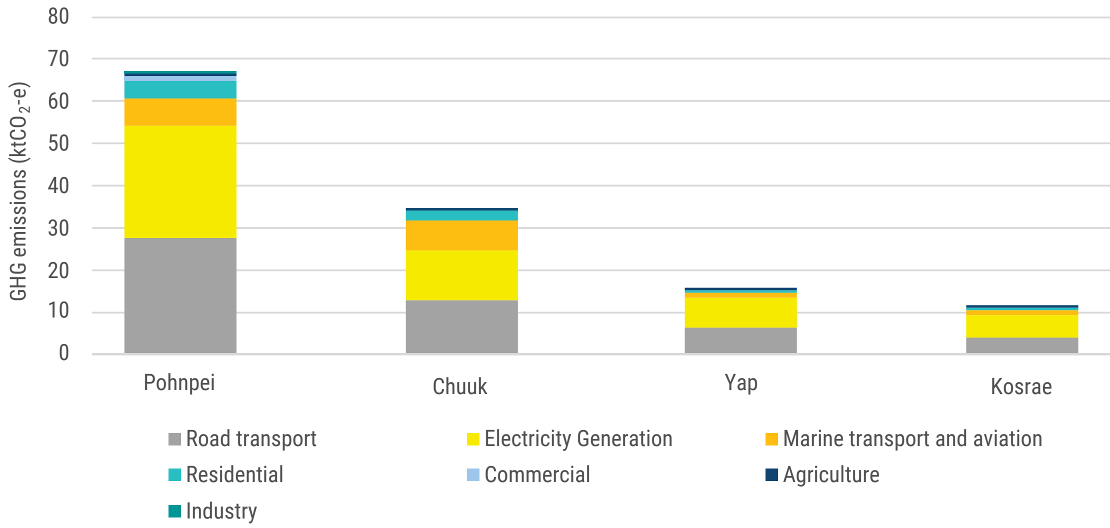
Renewable energy share in the total final energy consumption (TFEC): Renewable energy delivered approximately 17.2 per cent of TFEC in 2019, which is equivalent to 12.2 per cent of TPES. This includes traditional biomass usage in the residential sector. If traditional biomass is excluded, the renewable share was 0.8 per cent of TFEC. While endowed with an abundance of renewable energy potential, the Federated States of Micronesia still relies heavily on fossil fuels (i.e., oil products) to meet its stationary and mobile energy demands.

By state, Yap had the highest share of modern renewable energy (excluding traditional biomass) in TFEC at 4.4 per cent, since its renewables share in power generation was the largest, coming from solar and wind generation. Pohnpei and Kosrae had a similar share of 0.6 per cent each. Chuuk had the lowest share of modern renewable energy (excluding traditional biomass) in TFEC at 0.2 per cent.

Energy intensity: Energy intensity under SDG 7.3 is defined as the total primary energy supply (TPES) in MJ/US$$_{2017}$. The energy intensity in 2019 was estimated to be 5.2 MJ/US$$_{2017}$. By state, Kosrae had the least efficient energy system since its energy intensity was the highest compared to other states, measured at 7.1 MJ/US$$_{2017}$. The energy intensities of Pohnpei and Chuuk were also slightly higher than the national value, which were 5.4 MJ/US$$_{2017}$ and 5.3 MJ/US$$_{2017}$, respectively. Yap had the lowest energy intensity at 3.7 MJ/US$$_{2017}$.

GHG emissions: The energy sector emissions, from the combustion of fossil fuel, were calculated based on IPCC Tier 1 emission factors assigned in the LEAP model and expressed in terms of 100-year global warming potential (GWP) values. GHG emissions from the energy sector were estimated at 128.1 ktCO$_2$-e in 2019. Emissions from the transport sector were the largest at 66.1 ktCO$_2$-e, arising from direct fuel combustions in internal combustion engines, followed by the power generation sector at 51.6 ktCO$_2$-e. The residential sector accounted for 7.3 ktCO$_2$-e resulting from use of oil products and biomass combustions for cooking. The remaining emissions came from the agriculture, commercial and industrial sectors. By state, Pohnpei accounted for 52 per cent of energy demand followed by Chuuk at 27 per cent. Yap and Kosrae accounted for 12 per cent and 9 per cent, respectively. Figure 6 presents emissions by sector for different states.

Figure 6. GHG emissions by sector for different states in 2019



Source: ESCAP analysis.

2.2.3. National energy policies, plans, strategies and institutions

Several stakeholders are responsible for the operation of the energy sector of the Federated States of Micronesia. These include the National Energy Working Group, coordinated by Energy Division of Department of Resources and Development (DoRD), which is responsible for planning, managing and coordinating the national energy sector. The State Energy Working Group is responsible for overseeing and implementing the state efforts in the energy sector. Public utilities companies in each state, such as Pohnpei Utilities Corporation (PUC), Yap State Public Service Corporation (YSPSC), Chuuk Public Utility Corporation (CPUC) and Kosrae Utilities Authority (KUA), are the operators of the state power system including water.

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

- **Strategic Development Plan 2004-2023** has some comprehensive visions on energy, including to decrease the import of and reduce the use of imported petroleum fuels by 50 per cent by 2020. This is to increase renewable power to 10 per cent in urban centres and 50

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

per cent in rural areas by 2020. This increase will also meet the standards of the United States of America for energy efficiency in all new public and half of private buildings by 2006. The plan also includes a target to reduce private motor vehicle ownership/number of vehicles by 10 per cent, which was supposed to be achieved by 2010 (Government of the Federated States of Micronesia, 2004).

- **National Energy Policy and Action Plans 2012** aimed to assist the country in becoming less dependent on fossil fuel and more prepared to withstand the heavily fluctuating energy prices. The targets under this policy are to reach at least 30 per cent of renewable energy share in total energy production and 50 per cent of energy efficiency improvement by 2020 (Government of the Federated States of Micronesia, 2012).
- **Energy Master Plans for the Federated States of Micronesia.** The Energy Master Plan provides a least-cost strategy to achieve both the national's and state's energy goals. The Federated States of Micronesia will achieve its goal of 100 per cent electrification by 2027 and will achieve 63 per cent renewable energy (RE) generation by 2027, increasing to 84 per cent by 2037 (Castalia, 2018).
- **The Updated Nationally Determined Contributions (NDCs)** set a conditional mitigation target of increasing access to electricity to 100 per cent nationwide by 2030, increasing electricity generation from renewable energy to more than 70 per cent of total generation in 2030 and reducing carbon dioxide emissions from electricity generation by more than 65 per cent below 2000 levels in 2030 (relative to the year 2000 inventory). In the Federated States of Micronesia, electricity generation accounts for 64 ktCO_2-e which indicates that the conditional target of reducing emissions from electricity generation will be around 41.6 ktCO_2-e (Government of the Federated States of Micronesia, 2022).

2.2.4. National energy resources and potentials

The Federated States of Micronesia depends on indigenous resources and energy imports to meet its energy needs and does not have oil and gas resources. The technical potential for renewable energy is high, but its development and deployment has been limited because of several barriers.

With substantial experience with solar PV technology, there are plans to further increase deployment in the next few years. However, feasibility studies must be conducted to better understand potentials at specific sites and ensure that the grid network is capable of handling high penetration of renewable energy. The Federated States of Micronesia have high solar insolation ranging from 4 kWh/m2 to 6 kWh/m2 (Government of the Federated States of Micronesia, 2012). However, available energy varies from state to state because of local cloud formation on islands with mountains, such as in Pohnpei and Kosrae.

The wind potential in the Federated States of Micronesia has not been assessed very well. Because of its low latitude, the country may have moderate resource availability. The average wind speed at 50 metres is between 4 m/s and 8 m/s (Government of the Federated States of Micronesia, 2012). Wind energy generation has been developed in Yap but not in the other states. In addition, typhoons may pose a risk for wind power systems in the country.

In terms of hydropower, Kosrae has limited potential. Yap and Chuuk have no hydropower potential. There are several potential hydro sites in Pohnpei, with a hydropower installation on the Nanpil river, however further feasibility studies must be conducted. Currently, no sufficient mature ocean energy technology that can be developed in the Federated States of Micronesia despite its vast and wide ocean.

Except for traditional biomass use for cooking, there has been no development of biofuel for energy production. The Federated States of Micronesia can utilize coconut oil in fuel mix for power generation to reduce the use of diesel. However, further studies must be conducted to examine its sustainability and techno-economic potential. Table 1 presents a strengths, weaknesses, opportunities and threats (SWOT) analysis of renewable energy resources in the Federated States of Micronesia.

Table 1. **SWOT analysis of renewable energy resources in the Federated States of Micronesia**

	Strengths	Weaknesses	Opportunites	Threats
Solar energy	- Abundant resource availability - Potential to deliver sustainable electricity	- Absence of financial mechanisms - Grid instability	- Huge potential to meet the supply and demand gap - Reduction in GHG emissions	- High capital cost
Wind energy	- Moderate availability of suitable sites with adequate wind speeds	- Grid instability	- Developers in the market already exist	- High capital cost
Hydro energy	- Endowed with water resources, particularly in Pohnpei	- Seasonal variability - Small catchment	- Developers in the market already exist	- Disturbance in biodiversity
Biomass and biofuel energy	- Availability of energy crops	- Absence of financial mechanisms	- Opportunity to mix coconut oil with diesel - Waste-to energy potential	- Very high capital cost for waste-to-energy thermal plant

Source: ESCAP.

3. Modelling assumptions

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

3.1. Scenario definitions

NEXSTEP is designed for scenario analysis, using the LEAP modelling system to enable energy specialists to model energy system evolution based on current energy policies. The baseline year 2019 was chosen, as it is the most recent year with sufficient data and information for modelling. In the NEXSTEP model for the Federated States of Micronesia, five scenarios have been developed. These include three core scenarios: (a) business-as-usual (BAU) scenario; (b) current policy scenario (CPS); and (c) Sustainable Development Goal (SDG) scenario. In addition, the towards net-zero (TNZ) emissions by 2050 scenario has been developed to present technological options and policy measures that would be required for the Federated States of Micronesia to transition beyond 2030.

3.1.1. The business-as-usual (BAU) scenario

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

3.1.2. Current policy scenario (CPS)

Inherited from the BAU scenario, this scenario considers initiatives implemented or scheduled to be implemented during the analysis period of 2019-2030 to establish baseline performance, with reference to the SDG 7 and NDC targets, as well as national targets for energy efficiency improvement and renewable energy share. Otherwise, the energy intensities from different demand sectors are assumed constant throughout the analysis period. Only policies with concrete measures have been considered in this scenario. Plans, strategies and policies that are unlikely to be implemented have not been considered but are compared with scenario results and findings later in this Road Map.

3.1.3. The Sustainable Development Goals (SDG) scenario

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

3.1.4. Towards net-zero (TNZ) emissions by 2050 scenario

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

3.2. Assumptions

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

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

Parameters	Business-as-usual scenario	Current policy scenario	Sustainable Development Goal scenario
Economic growth	1.17 per cent per annum.[a]		
Population growth	0.4 per cent per annum.[b]		
Urbanization rate	22.8 per cent in 2019, growing to 23.9 per cent in 2030.[c]		
Commercial floor space	Assumed annual energy consumption increasing at the same growth as GDP		
Industrial activity	Assumed annual energy consumption increasing at the same growth as GDP		
Transport activity	Passenger transport activities and freight transport activities are assumed growing at a rate like the growth in GDP per capita		
Residential activity	The appliance ownership for electrical appliances is projected to grow at a rate like the growth in GDP per capita.		
Access to electricity	Projected based on the historical electricity access between 2000 and2020.		100 per cent electricity access by 2030
Access to clean cooking fuels	Projected based on the historical penetration rate between 2000 and 2020.		100 per cent clean cooking access rate by 2030
Energy efficiency	Additional energy efficiency measures not applied	Improvement based on current policies	Global target of energy intensity adopted
Power plant	Considers 2019 RE share in power generation and grid emissions	Considers capacity expansion based on data from the Energy Master Plan	Considers generation to reach at least 70 per cent from renewable energy

a Historical data and estimation from World Bank, 2023b.

b Historical data and estimation from World Bank, 2023b.

c This assumes that the urbanization rate grows with an annual rate of 0.44 per cent, with reference to the national historical urbanization growth from 2010 to 2020.

4. Energy transition outlook in the current policy scenario

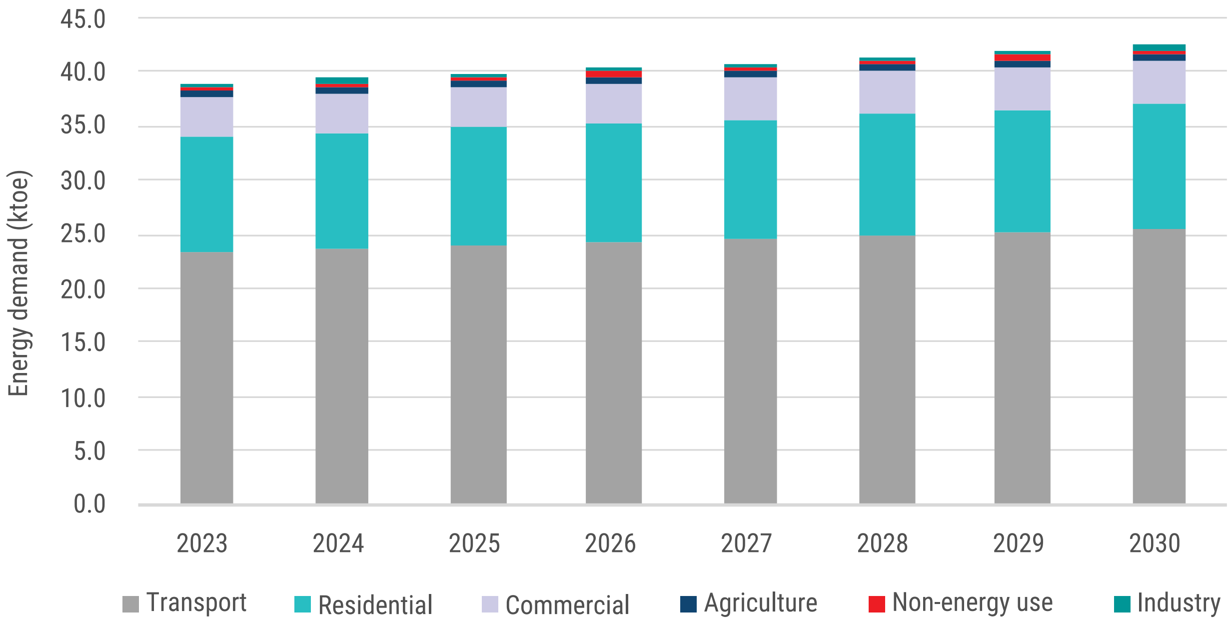

Energy
Renewable
Energy

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

4.1. Energy demand

Under the current policy setting, the demand for total final energy is expected to increase from 37.1 ktoe in 2019 to 42.4 ktoe in 2030, marking an average annual growth rate of 1.2 per cent. In 2030, the transport sector will remain the largest energy consuming sector with 60.1 per cent, while the residential sector share will be 27.3 per cent. Consumption of the commercial sector will be at 9.3 per cent followed by the agriculture sector at 1.5 per cent. The non-energy use and industrial sectors will account for the remaining 1.9 per cent of energy demand altogether. Figure 7 displays the forecast of TFEC by sector under the current policy scenario.

Figure 7. Energy demand outlook in the current policy scenario 2023 - 2030



Source: ESCAP.

4.1.1. Transport sector

The transport sector will consume 25.5 ktoe, an annual growth of 1.2 per cent, up from 22.4 ktoe in 2019. Road transport will consume 77.7 per cent of the energy requirement in the transport sector followed by marine transport at 22.1 per cent. Among the land vehicle categories in 2030, private cars will consume 9.5 ktoe, followed by freight trucks at 8.7 ktoe, freight vans at 0.8 ktoe, buses, minibuses, and taxis at 0.3 ktoe, as well as other vehicles at 0.5 ktoe. Among the maritime transport categories in 2030, fishing boats (small and large altogether) will consume the most at 4.3 ktoe, followed by passenger boats at 0.9 ktoe, and freight cargos/barges at 0.5 ktoe.

The Strategic Development Plan 2004-2023 aimed to reduce the number of private vehicles by 10 per cent by 2010. However, no specific technical details have been provided in the documents. Furthermore, it seems that the number of vehicles has increased significantly between 2010 and 2020 (PCREEE, 2020).

4.1.2. Residential sector

Energy demand in the residential sector will increase from 9.9 ktoe in 2019 to 11.6 ktoe in 2030, with an annual growth of 1.4 per cent. Around three quarters of energy demand will be used for cooking. The remaining 25 per cent will be consumed to power electric appliances. The urban and rural split of energy consumption would be 26.5 per cent and 73.5 per cent, respectively. In terms of fuel, biomass will be the main energy source at just around 59.3 per cent, followed by electricity at 26 per cent and oil products at 14.7 per cent. Biomass and oil products are used mainly for cooking purposes. Electricity will be used mainly for refrigeration (32.4 per cent), lighting (23 per cent), televisions (16.3 per cent), electric fans (10.1 per cent) while the remainder will be used for irons, washing machines, etc.

4.1.3. Commercial sector

Total energy consumption in the commercial sector (including government buildings) under the CPS will increase from 3.5 ktoe in 2019, at an average annual growth of 1.2 per cent, to 3.9 ktoe in 2030. Supermarkets and shops will account for a total of 26.7 per cent of the energy demand followed by government buildings (17.9 per cent) and educational institutions (16.5 per cent). Hotels and restaurants will consume 15.1 per cent while healthcare facilities will consume 14.2 per cent of energy demand. Private office and worship centres will account for 8.6 per cent and 0.9 per cent of commercial sector's energy demand, respectively.

Under the National Energy Policy and Action Plan, the Government of the Federated States of Micronesia planned to promote energy efficiency in office equipment by adopting the Energy labellng initiative and to encourage developers to adopt building energy standards (Government of the Federated States of Micronesia, 2012). However, the Federated States of Micronesia identified that no building energy performance directive was passed or endorsed by the congress, and the country did not participate in the 2019 SPC Pacific Appliance Labelling Project, which has now ended.

4.1.4. Industrial and agriculture sector

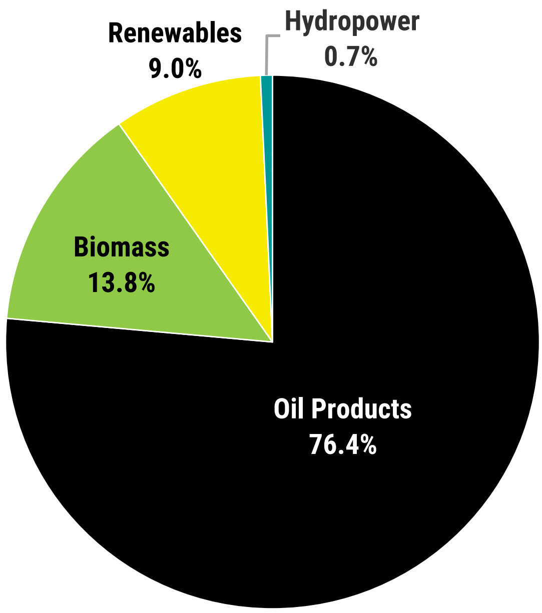
Total energy consumption in the industrial sector will increase slightly from 0.32 ktoe in 2019, at an average annual growth of 0.7 per cent, to 0.34 ktoe in 2030. Similarly, energy consumption in the agriculture sector will increase slightly from 0.55 ktoe in 2019 to 0.63 ktoe in 2030.

4.2. Energy supply outlook

Primary energy supply

In the CPS, TPES is forecasted to increase from 48.8 ktoe in 2019 to 49.6 ktoe in 2030. The fuel shares in 2030 (figure 8) will still be dominated by oil products 37.9 ktoe (76.4 per cent). However, there will be a reduction of 3.9 ktoe compared to 2019 value. Biomass will supply 6.9 ktoe (13.8 per cent), hydropower 0.4 ktoe (0.7 per cent) and other renewables 4.5 ktoe (9 per cent).

Figure 8. Total primary energy supply by fuel type in 2030 in the current policy scenario



Source: ESCAP.

Electricity generation

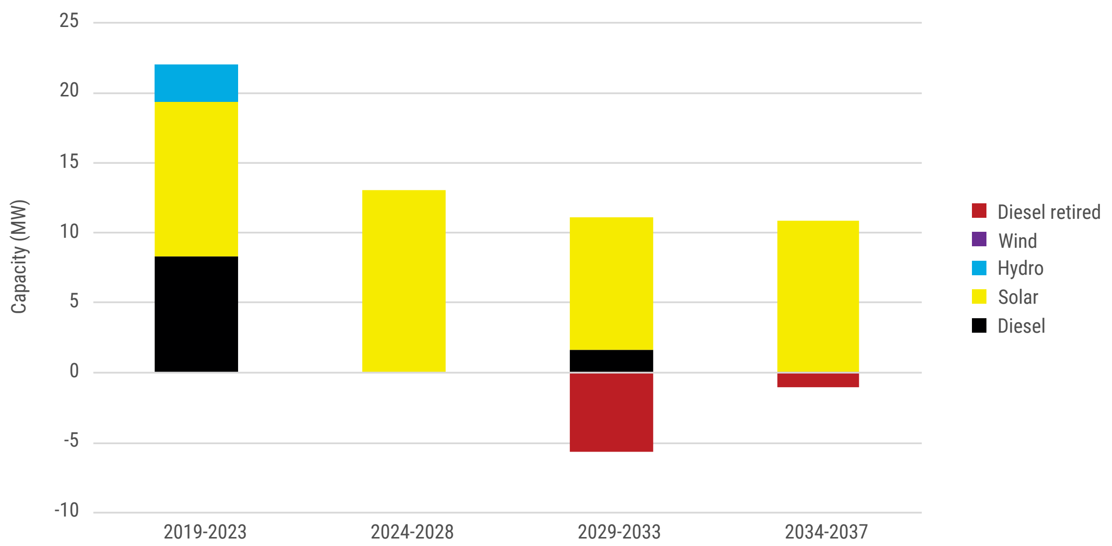
To assure sustainability of the energy sector development and create the basis for enhanced deployment of renewables in the future, the Federated States of Micronesia have set a target to increase RE share to 63 per cent by 2027 and 84 per cent by 2037 under the Energy Master Plan. According to the capacity expansion plan presented under the Energy Master Plan, as outlined in table 3 and figure 9, the installed power generation capacity for the country is forecasted to be 74.1 MW in 2030. Fossil fuel will continue to dominate at 51 per cent while renewables share will be 49 per cent. The capacity share of renewable energy increases from 15.3 per cent in 2019.

Electricity generation is expected to rise from 80.1 GWh in 2019 to 97.6 GWh in 2030. The renewable energy share in electricity supply will increase from 5.4 per cent in 2019 to 57.7 per cent in 2030. The total electricity requirement (considering both final energy demand as well as transmission and distribution losses) in the current policy scenario would be 96.6 GWh by 2030.

Table 3. Power capacity expansion plan

States	2019-2023	2024-2028	2029-2033	2034-2037
Chuuk	4 MW solar PV with 7 MWh storage	4 MW solar PV with 13 MWh storage	2 MW solar PV with 10 MWh storage 1.3 MW diesel retired	2 MW solar PV with 10 MWh storage
Kosrae	2 MW solar PV with 5 MWh storage	2 MW solar PV with 8 MWh storage	1 MW solar PV with 3 MWh storage	1 MW solar PV with 1 MWh storage 1 MW diesel retired
Pohnpei	3 MW solar PV with 1 MWh storage 7.5 MW diesel added 2.7 MW hydropower	5 MW solar PV with 5 MWh storage	4 MW solar PV with 7 MWh storage 1.1 MW diesel retired	6 MW solar PV with 21 MWh storage
Yap	2 MW solar PV with 3 MWh storage 0.83 MW diesel added	2 MW solar PV with 7 MWh storage	2.5 MW solar PV with 10 MWh storage 1.65 MW diesel added 3.2 MW diesel retired	1.8 MW solar PV with 10 MWh storage

Figure 9. Power and heat capacity expansion plan 2019 - 2037

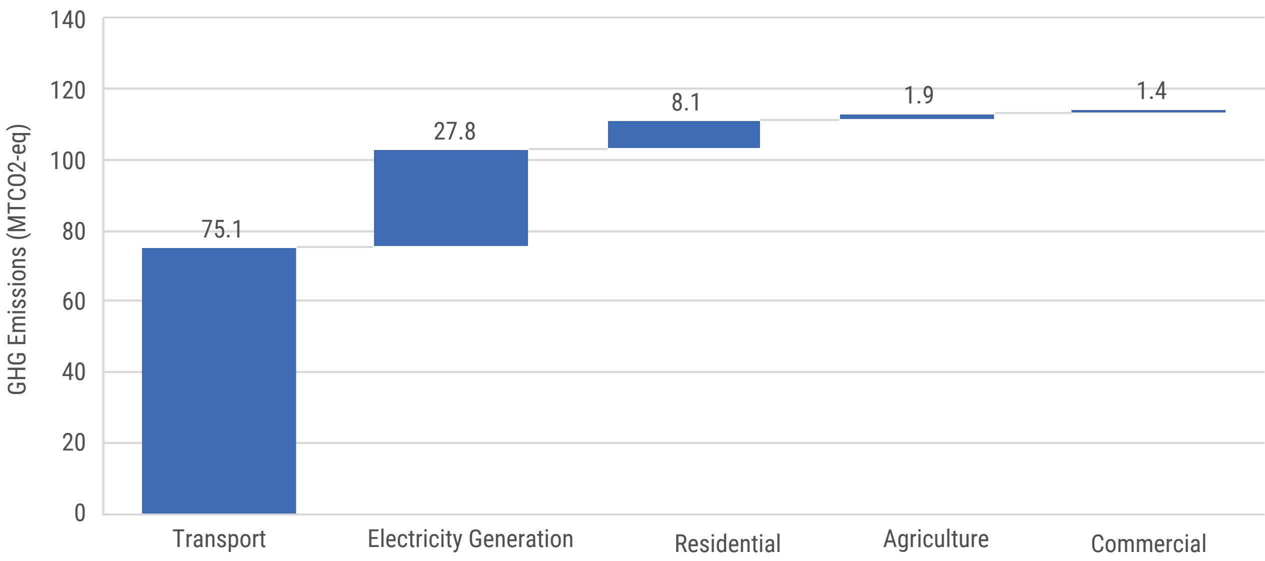


Source: ESCAP.

4.3. GHG emissions

GHG emissions, in the CPS, are projected to reach 114.6 $ktCO_2$-e by 2030, which is a decrease of 72.9 $ktCO_2$-e or 38.9 per cent compared to the BAU scenario. This reduction is attributable mainly to Government's plan to increase renewable energy in power generation. Most emissions will come from the transport sector (65.6 per cent), followed by the electricity generation (24.3 per cent) and residential (7.1 per cent) sectors. The remaining emissions will be shared by commercial, industrial and agriculture sectors. Figure 10 shows the emissions distribution by sector in 2030.

Figure 10. Distribution of emissions by sector in 2030 in the current policy scenario



Source: ESCAP.

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

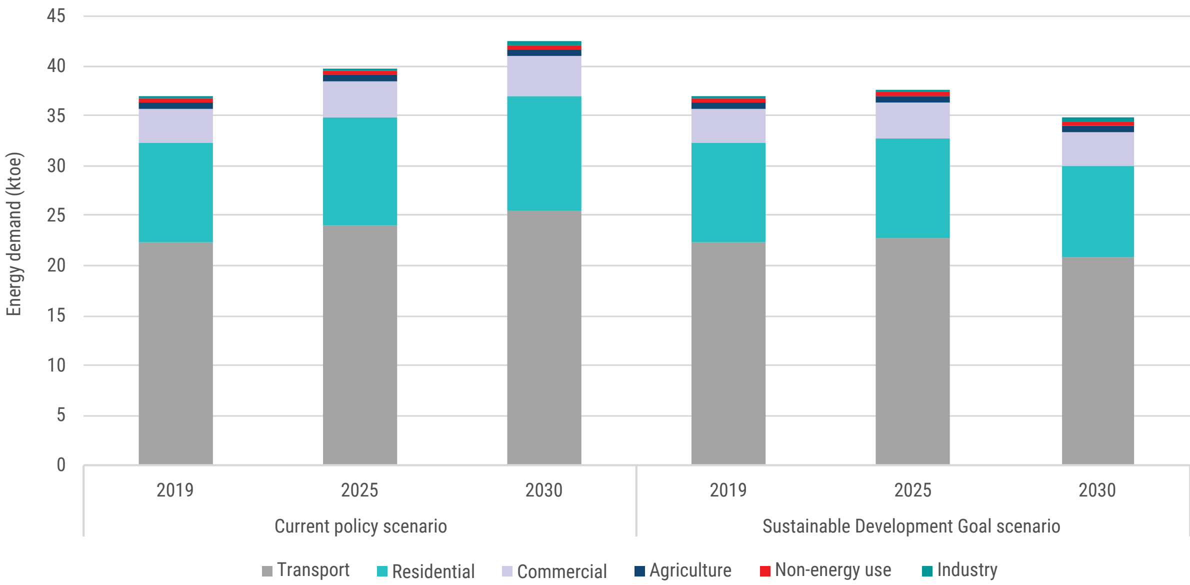
5. SDG scenario: An assessment of SDG 7 targets and indicators

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

5.1. Energy demand outlook

In the SDG scenario, TFEC decreases from 37.1 ktoe in 2019 to 34.8 ktoe in 2030, which is a 7.6 ktoe reduction compared to the CPS. This reduction is due to additional energy efficiency modelled to ensure the achievement of the SDG 7.3 target. In 2030, the transport sector will have the largest share of TFEC at 20.8 ktoe (59.8 per cent), followed by the residential sector at 9.2 ktoe (26.3 per cent). Commercial and agriculture sectors will account for 3.4 ktoe (9.8 per cent) and 0.6 ktoe (1.8 per cent), respectively. The industrial sector will account for 0.3 ktoe (1 per cent) while non-energy use will account for 0.5 ktoe (1.3 per cent). Figure 11 shows the total final energy consumption by scenario in 2030.

Figure 11. Comparison of energy demand between the current policy and Sustainable Development Goal scenarios



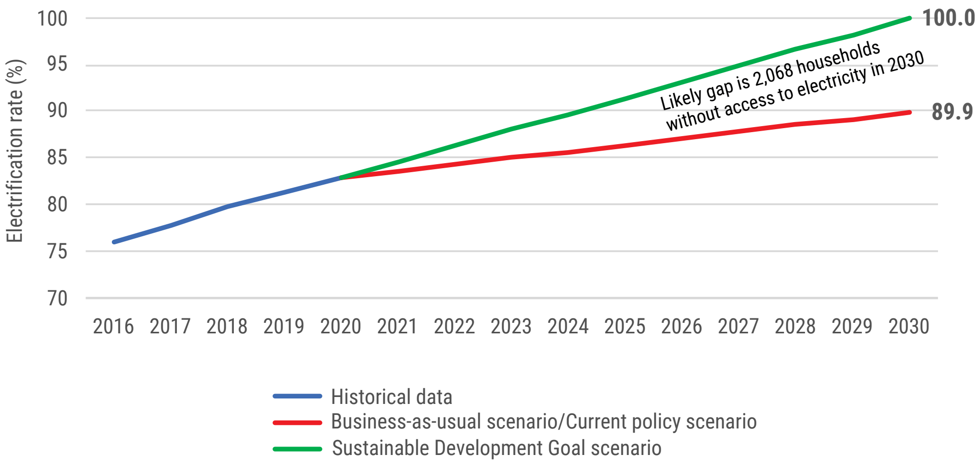
Source: ESCAP analysis.

5.2. SDG 7 targets

5.2.1. Access to electricity

Around 18.2 per cent of the population of the Federated States of Micronesia lacked access to electricity in 2019, primarily in rural or maritime areas and informal settlements. Unfortunately, the electrification rate has been growing at a slower rate pace between 2020 and 2021 at 0.8 per cent. It is predicted that electricity access will only reach 89.9 per cent at the current rate (figure 12). Achieving universal access to electricity is a priority for the Government of the Federated States of Micronesia. The updated NDC states that the objective is to reach a rate of 100 per cent by 2030. NEXSTEP analysis suggests that mini/off-grid systems technologies (i.e., solar or wind mini-grid) would be the more appropriate technologies, based on the cost-effectiveness, climate resiliency and faster implementation methods of the technology. In a remote area where the household distribution is quite sparse, stand-alone solar PV systems can be considered.

Figure 12. Access to electricity in the business-as-usual, current policy and Sustainable Development Goal scenarios in the Federated States of Micronesia

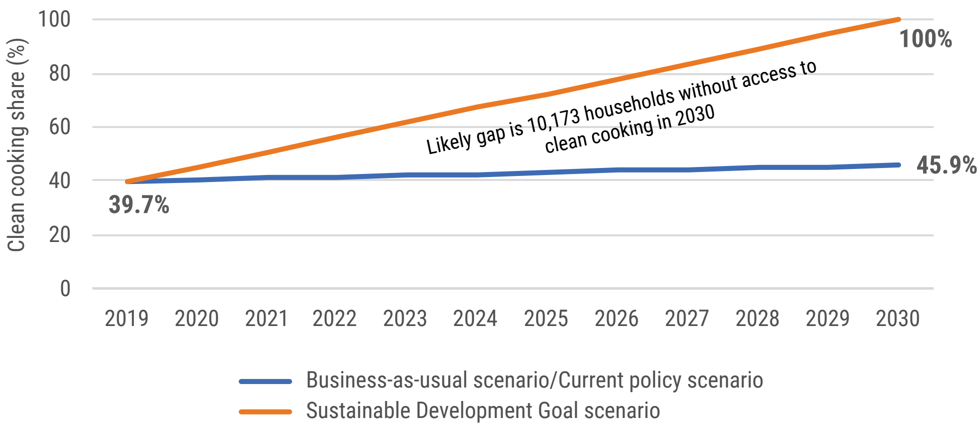


Source: ESCAP analysis.

5.2.2. Access to clean fuels and technologies for cooking

An accelerated effort is required to achieve universal access to clean cooking. As of 2019, 39.7 per cent of households relied on polluting cooking technologies, specifically kerosene and solid fuel stoves (assuming biomass as primary fuel). Access to clean cooking fuels and technologies will not be achieved in the CPS, reaching only 45.9 per cent in 2030 and leaving 54.1 per cent of the population relying on inefficient and hazardous cooking fuels and technologies. However, under the SDG scenario, the clean cooking access rate is set to achieve universal access (100 per cent) by 2030 (figure 13).

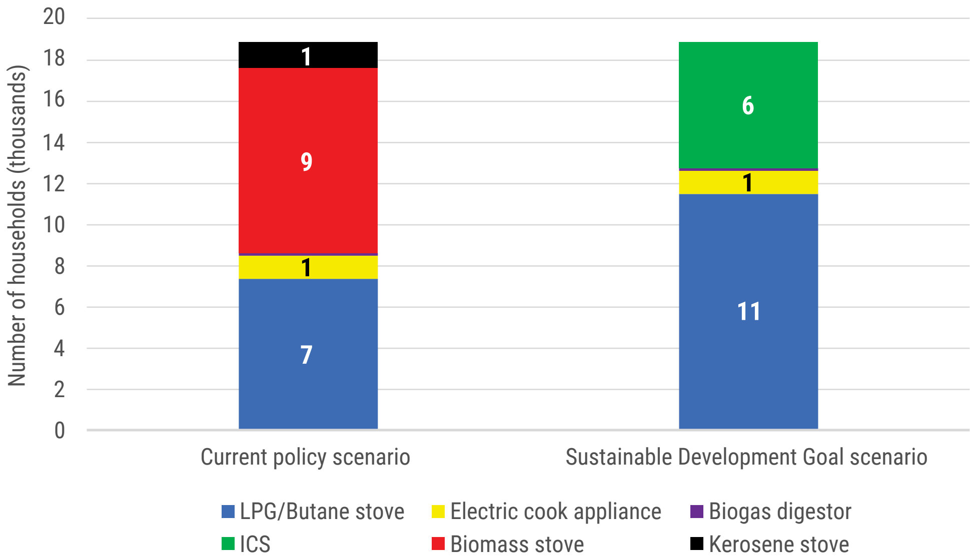
Figure 13. Access to clean cooking in the business-as-usual, current policy and Sustainable Development Goal scenarios in the Federated States of Micronesia



Source: ESCAP analysis.

NEXSTEP analysis indicates that LPG/butane can stoves would be the most appropriate solution for the Federated States of Micronesia by 2030 due to cost effectiveness since the technology is readily available in the country (figure 14). The annualized cost of LPG/butane can stove will be around $124 to $162 per unit while the electric cook stove will be around $180 to $244 per unit (table 4). The annualized cost varies since the electricity tariffs and LPG costs vary between states. Electric cooking stoves may not be suitable now for households since the electricity tariff is quite high in the country. ICS stoves, however, can play an intermediary role in the area where the distribution of LPG/butane cookstoves might be difficult. To minimalize canister waste, a recycling and reuse mechanism must be developed. Box 1 explains the basis for evaluation of clean cooking technologies. Annex IV summarizes the cost and technical assumptions used in the economic analysis.

Figure 14. Share of clean cooking technologies by 2030 under the current policy and Sustainable Development Goal scenarios



Source: ESCAP analysis.

Table 4. Annualized unit cost of cooking technologies

Technology	Annualized unit cost in US dollars
Electric cooking stove	$180 - $244
Improved cooking stove (ICS)	$54 - $91
LPG/Butane stove	$124 - $162

Source: ESCAP.

Box 1. Evaluation of clean cooking technologies

Electric cook stoves

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

Improved cook stoves

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

LPG/butane can cook stoves

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

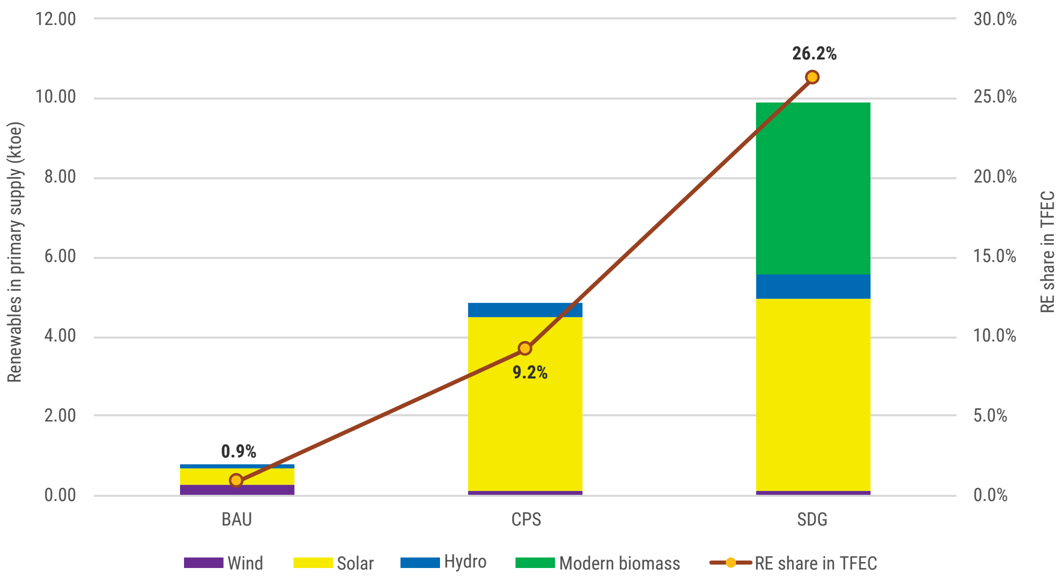
a World Health Organization, "Defining clean fuels and technologies", 2024. Available at https://www.who.int/tools/clean-household-energy-solutions-toolkit/module-7-defining-clean

b Energy Sector Management Assistance Program (ESMAP), "Multi-tier framework for energy access (MTF)", 2024. Available at https://www.esmap.org/mtf_multi-tier_framework_for_energy_access

5.2.3. Renewable energy

SDG 7.2 does not have a quantitative target but suggests a "substantial" increase of the renewable energy share in TFEC. The share of renewable energy in TFEC in 2030 will be 0.9 per cent in the BAU scenario, which is expected to grow to 9.2 per cent in the current policy scenario (figure 15). This increase is largely driven by the increase in the renewable energy share in power generation as stipulated in the current capacity expansion plan. The renewable energy share in TFEC is further increased to 26.2 per cent in the SDG scenario, resulting from the increased usage of efficient cooking technologies, improvement in energy efficiency in the residential sector as well as a higher share of renewable energy installed capacity in power generation.

Figure 15. Renewable energy in TPES and TFEC in 2030

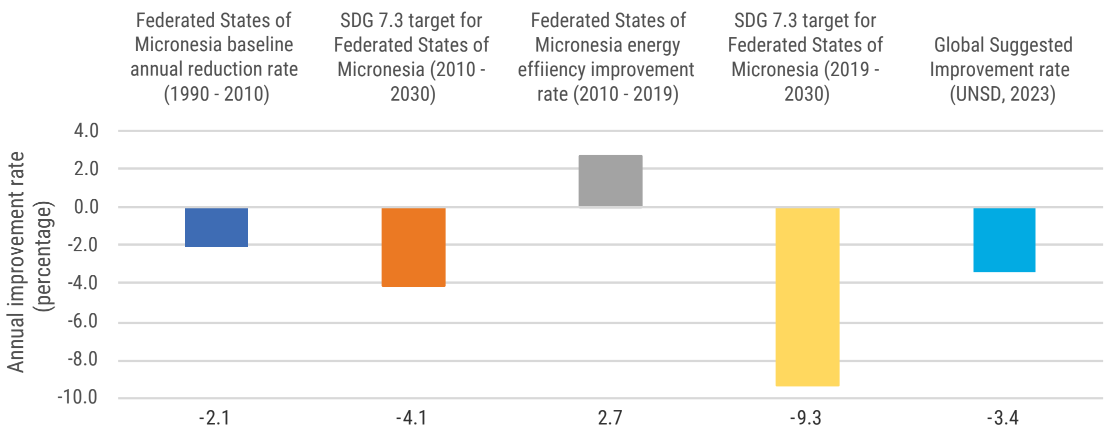


Source: ESCAP analysis.

5.2.4. Energy efficiency

Under the SDG 7.3 target, energy intensity is defined as the total primary energy supply (TPES) in MJ/US$$_{2017}$. Energy intensity in the Federated States of Micronesia has declined at an average annual rate of 2.1 per cent between 1990 and 2010. A doubling of the 1990-2010 improvement rate is required to achieve the SDG 7.3 target, which requires an average annual rate increase of 4.2 per cent between 2010 and 2030. However, between 2010 and 2019, the annual improvement rate was -2.7 per cent. To reach the expected 2030 intensity, the annual improvement rate between 2019 and 2030 must be around 9.3 per cent (figure 16), which is quite challenging. Therefore, NEXSTEP analysis suggests that the energy intensity target of the Federated States of Micronesia be aligned with the global target of 3.4 per cent annual improvement (IEA and others, 2023). This corresponds to a 2030 energy intensity target of 3.5 MJ/US$$_{2017}$.

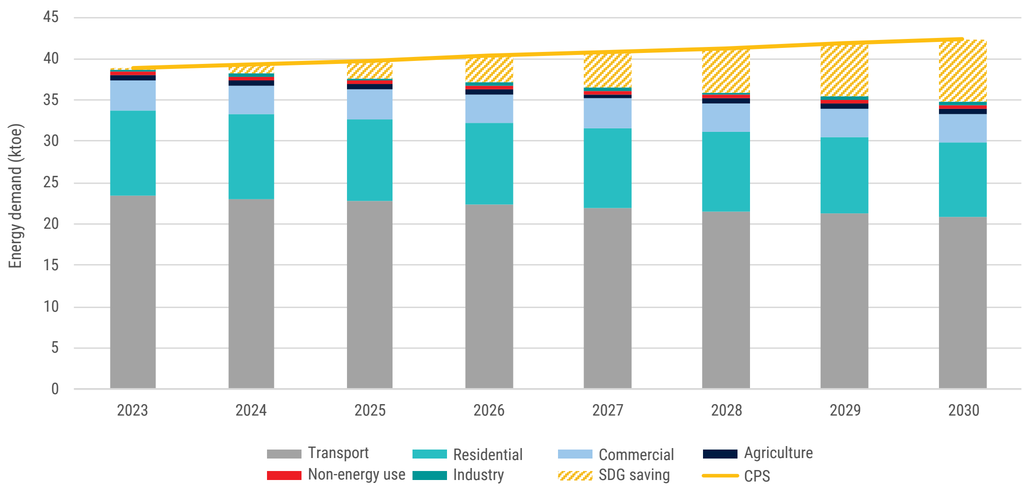
Figure 16. Energy efficiency target of the Federated States of Micronesia



Source: ESCAP analysis.

Under the CPS, energy intensity in 2030 was estimated to be 4.6 MJ/US$$_{2017}$, marking a reduction from 5.2 MJ/US$$_{2017}$ in 2019. The annual improvement rate is expected to be only 1 per cent between 2019 and 2030 due to limited implementation of energy efficiency measures. NEXSTEP analysis finds that the Federated States of Micronesia can further reduce energy intensity to 3.5 MJ/US$$_{2017}$, to align with the global energy efficiency target of 3.4 per cent annual improvement for SDG 7. This requires 7.6 ktoe of energy demand reduction compared to the CPS. Figure 17 shows additional energy saving opportunities under the SDG scenario, compared to the CPS.

Figure 17. Energy saving potential in different sectors and subsectors under the SDG scenario compared to the current policy scenario



Source: ESCAP analysis.

5.2.5. Transport sector

In the SDG scenario, the transport sector will consume 20.8 ktoe in 2030, a reduction of 4.7 ktoe compared to CPS (table 5). Road transport will account for 74.7 per cent of transport sector's energy demand. Marine transport and aviation will consume around 25 per cent and 0.3 per cent, respectively.

Table 5. **Additional energy saving in the transport sector under the Sustainable Development Goal scenario by 2030, compared to the current policy scenario**

Areas of intervention	Measure	Energy demand reduction in 2030 (ktoe)
Public transport	Increase public transport utilization for road transport and encouraging walking/cycling to reduce passenger kilometres by 10 per cent	2.3
Fuel economy	Improved fuel economy of passenger cars from 7.5 km/l to 10 km/l by 2030	0.7
Fuel economy	Improved fuel economy of freight trucks by 15 per cent through scheduling and maintenance.	1.3
Marine transport	Implement routine inspection and maintenance in maritime transport to reduce energy consumption by 10 per cent	0.4
Total		**4.7**

Source: ESCAP.

The Federated States of Micronesia can save energy demand by encouraging mode shifting as well as improving fuel standards. NEXSTEP analysed that the Government can achieve a reduction in passenger-km of private cars by 10 per cent by encouraging walking and bicycling for short distance travel, and by promoting the utilization of public transport. In terms of efficiency, it is suggested that fuel economy for passenger cars can be improved from 7.5 km/l to 10 km/l. Harsh environmental conditions (high humidity and salty air) and poor road conditions are two major factors that significantly reduce vehicle performance. Consequently, regular maintenance such as applying oil-based rustproofing, undercoating and washing is required. In addition to regular maintenance, improving road condition by sealing the unsealed road might also help improve the fuel economy of passenger cars. The same can be implemented for freight trucks where additional measures such as scheduling might also be required. Water transport consumes a quarter of energy demand in the transport sector. The Government can implement Ship Energy Efficiency Management Plan (SEEMP) for all shipping companies (box 2).

Box 2. Examples of marine energy efficiency measures[a]

Ship Energy Efficiency Management Plan (SEEMP) can be described as an operational measure that establishes a mechanism to improve the energy efficiency of a ship in a cost-effective manner.b It allows shipping operators to track and improve operational and fleet performance with the aid from Energy Efficiency Operational Indicator (EEIO) as a voluntary monitoring tool. The IMO also identifies that propeller polishing and hull cleaning might save energy demand by 10 per cent.[b] These shares are an indicative case to demonstrate how such changes in the transport sector will have an impact on energy saving. SEEMP has been made mandatory for new and existing ships which have a gross tonnage capacity above 4,000 tons from 2013 onwards, with the exception of ships operating domestically. The implementation of SEEMP is ship-specific and can be implemented in four steps: (1) planning; (2) implementation; (3) monitoring; and (4) self-evaluation and improvement.

a Lloyd's Register, "Implementing a Ship Energy Efficiency Master Plan (SEEMP): Guidance for shipowners and operators", 2012; Resolution MEPC.213(63). Available at https://wwwcdn.imo.org/localresources/en/KnowledgeCentre/IndexofIMOResolutions/MEPCDocuments/MEPC.213(63).pdf

b International Maritime Organization (IMO), Improving the Energy Efficiency of Ships , 2023. Available at https://www.imo.org/en/OurWork/Environment/Pages/Improving%20the%20energy%20efficiency%20of%20ships.aspx

5.2.6. Residential sector

Energy demand in the residential sector will reduce from 9.9 ktoe in 2019 to 9.2 ktoe in 2030, a 2.4 ktoe reduction compared to CPS. In addition to achieving universal access to clean cooking (100 per cent), phasing-out of inefficient cooking technologies by efficient LPG/butane gas stoves will help reduce cooking demand since this technology is more efficient compared to other stoves. ICS can be promoted in some households where access to sustainable and reliable supply of LPG/butane gas is limited. ICS is also more efficient compared to the traditional biomass-based cooking stoves.

To reduce the demand for electricity, adoption of MEPS will be beneficial to reduce electricity consumption for lighting, refrigeration, televisions and electric fans (the four appliances with the largest energy consumption). More can be done to raise community awareness about the benefits of energy-efficient technologies. Similar to promoting clean cooking technologies, a participatory approach involving key stakeholders, together with frequent monitoring, evaluation and feedback should be pursued to ensure the successful implementation of programmes. In addition, energy-efficient technology should garner more attention and be integrated into national policies and plans. Table 6 shows additional opportunities for reducing demand for energy in the residential sector through different measures.

Table 6. Additional energy saving in the residential sector under the Sustainable Development Goal scenario by 2030, compared to the current policy scenario

Sector	Measure	Energy demand reduction in 2030 (ktoe)
Residential cooking	Phase out inefficient cookstoves by electric cookstoves and ICS	2.1
Residential MEPS lighting	Promote the adoption of efficient lighting	0.2
Residential MEPS refrigeration	Promote the adoption of efficient refrigeration	0.1
Residential MEPS television	Promote the adoption of efficient television	0.01
Residential MEPS electric fan	Promote the adoption of efficient electric fan	0.04
Total		**2.4**

Source: ESCAP.

5.2.7. Commercial sector

In the SDG scenario, the commercial sector will consume 3.4 ktoe in 2030, which is a reduction of 0.5 ktoe compared to CPS (table 7). To achieve this, NEXSTEP suggests that the Government adopt green building measures in the commercial sector (box 3) by setting up a green building code, which mandates a set of minimum building standards. This will ensure sustainable building designs for upcoming buildings. Moreover, this can be equally applied to existing buildings scheduled for retrofitting. This amounts to an estimated reduction of 0.5 ktoe.[7] Notwithstanding, one possibility in promoting sustainable measures in existing buildings is the high upfront cost to conduct energy audits and the subsequent implementation of measures. The Government should consider providing financial incentives and simultaneously raise energy conservation awareness amongst the public.

Box 3. Policy options for a more sustainable building sector

The building sector contributes significantly to the global energy consumption and GHG emissions. This calls for the adoption of green building measures and designs in new and existing building stocks to allow energy savings and rapid reduction of GHG emissions 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.*[a] Green building adoption can be made obligatory through the implementation of building codes or promoted with certification/rating systems.

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

a Green Building Council Australia (GBCA), "What is green building?" 2025. Available at https://new.gbca.org.au/about/what-green-building/b International Code Council (ICC), "International Green Construction Code (IgCC)", 2021. Available at https://www.iccsafe.org/products-and-services/i-codes/igcc/

b ???

c State of California, "CALGreen", 2021. Available at https://www.dgs.ca.gov/bsc/calgreen

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

Table 7. Additional energy saving in the commercial sector under the Sustainable Development Goal scenario by 2030, compared to the current policy scenario

Building categories	Measure	Energy demand reduction (ktoe)2030
Private offices	Green building code to ensure the adoption of energy-efficient appliance and the improvement of thermal efficiency – 15 per cent improvement in energy intensity	0.05
Government buildings		0.11
Supermarkets and shops		0.13
Hotel and restaurants		0.07
Healthcare facilities		0.07
Educational institutions		0.09
Worship centres		0.01
Total		**0.5**

Source: ESCAP.

7 This assumes a 15 per cent energy savings potential. However, energy savings potential is building-specific, depending on the baseline design, climate and energy efficiency measures.

5.3. Energy supply outlook

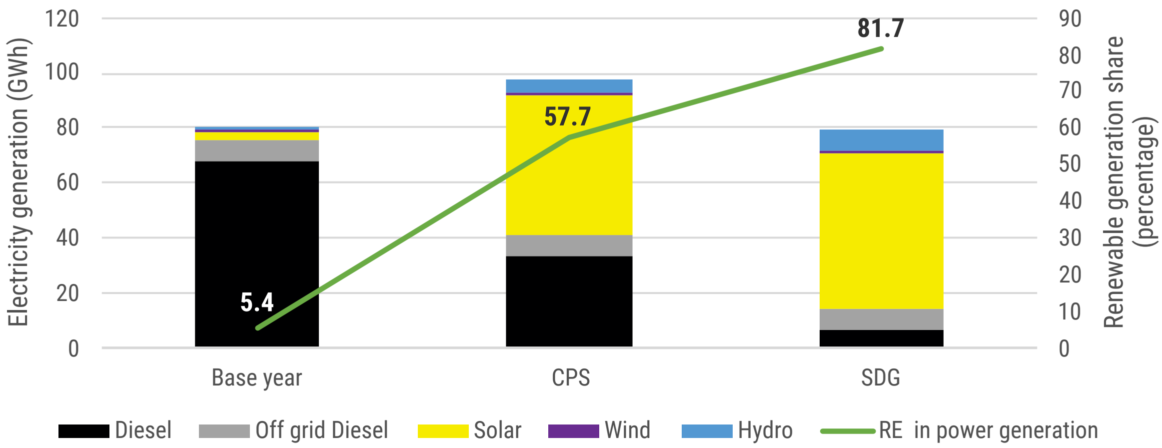
Primary energy supply

In the SDG scenario, the TPES is forecasted to decrease from 48.8 ktoe in 2019 to 37.3 Mtoe in 2030. The projected fuel shares for 2030 are as follows: oil products 27.4 ktoe (73.5 per cent); biomass 4.3 ktoe (11.5 per cent); hydropower 0.6 ktoe (1.7 per cent); and other renewables 5 ktoe (13.3 per cent). The supply reduction of 12.4 ktoe as compared to the CPS comes from the additional energy efficiency improvements discussed in the previous section. Moreover, as electricity demand decreases, the fuel consumption for power generation declines as well.

Electricity generation

In the CPS scenario, the share of renewable energy in the supply of electricity will increase from 5.4 per cent in 2019 to 57.7 per cent in 2030. The Federated States of Micronesia, unfortunately, will not achieve its renewable energy target of 70 per cent by 2030 since the demand for electricity is still high and thus requires supply from diesel generation. In this scenario, the suggested energy efficiency measures will help reduced the electricity requirement to 77.1 GWh in 2030 (a 19.5 GWh reduction compared to CPS). In the SDG scenario, the share of renewable power generation capacity has been further increased while diesel power generation has been reduced to enable the Federated States of Micronesia to achieve its renewable energy target (figure 18). The share of solar PV generation will be around (70.6 per cent). Since Pohnpei has hydropower potential and Yap has wind potential, the generation share from both wind and hydropower will be around 11.1 per cent. Therefore, the renewable generation share will be around 81.7 per cent leaving the remain 18.3 per cent from diesel generation.

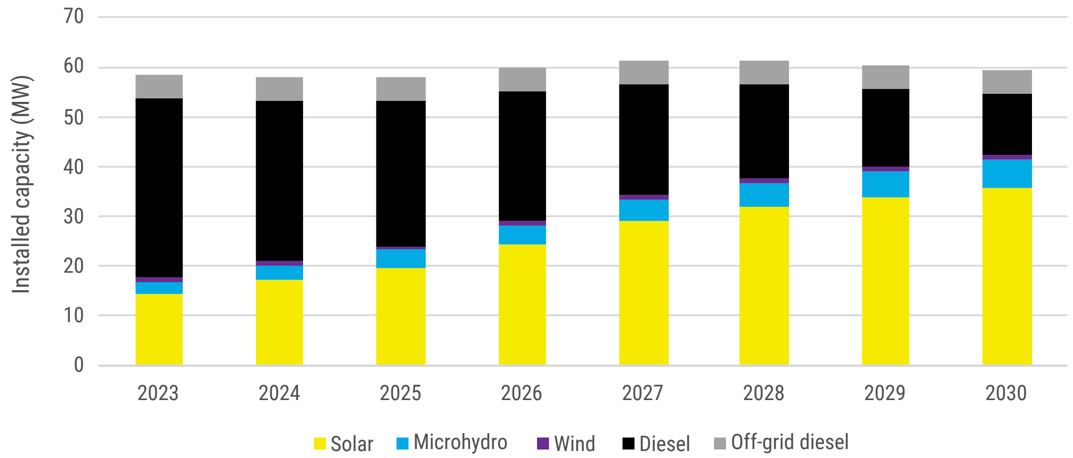
Figure 18. Power generation comparison in the base year, in the current policy and Sustainable Development Goal scenarios 2030



Source: ESCAP analysis.

This target is achieved by increasing the capacity of solar to 35.5 MW and mini hydro to 5.9 MW, while wind capacity remains the same. The total installed capacity of diesel-fuelled powered plants, however, must be capped at 17.2 MW to allow the increase in RE share, as shown in figure 19.

Figure 19. Power plant installed capacity 2023 – 2030



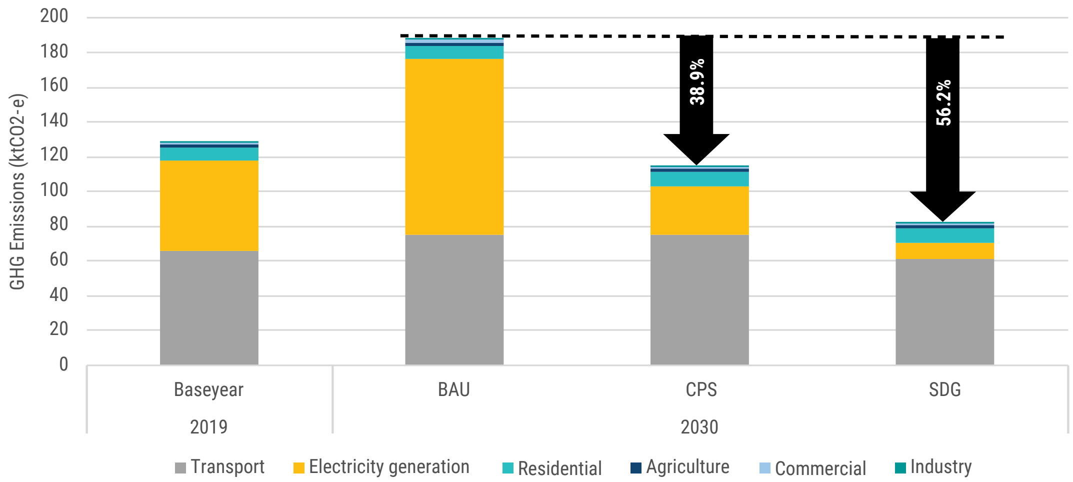
Source: ESCAP analysis.

5.4. Nationally Determined Contribution Targets

Emissions from the combustion of fossil fuel are calculated using the IPCC Tier 1 emission factors. For the combustion of biomass and biomass products, carbon emissions are not attributed to the energy sector, but are accounted for in the agriculture, forest and land-use change (AFOLU)[8] sector as per the accounting system suggested by IPCC. Nevertheless, the emissions of other GHGs, such as methane and nitrous oxide, are included in the total emissions in the energy sector.

Emissions analysis in this study suggests that the BAU emissions in 2030 will be 187.5 ktCO_2-e. The Federated States of Micronesia have committed to reducing carbon dioxide emissions from electricity generation by more than 65 per cent below 2000 levels (relative to the year 2000 inventory, electricity generation accounts for 64 ktCO2-e meaning the emission from electricity generation must be less than 22.4 ktCO_2-e). Under the CPS, the Federated States of Micronesia will not be able to achieve this conditional NDC target by 2030. Although total emissions are expected to decrease from 128.1 ktCO_2-e in 2019 to 114.6 ktCO_2-e in 2030 (figure 20), the emissions from electricity generation will still be 27.8 ktCO_2-e. The decrease in GHG emissions, relative to the BAU scenario, is due to the increase of renewable share in electricity supply as per the capacity expansion plan.

Figure 20. Emissions trajectories for the business-as-usual, current policy and Sustainable Development Goals scenarios

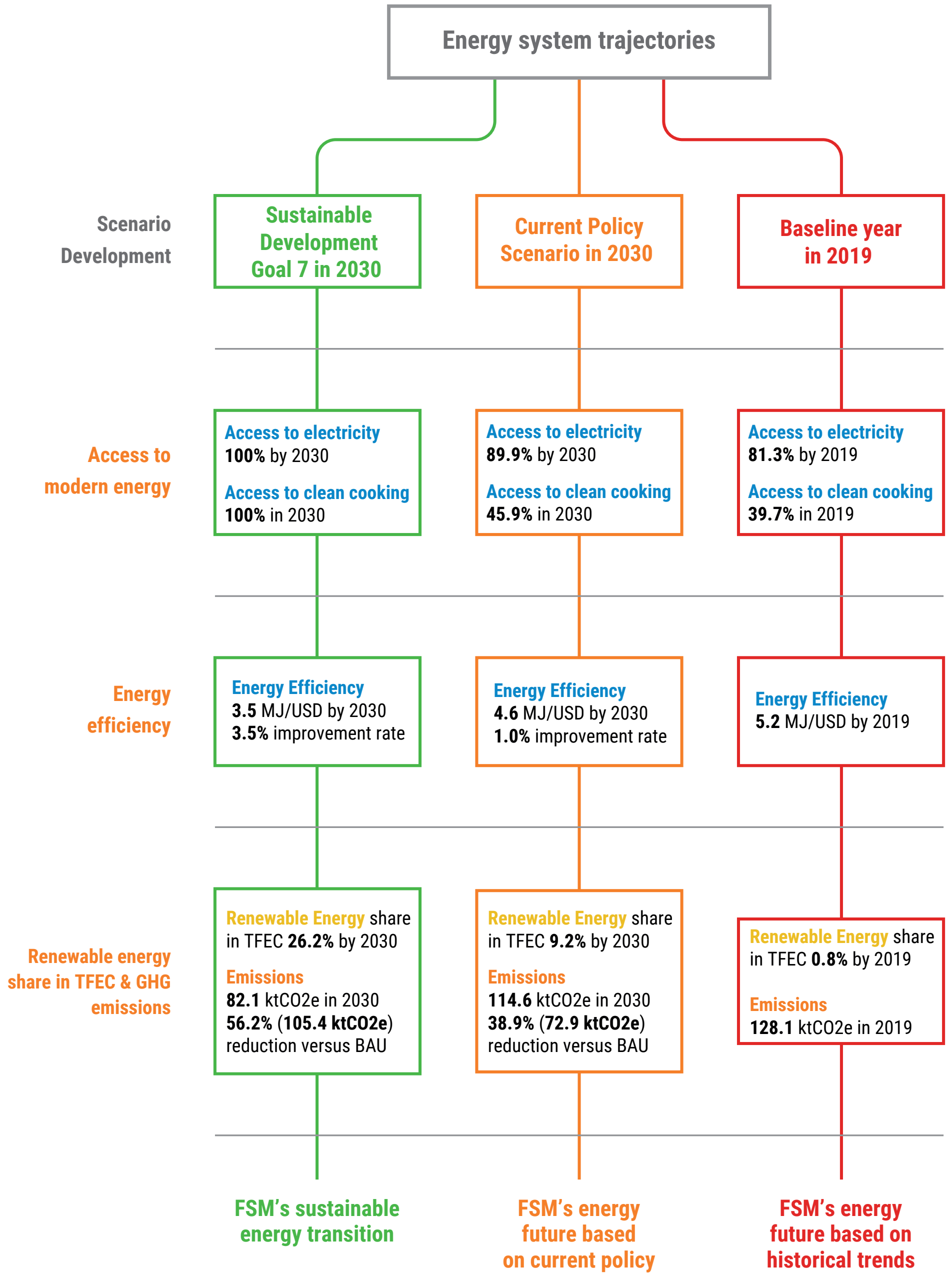


8 The AFOLU sector is not within the scope of NEXSTEP.

The Federated States of Micronesia can further enhance its efforts to achieve higher emissions reduction by accelerating the implementation of energy saving measures in order to align with the global improvement target of 3.4 per cent as well as to increase renewable capacity to reach the renewable capacity target discussed in the previous section. In the SDG scenario, total emissions are expected to further decrease to 82.1 ktCO_2-e by 2030, corresponding to a 105.4 ktCO_2-e (or a 56.2 per cent) reduction compared to the BAU scenario. The emissions from electricity generation will be 8.7 ktCO_2-e meeting the conditional NDC target.

The Federated States of Micronesia must accelerate and strengthen its effort to achieve 100 per cent access to electricity and clean cooking technology, increase the renewables share and improve energy efficiency. These can be considered for enforcement in the updated national energy policy. Figure 21 summarizes the SDG 7 indicators from the baseline year and two main scenarios.

Figure 21. Summary of SDG 7 indicators for the baseline year and current policy and Sustainable Development Goals scenarios for the Federated States of Micronesia



Source: ESCAP.

5.5. Comparison of SDG 7 targets in 2030 by states

All states will achieve 100 per cent electrification access by 2030 under the SDG scenario by accelerating the deployment of renewable grids as well as standalone PV systems in areas where the distribution of households is quite sparse. All states will also achieve 100 per cent clean cooking access by promoting the utilization of LPG/butane gas stoves. In areas where the distribution of LPG/butane gas stove will be difficult, ICS can be implemented. Energy intensity will reduce significantly given the implementation of several energy efficiency measures in the transport, residential and commercial sectors. All states will reach a 70 per cent renewable target. Table 8 summarizes SDG 7 indicators for different states.

Table 8. SDG 7 targets for different states of the Federated States of Micronesia

	National	Pohnpei	Kosrae	Chuuk	Yap
Universal access to electricity in 2030	100 per cent	100 per cent	100 per cent	100 per cent	100 per cent
Universal access to clean cooking in 2030	100 per cent	100 per cent	100 per cent	100 per cent	100 per cent
Energy efficiency in 2030	3.5 MJ/US$	3.4 MJ/US$	4.5 MJ/US$	3.8 MJ/US$	2.2 MJ/US$
Renewable energy share in TFEC in 2030	26.2 per cent	13.4 per cent	22.9 per cent	24.3 per cent	25.5 per cent
Renewable energy share in power generation in 2030	81.7 per cent	70 per cent	84.7 per cent	87.4 per cent	92 per cent
GHG emissions in 2030	82.1 $ktCO_2$-e	44.9 $ktCO_2$-e	6.7 $ktCO_2$-e	25.1 $ktCO_2$-e	8.7 $ktCO_2$-e

Source: ESCAP.

6. Going beyond SDG 7 with ambitious scenarios

The SDG scenario, as discussed in the previous chapter, sets out various strategies for facilitating an economy-wide strategy of 100 per cent access to modern energy, higher renewable energy penetration and energy-efficiency improvement in alignment with the 2030 Agenda for Sustainable Development and the Paris Agreement. It also identifies appropriate technology options in advancing sustainable energy transition in the Federated States of Micronesia. The measures that have been discussed in the previous chapter, have allowed an energy demand reduction of 7.6 ktoe and an emissions reduction of 105.4 ktCO_2-e in the SDG scenario, relative to BAU by 2030. This allows for a sufficient reduction in GHG emissions to meet even the conditional NDC targets and a significant increase in the renewable energy share in TFEC. Transitioning beyond 2030, one additional scenario has been developed. The towards net-zero (TNZ) emissions by 2050 scenario aims to assess the potential of transitioning beyond 2030 by identifying technological interventions, defining the time frame of implementation of different measures and suggesting policy recommendations to help put energy sector of the Federated States of Micronesia on the right path to achieving net-zero GHG emissions by 2050.

6.1. Towards net-zero (TNZ) emissions by 2050 scenario

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

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

Achievement of the net-zero emissions target will require decarbonization of the energy sector of the Federated States of Micronesia, which will best be achieved by: (a) decarbonizing the power sector; and (b) switching all energy sources to electricity. Fortunately, some of the necessary net-zero technologies for decarbonizing the energy system, such as electric cook stoves and electric vehicles, are readily available commercially.

Building on the SDG scenario and extending the timeframe to 2050, the TNZ scenario suggests the following additional measures. On the demand side, a 100 per cent utilization of electric cook stoves will be needed to decarbonize the residential sector by 2050. The transport sector will require the adoption of 100 per cent e-mobility (box 4).

Box 4. Electric vehicles gain global interest

Electric vehicles have garnered great interest globally, growing exponentially during the past decade. Electric car sales passed 2 million globally in 2019, with a projected compound annual growth rate of 29 per cent through to 2030.[a] Various government policies have been introduced that directly or indirectly promote the adoption of electric vehicles as a means to achieve environmental and climate objectives. For example, 17 countries have stated their ambition to phase out internal combustion engines before 2050, while the European Union's stringent CO2 emissions standard has accelerated the adoption of electric vehicles.[b]

Despite supply chain bottlenecks and the COVID-19 pandemic, electric car sales hit a new high in 2021. Sales nearly doubled to 6.6 million, representing a world sales share of approximately 9 per cent, compared to 2020, increasing the total number of EVs on the road to 16.5 million. In 2021, the sales share of EVs rose by 4 percentage points. China had the most sales in 2021, tripling those of

2020 with 3.3 million, followed by Europe with 2.3 million sales, an increase from 1.4 million in 2020. In 2021, 630,000 EVs were sold in the United States of America, doubling their market share to 4.5 per cent. Electric car sales increased more than twice as much in emerging nations, although they are still relatively small.[c]

Vehicles which have an electric motor assisting the conventional internal combustion engines, that cannot be charged are not considered to be electric vehicles. The following categories may be considered as EV: (1) battery electric vehicle (BEV); (2) plug-in hybrid electric vehicle (PHEV); and (3) fuel cell electric vehicle (FCEV). The Government of the Federated States of Micronesia can take the lead with government-owned vehicles before promoting it to the public.

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

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

c Ibid.

In the commercial sector, expanding energy efficiency in building codes to all types of buildings will be required. In the industrial sector, fuel switching has a significant role, particularly switching from fossil fuel to electricity. NEXSTEP has not performed a quantitative analysis on hydrogen for implementation in the Federated States of Micronesia since hydrogen is not commercially available and the technology has several uncertainties. Further investigation is needed to identify the techno-economic potential of hydrogen in the long run (box 5).

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

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

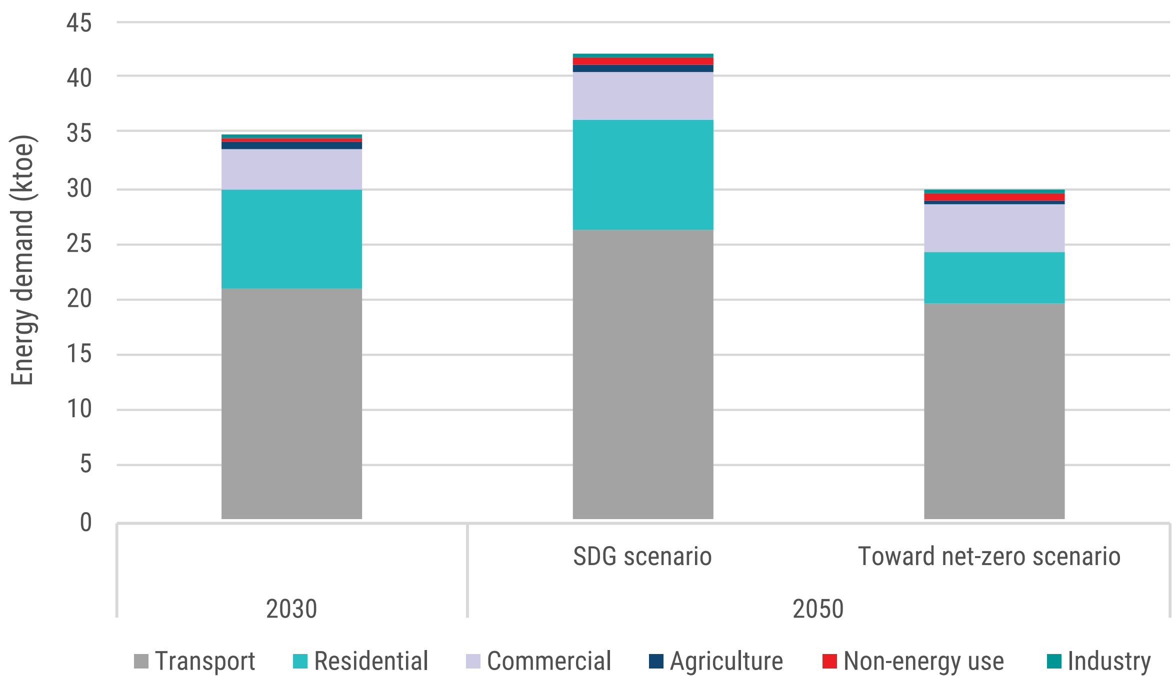
The implementation of green hydrogen, however, is still limited due to high production costs and the need for associated infrastructure. The International Energy Agency (IEA) reported that producing hydrogen from low-carbon energy is still costly at the moment despite the declining costs of renewables.[b]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

a REN21, "Renewables 2023: Global Status Report collection: Renewables in energy demand", Paris, 2023. Available at https://www.ren21.net/wp-content/uploads/2019/05/GSR2023_Demand_Modules.pdf

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

With these measures, the total energy demand is expected to decrease from 34.8 ktoe in 2030 to 30.1 ktoe in 2050, a reduction of about 12.3 ktoe relative to the SDG scenario (figure 22). Consumption of the transport sector will remain the largest at 65.2 per cent, followed by the residential sector at 15.4 per cent. The commercial sector will account for 14.3 per cent, the agriculture sector at 1.8 per cent, and the industrial sector at 1.3 per cent.

Figure 22. Comparison of total final energy demand in 2050 by sector

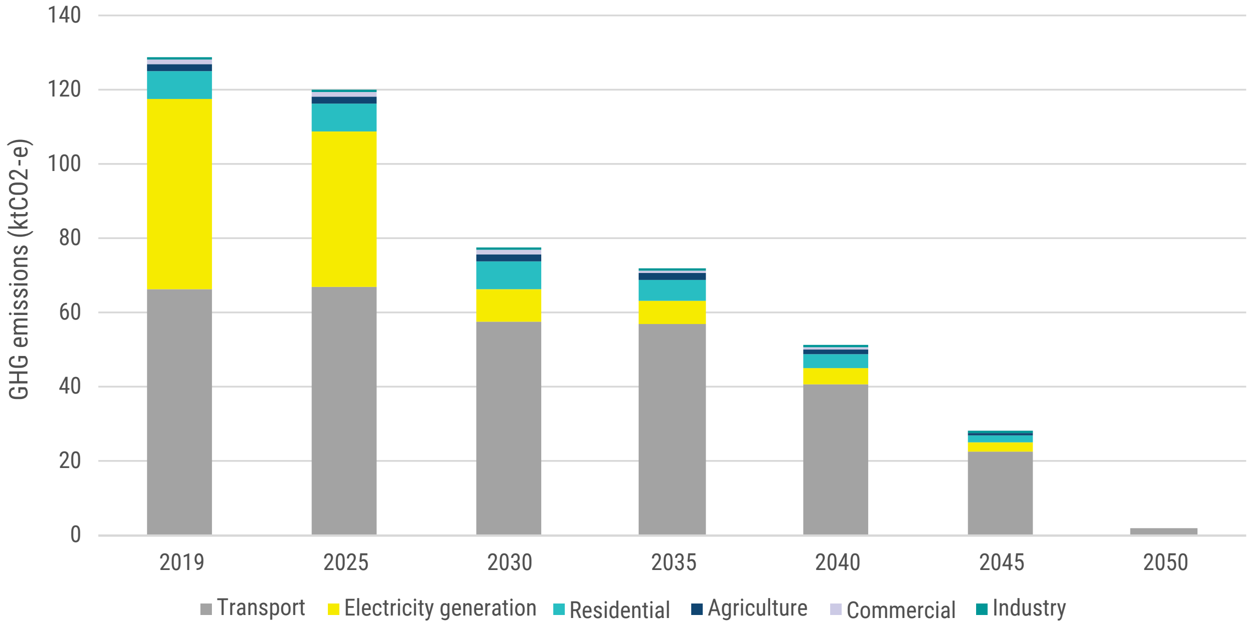


Source: ESCAP analysis.

Despite requiring less amount of energy compared to the SDG scenario by 2050, the electrification of the energy system in the TNZ scenario will require an additional 250.7 GWh electricity compared to the SDG scenario. A decarbonized electricity supply is also required to complement the hastened adoption of electricity-based technologies, such as electric vehicles and electric cooking stoves, to realize the greatest potential of electrification. NEXSTEP estimated that an additional 252.6 MW solar PV is required to fulfil the rising demand for electricity.

A significant emissions reduction is projected in the TNZ emissions by 2050 scenario, achieved because: (1) full implementation of fuel switching; and (2) complete decarbonization of the electricity supply. In this scenario, the emissions start to decline gradually until 2050 due to the implementation of several measures discussed above (figure 23). However, due to certain technological limitations in the transport sectors, a small number of emissions would still be produced. These could be offset by other means such as management of Land Use, Land Use Change and Forestry (LULUCF). In 2050, it is expected that the transport sector will still emit 2.2 ktCO_2-e from the aviation system. Therefore, carbon sinks, such as reforestation or forest management, or other carbon capture technologies should be considered to absorb the remaining carbon emissions.

Figure 23. GHG emissions in the towards net-zero emissions by 2050 scenario



Source: ESCAP analysis.

7. Economic analysis and financing options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Sustainable energy transition offers financial benefits in the long-term, as the shift to low carbon approaches generates positive economic returns. The transport, residential and commercial sectors have a high GHG mitigation potential and most scenarios offer lower cost pathways compared to business-as-usual over the longer term. For example, shifting transport modes and improving the fuel economy within the transportation sector would provide the highest cost saving with high abatement potential.

The Federated States of Micronesia can consider establishing energy services companies (ESCOs) to promote energy efficiency. The key to supporting the growth of ESCOs is the availability of accessible financing. The Federated States of Micronesia might learn from other countries, such as Thailand, which has previously demonstrated leadership in this approach by establishing a "revolving fund" for energy conservation and efficiency. ESCOs can borrow funds from financial institutions at an interest rate lower than commercial rates, over an extended repayment period (box 6).

Box 6. Case study – Energy Efficiency Revolving Fund in Thailand

In 2003, the Government of Thailand launched the Thai Energy Efficiency Revolving Fund (EERF) as part of its Energy Conservation Programme. The EERF works to overcome barriers within the Thai financial sector in order to stimulate adequate financing for energy efficiency and reduce greenhouse gas emissions. The fund was aimed at strengthening the capacity of commercial banks to finance EE projects and developing the ESCO fund to enable smaller companies to access EE financing. It also works with the Bureau of Investment to provide tax/duty exemptions for EE products. The establishment and implementation of the Revolving Fund has been successful in supporting initial investments in energy efficiency and creating a self-sustained market by encouraging the involvement of commercial banks in this area.

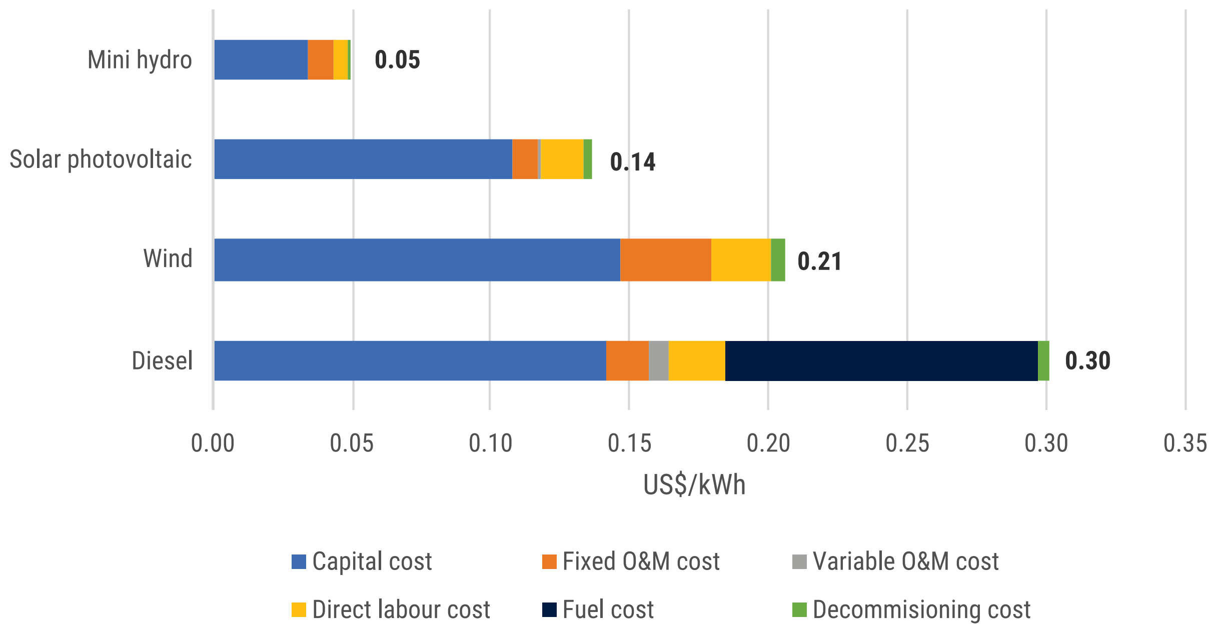
Initiated in 2003, the fund was created to attract investments in energy efficiency, create confidence of entrepreneurs and promote ESCOs as a vehicle to improve energy efficiency. The fund was made available by DEDE with financial support from the Ministry of Energy. The total budget for five phases of the fund was $245.10 million. Phase 5 of the fund operated from June 2010 to May 2013. During the first phase (2003-2006), the fund was made available to commercial banks without an interest rate, however, an interest rate of 0.5 per cent was introduced from Phase 2 and continued at the same rate through to Phase 5. Facility owners, ESCOs and project developers are eligible to borrow from this fund for a maximum of seven years for EE and RE projects. The size of single loans was capped to about $1.56 million with an interest rate of 4 per cent. Until 2013, 295 project proposals were received (60 per cent EE projects and 40 per cent RE projects) for a total investment of $498.7 million of which $226 million was contributed from this fund and the remainder supported by financial institutions.[a]

a Achavangkool, A. (2014). "Experiences on energy efficiency financing instruments in Thailand", presentation made at the Inter-regional Workshop on Energy Efficiency Investment Projects Pipeline, Thailand. Available at https://unece.org/fileadmin/DAM/energy/se/pdfs/gee21/Inter-regional_Workshop_EE_Bangkok_April_14/InformationReportThailandFinal.pdf

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

NEXSTEP has calculated LCOE for the Federated States of Micronesia (figure 24) using cost figures presented in Annex 3. This makes the LCOE entirely reflective of the national context of the country. The LCOE component analysis for the Federated States of Micronesia highlights that renewable electricity generation technologies, e.g., mini hydro ($0.49 /kWh), solar photovoltaic ($0.14/kWh) and wind ($0.21/kWh), are cheaper than diesel-fired generation technologies today. The given LCOE for renewable energy is without energy storage addition. Box 7 shows the impact of battery energy storage systems (BESS) on LCOE. Nevertheless, it must be noted that the distant location of the Federated States of Micronesia makes the cost of materials to be more expensive. Additionally, the RE market in the Federated States of Micronesia has not yet matured and the supply chain is still evolving, which drives up costs. A detailed cost assessment of renewable energy systems will need to be undertaken as part of any RE project planning.

Figure 24. Comparison of levelized cost of electricity (LCOE) in US$/kWh



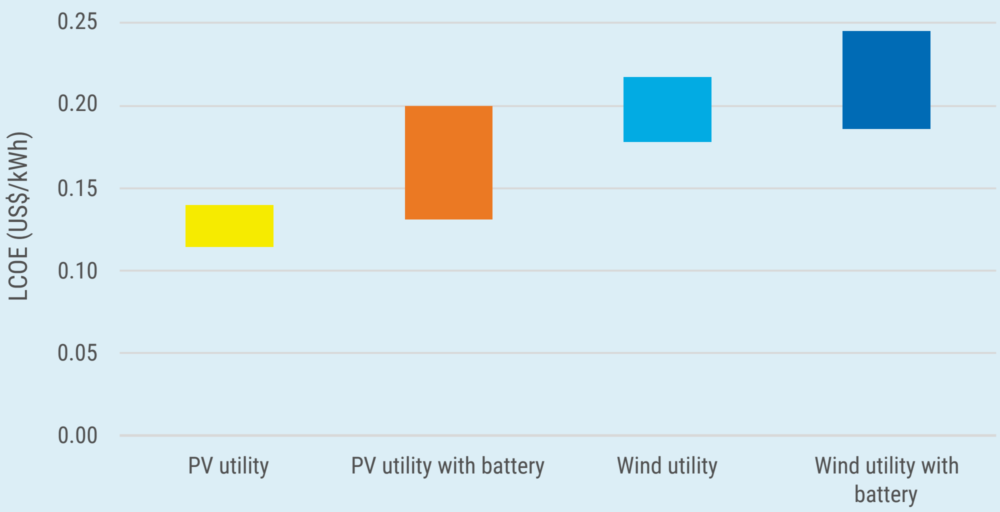
Source: ESCAP analysis.

Box 7. LCOE of electricity generation with battery energy storage system

A battery energy storage system will play a critical role in a fully decarbonized energy system. However, calculating the requirement of battery capacity at the national level is impractical since the ratio between battery and solar PV capacity varies depending on the size and location of the project. For example, the Port Blair project in India has a battery-to-renewable capacity ratio of 1.25 (8 MW/10 MWh Li-ion). However, the Maktoum project in the United Arab Emirates has a ratio of 6 (1.25 MW/ 7.5 MWh). In France, the Diamant and the Barzhour projects have different factors despite being installed in the same country. Therefore, storage capacity is better estimated at the project level. Because of its inherent difficulties, NEXSTEP analysis has not estimated specific storage capacity at the national level. Instead, an indicative ratio between battery and solar PV capacity has been considered, which is expected to be around 2.5, as shown in figure 25.[a]

Using this factor, NEXSTEP has estimated the LCOE of a utility-scale renewable project with and without storage. Without storage, the LCOE of utility-scale solar photovoltaic will range from $0.11 to $0.14kWh, while the LCOE of utility-scale wind will range from $0.18 to $0.21 /kWh. With storage, the LCOE of utility-scale solar photovoltaic will range from $0.13 to $0.20 /kWh while the LCOE of utility-scale wind range from $0.19 to $0.25/kWh depending on the storage capacity (the given LCOE range is based on a battery versus capacity ratio between 1 and 4). The higher the battery size, the higher the LCOE. Therefore, finding the optimum battery sizing will be critical for the development of renewables with BESS projects.

Figure 25. LCOE comparison with and without batteries for the Federated States of Micronesia



Source: ESCAP analysis.

a Hector Beltran, "Battery size determination for photovoltaic capacity firming using deep learning irradiance forecasts", Journal of Energy Storage, vol. 33 (January 2021). Available at https://www.sciencedirect.com/science/article/abs/pii/S2352152X20318594

NEXSTEP estimated that the capacity of wind will be around 0.8 MW, solar will be around 252.5 MW, and hydropower will be around 5.9 MW in 2050. The investment costs required in power generation will be $647.6 million until 2050 with net benefit of around $932.4 million.

There are several pathways that the country may explore, in collaboration with citizens and/or private investors, in order to achieve a net-zero carbon power supply objective. One workable solution that can be considered is the independent power producer (IPP) mechanism. IPPs are effective in combating power outages and other power-related problems. The IPP mechanism can leverage and encourage private sector investment to deliver major renewable infrastructure projects in the Federated States of Micronesia. A case study from the Palau Public Utilities Company (PPUC) shows that the IPP mechanism can reduce generation costs to around $0.14/kWh, with limited energy storage capacity.

In the future, when there are more private investments, the renewable energy auction approach can be considered. This approach is likely to substantially decrease the cost of electricity supply through competitive bidding and therefore, return a greater net benefit. The recent auctions e.g., the 60 MW solar PV auction in Cambodia has achieved $0.04/kWh. A renewable energy auction, also known as a "demand auction" or "procurement auction", is essentially a call for tenders to procure a certain capacity or generation of renewables-based electricity. The auction participants submit a bid with a price per unit of electricity at which they are able to realize the project. The winner is selected on the basis of the price and other criteria, and a power purchase agreement is signed. RE auctions have the ability to achieve deployment of renewable electricity in a well-planned, cost-efficient and transparent manner. Most importantly, it makes the achievement of targets more precise than would be possible by other means, such as a Feed-in-Tariff (FiT).

Auctions are flexible and they allow governments to combine and tailor different design elements to meet deployment and development objectives. Unlike FiTs, where the government decides on a price, auctions are an effective means of discovering the price appropriate to the industry, which is the key to attracting private sector investment. In addition, an auction provides greater certainty about future projects and is a fair and transparent procurement process. However, the administrative and logistic costs associated with auctions are very high unless multiple auctions are undertaken at regular intervals. Further details of designing renewable energy auction can be found in box 8.

Box 8. Key design principles of a renewable auction

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

- Auction demand. Governments need to clearly indicate the scale or size of each auction, the preferred technology (technology neutral of a specific technology), auction frequency and the upper and lower limits of projects size and price.

- Pre-qualification. A strict or high pre-qualification for bidders will leave out the smaller entities, while a relaxed pre-qualification may undermine the quality of the project and increase the administrative costs. Governments need to make a trade-off, depending on the project size and other development objectives.

- Selection criteria. Commonly two selection criteria are used: (a) the lowest bid where only the lowest bidder will win; and (b) lowest bids plus other objectives where in addition to the price, other objectives such as local content and jobs are taken into consideration.

- Payment modalities. The pay-as-bid model is good to minimize the cost. However, the marginal cost payment model, where the same price (selected based on the highest cost winner) is paid to all winners is also practised.

- Penalties for non-compliance. There could be cases where the developer either delays the project or fails to complete. To avoid such cases, penalties should be in place. There are two modes of penalty. In the monetary penalty, money will be deducted from bidder's "bond", or the price of energy will be reduced for a delayed completion. A form of non-monetary penalty can be the exclusion of the bidder from future auctions.

8. Policy recommendations

8.1. Scenario evaluation

The CPS, SDG and the ambitious TNZ emissions by 2025 scenarios have been evaluated and ranked, using the Multi-Criteria Decision Analysis (MCDA) tool, with a set of 12 criteria and weighting assigned to each criterion (table 9). While the criteria and weights have been selected based on expert judgement, ideally the process should also include stakeholder consultations. If deemed necessary, this step can be repeated using the NEXSTEP tool in consultation with stakeholders where the participants may want to change the weighting of each criterion. The following factors have been considered to assume comparative weighting across the set of criteria, where the total weight needs to be 100 per cent:

(a) Universal access to electricity to be achieved;

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

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

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

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

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

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

Table 9. Criteria with assigned weighting for the Multi-Criteria Decision Analysis (MCDA)

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

Source: ESCAP.

Table 10 shows the summary of results obtained through this evaluation process. The scenario evaluation suggests that the towards net-zero emissions by 2050 scenario is the highest-ranked energy transition pathway for the Federated States of Micronesia since there will be a significant improvement in energy efficiency, increase in renewable share and reduction in emissions. Most importantly, it would set the course of the energy sector to achieve the goal of net-zero emissions. Therefore, the Federated States of Micronesia should begin developing and aligning strategies and plans in line this scenario, which will also ensure the achievement of all SDG 7 targets as well as NDC conditional target since the scenario is developed based on SDG scenario.

Table 10. Scenario ranking based on the Multi-Criteria Decision Analysis (MCDA)

Scenarios	Weighted scores	Rank
Towards net-zero emissions by 2050	56.2	1
Sustainable Development Goal scenario	50.6	2
Current policy scenario	26.6	3
Business-as-usual scenario	20.0	4

Source: ESCAP.

8.2. Revisiting existing policies

The current energy policies of the Federated States of Micronesia have been evaluated based on the outputs from the LEAP model, in order to highlight any revisions required to achieve the SDG 7 and NDC targets by 2030. These are summarized in table 11.

Table 11. Assessment of SDG 7 and NDC targets

Category	Existing policy	Policy evaluation	NEXSTEP analysis
Access to electricity	Energy Master Plans for the Federated States of Micronesia aims 100 per cent electrification by 2027 (Castalia, 2018). The Updated Nationally Determined Contribution (NDC) sets a conditional mitigation target of increasing access to electricity to 100 per cent nationwide by 2030 (Government of the Federated States of Micronesia, 2022).	The Federated States of Micronesia is on track to achieve 100 per cent universal access to electricity by 2024.	There may be some unregistered households and gers that still have no access to electricity. In such minor cases, solar mini-grids and solar home systems, could be considered.
Access to clean cooking	Not available.	The NEXSTEP analysis projects that the Federated States of Micronesia may only reach a 64.8 per cent clean cooking access rate as per the historical improvement trend.	In consideration of comments from stakeholders, NEXSTEP analysis suggests bridging the remaining gap with LPG/butane gas cooking stoves and ICS as the most appropriate clean cooking solution to achieve 100 per cent access to clean cooking.

Category	Existing policy	Policy evaluation	NEXSTEP analysis
Renewable energy in TFEC	Not available.	The share of renewables in TFEC is projected to be 9.2 per cent in the CPS due to the planned increase of renewable power capacities under the existing capacity expansion plan.	The renewable energy share in TFEC will further increase to 26.2 per cent in the SDG scenario. This increase is attributed to phasing out of inefficient traditional biomass and kerosene stoves with LPG/butane gas cooking stoves and ICS. This increase is also because of the additional measures taken to increase energy efficiency.
Renewable energy in the power sector	The Updated Nationally Determined Contribution (NDC) sets a conditional mitigation target of increasing electricity generation from renewable energy to more than 70 per cent of total generation in 2030 (Government of the Federated States of Micronesia, 2022).	The NEXSTEP analysis estimates that the Federated States of Micronesia will reach a 57.7 per cent renewable generation, falling short from the target. This is due to the fact that significant amount of diesel generation will still be in operation in the Federated States of Micronesia to meet the increasing electricity demand.	The renewable energy share in power generation will further increase to 81.7 per cent in the SDG scenario. This increase is attributed to the proposed energy efficiency measures to reduce electricity demand.
Energy efficiency	The National Energy Policy and Action Plan 2012 aims at 50 per cent improvement in energy efficiency by 2020 (Government of the Federated States of Micronesia, 2012).	Due to budget constraints, no energy efficiency measures have been implemented. The CPS will not achieve the suggested global energy efficiency improvement target of 3.4 per cent or 3.5 MJ/US$2017 in 2030. It is projected that the energy intensity will be 4.6 MJ/ $US\$_{2017}$ in 2030.	The energy intensity is further reduced to 3.5 MJ/$US\$_{2017}$ in 2030 under the SDG scenario, which meets the global energy efficiency target. Achievement of this target requires phasing out inefficient cooking technologies, accelerating the implementation of green building code in designated buildings, accelerating mode shifting and fuel economy improvement in the transport sector, and promoting equipment performance benchmarks and labelling.

Category	Existing policy	Policy evaluation	NEXSTEP analysis
Emissions reduction	The Updated Nationally Determined Contribution (NDC) sets a conditional mitigation target of reducing carbon dioxide emissions from electricity generation by more than 65 per cent below the 2000 level in 2030 (relative to the year 2000 inventory, electricity generation accounts for 64 $ktCO_2$-e meaning the conditional NDC target of reducing emissions from electricity generation will be around 41.6 $ktCO_2$-e) (Government of F.S. Micronesia, 2022).	The Federated States of Micronesia will not be able to achieve this conditional NDC target by 2030 under the current policy settings. Although total emissions are expected to decrease from 128.1 $ktCO_2$-e in 2019 to 114.6 $ktCO_2$-e in 2030, the emissions from electricity generation will still be 27.8 $ktCO_2$-e.	In the SDG scenario, total emissions are expected to further decrease to 82.1 $ktCO_2$-e by 2030, corresponding to a 105.4 $ktCO_2$-e (or a 56.2 per cent) reduction compared to the BAU scenario. The emissions from electricity generation will be 8.7 $ktCO_2$-e meeting the conditional NDC target.

Source: ESCAP.

8.3. Policy recommendations

8.3.1. Promote LPG/butane gas stoves and ICS to provide a sustainable solution to achieving universal access with multifold benefits.

Universal access to clean cooking solutions should be a key priority in the Federated States of Micronesia and needs to be included in the energy policy. NEXSTEP analysis suggests that the gaps in clean cooking in the Federated States of Micronesia be closed by promoting the use of LPG/butane gas stoves and ICS. These stoves are a key solution to achieving universal access to clean cooking by 2030. In the long term, however, electric cooking stoves must be considered to support the achievement of the TNZ emissions by 2050 scenario with no added burden on fuel imports.

Electric cooking stoves are more efficient than other cooking stoves, including gas stoves, but electric cooking stoves have higher annualized costs compared to LPG/butane gas stoves, since the electricity tariff is still expensive. The annualized cost of an electric cooking stove will be around $180 - $244, while the LPG cooking stove will be $124 - $162. In areas where LPG/butane gas stoves are not available, ICS can be considered. It is estimated that a total investment of $1.21 million will be required to distribute LPG/butane gas cooking stoves to 4,080 households ($0.66 million) and ICS to 6,093 households ($0.55 million). To minimalize the butane canister waste, a recycling and reuse mechanism must be developed.

8.3.2. Adopt a multisectoral approach to raise energy efficiency strategies by 2030 to align with global improvement target.

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

Achievement of the SDG 7 target of 3.5 MJ/US$ by 2030 (3.4 per cent annual improvement rate), will require a reduction of TFEC by 7.6 ktoe compared to the CPS. To achieve this target, the Government should consider accelerating the implementation of energy codes, improving equipment performance benchmarks and labelling, shifting transport modes and improving the fuel economy by 2030.

8.3.3. Fuel switching strategies, including electrification of the transport sector, can reduce emissions and dependence on imported fuels.

Electrification of the transport system will be critical for the Federated States of Micronesia in the long term due to increasing oil prices and rapidly growing share of electric vehicles in the global market. A vigorous adoption of electric vehicles, for example, would reduce the demand for oil products. Another advantage of EVs is their ability to absorb excess renewable energy. With specialized networks and large number of EVs plugged into the grid at any one time, there is the possibility to use the combined stationary battery capacity as an element of load levelling to enable higher penetration of renewables in the future. To promote the investments, the Federated States of Micronesia can set financial and tax incentives, and safety standards.

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

The Federated States of Micronesia will fall short in achieving the 70 per cent renewable share in power generation by 2030 since diesel generation will be required to fulfil the increasing electricity demand. Energy efficiency measures will be critical to help reduce the electricity demand decreasing the need for diesel generation. Discouraging new investments in diesel-fired power generation is also essential to meet the renewable energy targets. Policymakers should plan to retire existing diesel-fired power plants, and the importance of early action in this case cannot be overstated. A schedule for the planned retirement of existing diesel-fired power plants should be defined and implemented as quickly as possible to reach zero diesel power plants by 2050.

In the past, diesel-fired generation was a cheap and reliable, albeit polluting, method of generating electricity. This is no longer the case as renewables have matured and costs have dropped significantly. It is cheaper today to generate electricity from renewables such as solar, hydropower and wind compared to diesel-fired technologies. Strategies, such as IPP mechanisms and renewable auctions can be considered to provide revenue streams to attract investments in renewable energy generation.

8.3.5. Develop green financing policy

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

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

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

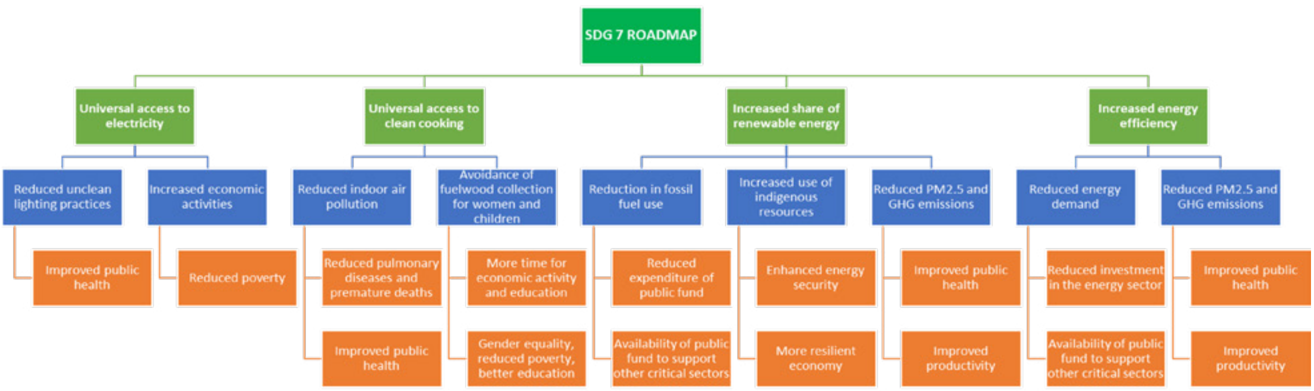
First, energy enables the delivery of a range of essential services to support healthcare facilities, supply clean water for essential hygiene, enable communication and IT, and refrigerate off-grid renewables for vaccine storage. These services are only possible with reliable, affordable supplies of energy and are essential in boosting the resilience of the country.

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

The COVID-19 pandemic caused immense socioeconomic disruption globally and the Federated States of Micronesia was no exception. With the Government's effective COVID-19 health strategies, according to WHO (2023), there were 26,547 confirmed cases of COVID-19 with 65 fatalities (as of 4 October 2023), and a total of 198,749 vaccine doses were administered (as of 27 March 2023). Notwithstanding, the country's GDP contracted by 1.8 per cent in 2020 and 3.2 per cent in 2021 (World Bank, 2023a). While grappling with the devastation caused by the pandemic, the Federated States of Micronesia should not lose sight of its progress and ambitions towards achieving the SDG targets. It should take the opportunity to build back better from the crisis, in order to become more resilient to face future challenges such as climate change.

Thus, it has never been more important to design a well-planned energy transition pathway that enables the country's energy sector to shield itself from the likely impacts of the COVID-19 pandemic and helps to build back better as part of the COVID-19 recovery. The SDG 7 roadmap has identified several key areas that will assist policymakers in strengthening policy measures to help recover from the COVID-19 impact while maintaining the momentum to achieving the 2030 Agenda for Sustainable Development and the Paris Agreement. Figure 26 presents how the SDG 7 Road Map will help to increase the capacity of the Federated States of Micronesia to recover from the COVID-19 pandemic.

Figure 26. SDG7 Road Map to increase the capacity of the Federated States of Micronesia to recover from the COVID-19 pandemic



Source: ESCAP.

8.4.1. Accelerating access to clean and modern energy services

Access to clean and modern energy services is essential for helping rural populations to combat the challenges related to the COVID-19 pandemic. Relying on traditional and hazardous technologies for cooking increases their susceptibility to the effects of the virus. Ongoing research is uncovering links between air pollution and the incidence of illness and death due to the COVID-19 pandemic. Recent research suggests that PM2.5[9] air pollution plays an important role in increased COVID-19 incidence and death rates. One such

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

study reported that PM2.5 is a highly significant predictor of the number of confirmed cases of COVID-19 and related hospital admissions (Andree, 2020). It is important to consider how the lack of access to clean cooking combines with the COVID-19 virus to affect the most vulnerable people.

The Federated States of Micronesia had around 60.3 per cent of the population or around 10,260 households that lacked access to clean cooking fuel in 2019. Women and children disproportionately bear the greatest health burden from polluting fuels and technologies in homes as they typically perform household chores, such as collecting firewood, cook with inefficient methods as with open fire, and spend more time exposed to harmful smoke from polluting stoves.

One medium-term impact of the COVID-19 pandemic was decreased investment in energy access, as national budgets come under strain and priorities shifted. In addition, access to clean cooking technologies is a major development challenge that is often forgotten. The World Health Organization (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. By 2019, there were around 48 annual fatalities due to household air pollution-related diseases in the Federated States of Micronesia (World Bank, 2022b).

The SDG 7 roadmap has identified technical options for connecting the remaining population to cleaner fuel and efficient technologies for cooking and heating. The benefits resulting from this measure, in the form of reduced mortality and health impacts outweigh the needed investment to advance the clean cooking rate and clean heating rate to reach 100 per cent. According to the World Bank (2022b), the cost of health damage from PM 2.5 exposure due to household air pollution in Pacific countries is around \$13 - \$15 million per year, which is significantly higher compared to the cumulative cost of providing clean cooking technologies of \$ 1.21 million.

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

NEXSTEP analysis identifies that there are ample opportunities for the Federated States of Micronesia to save energy by improving energy efficiency beyond its current practices. Several of these measures also provide cost savings and strengthen the country's energy security, making it less susceptible to fuel supply and price shocks. For example, the total energy saving potential in the transport sector through the introduction of mode shifting and the improvement of fuel efficiency in the SDG scenario will be around 4.7 ktoe in 2030. Savings from this improvement can be reinvested in other sectors, such as health, social protection and economic stimulus, which are critical in responding to and recovering from the COVID-19 pandemic.

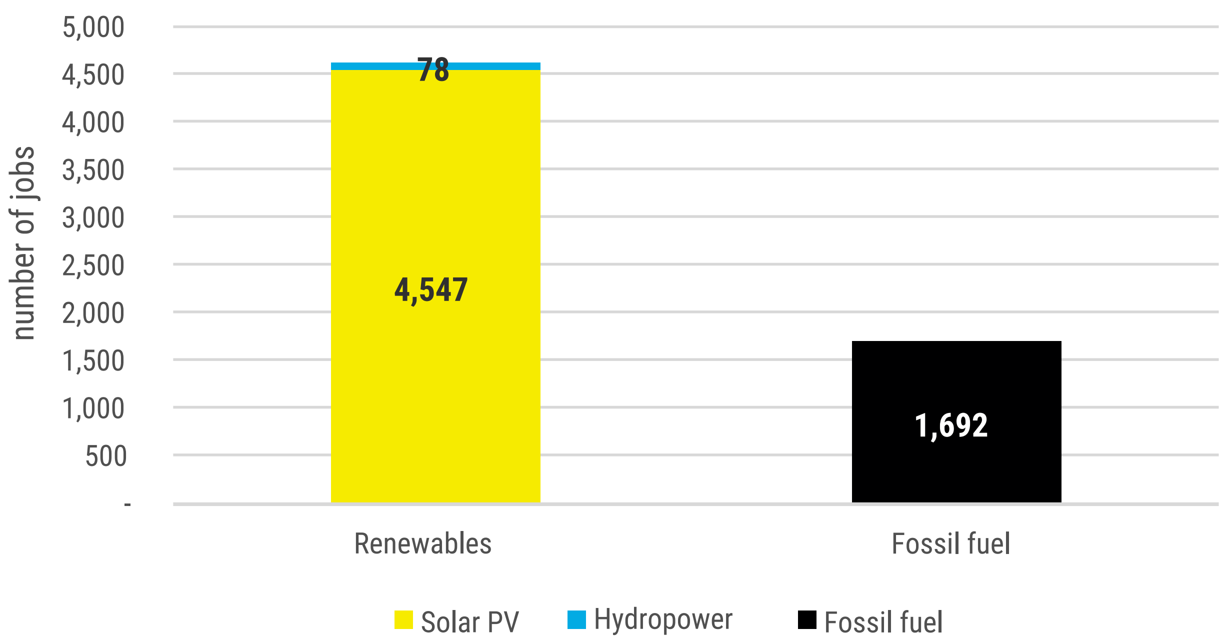
In the long run, electrification of the transport sector will provide multiple additional benefits (in addition to energy saving), including the reduction of expenditure on importing petroleum products and reducing local air pollution. Such measures are very important to solidifying the pathway to recovery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

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

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

Deployment of clean energy systems requires much less lead time than fossil fuel counterparts. Moreover, clean energy can create three times more jobs for the same amount spent on fossil fuel. Under the TNZ emissions by 2050 scenario, discussed in chapter 6, an additional 248.3 MW solar power plants and 5.2 MW hydropower compared to base year capacity are required. This will require an investment cost of around \$628 million for solar power plants and \$10.4 million for hydropower. The average job creation for solar PV and hydropower are around \$7.24 million and \$7.53 million, respectively (Garrett-Peletier, 2017). In contrast, Garrett-Peletier (2017) found that only 2.65 full-time equivalent jobs are created \$1 million of spending in fossil fuels. Therefore, these renewable investments will provide employment opportunities to around 2.54 million people compared with only around 0.93 million people employment opportunities generated from the same amount of investment in fossil fuel (figure 27).

Figure 27. Comparison of number of jobs created by renewable energy and fossil fuels



Source: ESCAP analysis.

8.4.4. Recovery options after the COVID-19 pandemic for the Federated States of Micronesia

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

9. Conclusion and the way forward

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

The Federated States of Micronesia is projected to fall short of achieving universal access to electricity by 2030 based on historical projection. Solar mini grids and solar home systems can be utilized to close the gap. Additionally, much needs to be done to achieve universal access to clean cooking by 2030. A coordinated approach is therefore highly desirable from both the private and public sectors to close the gaps in clean cooking and provide clean technologies to the remaining population. For example, LPG/butane gas cooking stoves, which build on commonly used practices, should be promoted to reduce fuel consumption and household indoor pollution. ICS can be promoted in areas where distributing LPG/butane gas stoves would be challenging.

Opportunities exist in the residential, transport and commercial sectors to save more energy through the implementation of energy efficiency measures particularly by adopting mode shifting, improving fuel economy and implementing energy management standards and energy codes. Increased efforts can help achieve the global energy efficiency improvement target of 3.4 per cent annually. Strengthening energy efficiency measures will support the Federated States of Micronesia in achieving its conditional NDC target.

The Federated States of Micronesia will fall short of achieving the renewable energy generation target by 2030. The renewable energy share in TFEC will improve slightly since the energy system will still depend on diesel to fulfil the increasing electricity demand. Improving energy efficiency and increasing modern renewable energy will further increase the share of renewable energy. The promotion of electric cooking stoves and electric vehicles in the long term will require substantial amount of electricity in the future. Diversification of generation sources using solar PV, wind and hydropower would help the country to meet the increasing demand for electricity, diversify generation sources and improve energy security. The scenario analysis using the MCDA tool suggests that the net-zero emissions scenario is the highest ranked scenario for navigating the energy sector towards 2050. In addition to achieving the SDG 7 targets, this scenario will also enable the Federated States of Micronesia to exploit its full potential for emissions reduction in the long term.

Annexes

I. National Expert SDG 7 Tool for Energy Planning (NEXSTEP) methodology

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

Table I. 1. Targets and indicators for SDG 7

Target	Indicators	2019	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.	81.3 per cent	100 per cent
	7.1.2. Proportion of population with primary reliance on clean fuels and technology for cooking.	39.7 per cent	100 per cent
7.2. By 2030, increase substantially the share of renewable energy in the global energy mix.	7.2.1. Renewable energy share in total final energy consumption.	0.8 per cent (excluding traditional biomass)	26.2 per cent
7.3. By 2030, double the global rate of improvement in energy efficiency.	7.3.1. Energy intensity measured as a ratio of primary energy supply to gross domestic product.	5.2 MJ/US$ (2017) PPP	3.5 MJ/US$ (2017) PPP

SDG 7.2. Renewable Energy

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

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

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

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

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

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

Base period improvement rate for the Federated States of Micronesia (1990-2010): 2.1 per cent.

Doubling the improvement rate requirement for the Federated States of Micronesia (2010-2030): 4.2 per cent.

Historical improvement rate for the Federated States of Micronesia (2010-2019): -2.7 per cent.

Required improvement rate for the Federated States of Micronesia in the remaining period to achieve the doubling improvement rate (1990-2010): 9.3 per cent.

SDG 7.3. improvement rate for the Federated States of Micronesia (suggested global improvement rate): 3.4 per cent.

II. Key assumptions for NEXSTEP energy modelling

(a) General parameters

Table II. 1. GDP, PPP and growth rate

Parameter	Value
GDP (2019, constant 2015 US dollar)	US$ 332 million
PPP (2019, constant 2017 US dollar)	US$ 394 million
Growth rate	1.17 per cent per annum

Table II. 2. Population, population growth rate and household size

Parameter	Value
Population (2019)	104,358
Population growth rate	0.4 per cent per annum
Number of households (2019)	17,024
Household size (constant throughout the analysis period)	6.1

(b) Demand-side assumptions

(i) Transportation

- Land and marine transport consumption is estimated using the vehicle statistics, load factor, annual travel mileage and estimated fuel economy as shown in table II.3. The factors are based on vehicle statistics compiled by the SPC, and assumptions made by ESCAP and the local SPC, as local specific data is scarce.
- Land transport activities in 2019 are estimated to have been 231.6 million passenger-kilometres and 124.6 million ton-kilometres. The growth in both passenger transport and freight transport activities is assumed as growing at the same rate as the GDP per capita.
- Marine transport activities in 2019 are estimated to have been 9.5 million passenger-kilometres and 68.9 million ton-kilometres. The growth, both in passenger transport and freight transport activities, is assumed to occur at the same rate as the GDP per capita.

Table II. 3. Passenger-km and ton-km distribution

Land transport					
Passenger transport	**Number of vehicles**	**Annual mileage (km)**	**Load factor (passenger-km/ vehicle-km)**	**Fuel consumption km/l**	**Percentage share of passenger-km**
Passenger car	9,409 (gasoline) 315 (diesel)	8146 7300	2.5 2.5	7.5 7.5	85.2
Motorcycle	46 (gasoline)	6,745	1.6	11.3	0.2
Taxi	75 (gasoline)	14,600	2.5	7.5	1.2
Bus	11 (gasoline) 22 (diesel)	22,177 23,227	30	3.4 3.7	9.8
Minibus	4 (diesel)	10,950	8	3.7	0.2
Tractor	5 (diesel)	1,400	1.8	10	~0.1
Other	4 (diesel) 5 (diesel)	18,812 9,967	2	7.6 8	3.5
Freight Transport	**Number of vehicles**	**Annual mileage (km)**	**Load factor (ton-km/vehicle-km)**	**Fuel consumption km/l**	**Percentage share of ton-km**
Freight truck	1,132 (gasoline) 150 (diesel)	14,881 14,934	13	2	91.9
Freight van	389 (gasoline) 52 (diesel)	15,245 15,247	9	8	8.1

Marine transport					
Passenger transport	**Number of vehicles**	**Annual mileage (km)**	**Load factor (passenger-km/ vehicle-km)**	**Fuel consumption**	**Percentage share of passenger-km**
Medical boat	9 (diesel)	527	1.8	1.3	0.1
Ferry	3 (gasoline) 9 (diesel)	2,600 4,160	50	0.05 0.05	23.8
Small fishing boat	3,544 (gasoline) 1,509 (diesel)	800 780	1.8	1.27 1.27	76.1
Freight Transport	**Number of vehicles**	**Annual mileage (km)**	**Load factor (ton-km/vehicle-km)**	**Fuel consumption**	**Percentage share of ton-km**
Cargo	5 (diesel)	4,992	600	0.05	21.7
Big fishing boat	3 (gasoline) 44 (diesel)	1,300 1,330	865	0.05 0.05	78.3

(ii) Residential

- The residential sector is further divided into urban and rural households. Urban households have achieved a 100 per cent electricity access rate, while rural households have achieved a 64.3 per cent electricity access rate; the overall clean cooking rate was 39.7 per cent in 2019. The breakdown is shown in table II.4.

Table II.4. Cooking distribution in urban and rural households

Stove type	Energy intensity (GJ/household)	Urban Percentage	Energy intensity (GJ/household)	Rural Percentage
LPG stove	9.1	11.4	9.1	1.9
Butane can stove	9.1	45.4	7.8	25.1
Electric stove	5.5	10.3	3.9	4.0
Biomass stove*	51.5	28.7	30.7	62.0
Kerosene stove*	38.6	4.0	12.4	6.5
Biogas digestor	115.9	0.2	17.6	0.6

* This is assumed as unclean fuel/technology.

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

Table II. 5. Residential appliance baseline assumptions

Appliance	Electricity intensity (kWh/HH/year)	Ownership – urban Percentage	Electricity intensity (kWh/HH/year)	Ownership – rural Percentage
Lighting	657.0	100	429.7	100
Air conditioner	1,314.0	10	831.8	9.6
Refrigerator	1,095.0	100	746.9	67.4
Television	408.8	100	354.2	91.5
Electric heater	180.0	90	180.0	66.2
Electric fan	219.0	100	215.0	98.8
Washing machine	15.6	60	12.6	48.5
Water pump	365.0	8	372.4	4.4
Iron	52.0	100	47.1	74.4

(iii) Commercial sector

- The total annual energy consumption in the commercial sector was 3.46 ktoe in 2019. It is projected to grow at an annual rate similar to the national GDP growth rate.

- The commercial sector is further differentiated into seven categories and the energy consumption by categories are as shown in table II.6.

Table II. 6. Commercial sector fuel consumption in 2019

Category	Floor space (m^2)	Fuel consumption (ktoe)		
		Electricity	Thermal	Total
Private offices	31,259	0.30	-	0.30
Government buildings	76,227	0.62	-	0.62
Supermarket and shops	83,666	0.78	0.15	0.93
Hotels and restaurants	46,233	0.42	0.10	0.52
Health facilities	35,200	0.42	0.07	0.49
Educational institution	83,943	0.51	0.06	0.57
Worship centres	15,121	0.03	-	0.03
Total	**371,649**	**3.08**	**0.38**	**3.46**

(iv) Industry

- The industry sector is differentiated into states. The fuel consumption by industry subcategories is as detailed in table II.7.
- The industrial GDP is assumed to grow at a rate similar to the national GDP growth rate. The energy intensity is assumed constant throughout the analysis period in the absence of energy efficiency interventions.

Table II. 7. Fuel consumption by industry subcategories in 2019

Industry	Fuel consumption (ktoe)					
	Coal	Natural gas	Oil products	Electricity	Biomass	Total
Pohnpei industry	-	-	0.06	0.12	-	**0.18**
Yap industry	-	-	-	0.13	-	**0.13**
Kosrae industry	-	-	-	0.01	-	**0.01**
Total	**-**	**-**	**0.06**	**0.26**	**-**	**0.32**

(v) Other sectors

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

Table II. 8. Consumption by other sectors in 2019

Category	Fuel consumption (ktoe)					
	Coal	Natural gas	Oil products	Electricity	Heating	Total
Agriculture	-	-	0.6	-	-	0.6
Non-energy use	-	-	0.4	-	-	0.4

III. Power technologies cost and key assumptions

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

Table III. 1. Power technologies key assumptions

Technology	Efficiency Percentage	Investment cost (US$/MW)	Fixed O&M (US$/MW-year)	Variable O&M (US$/MWh)
Diesel	45	1,100,000	8,000	6.4
Solar	-	2,500,000	15,000	0.5
Wind	-	4,000,000	60,000	-
Hydro	-	2,000,000	37,700	0.7

IV. Economic analysis data for clean cooking technologies

The NEXSTEP economic model utilizes the technological and cost parameters to estimate the annualized cost of clean cooking technologies (table IV.1). The calculation assumes an annual cooking thermal energy requirement of 1,533 MJ per household. In addition, a discount rate of 5.37 per cent is assumed.

Table IV. 1. Technology and cost data for clean cooking technologies

Technologies	Efficiency (Percentage)	Lifetime (years)	Stove cost (US$)	Variable O&M (US$/year) (ESCAP analysis)	Fuel cost (US$)
LPG/butane can stove	60 (World Bank, 2014)	7 (Clean Cooking Alliance, 2021)	30	10	0.95 – 3.25 per canister
Electric stove	84 (IEA, 2012)	15 (IEA, 2012)	37	10	0.31-0.61 per kWh
ICS stove	36 (ESCAP analysis)	4 (ESCAP analysis)	25	10	0.22 per kg

V. Summary results for the scenarios

	BAU scenario	CPS scenario	SDG scenario
Universal access to electricity in 2030	89.9%	89.9%	100%
Universal access to clean cooking in 2030	45.9%	45.9%	100%
Energy efficiency in 2030	6.5 MJ/US$	4.6 MJ/US$	3.5 MJ/US$
Renewable energy share in TFEC in 2030	0.9%	9.2%	26.2%
GHG emissions in 2030	187.5 ktCO_2-e	114.6 ktCO_2-e	82.1 ktCO_2-e
Renewable energy share in power generation in 2030	5.7%	57.7%	81.7%
Net benefits from the power sector	US$ 370 million	US$ 286 million	US$ 248 million
Total investment for the power sector up to 2030	US$ 48 million	US$ 84.1 million	US$ 97.7 million

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